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UTGIT AV

VIDENSKAPSSELSKAPET I KRISTIANIA

1921

I. MATEMATISK-NATURVIDENSKABELIG KLASSE

2. BIND

KRISTIANIA
I KOMMISSION HOS JACOB DYBWAD
A. W. BRØGGERS BOKTRYKKERI A/S
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Indhold.

KALKTUFSTUDIER I GUDBRANDSDALEN

AV

ROLF NORDHAGEN

(MED 44 TEKSTFIGURER OG 5 PLANCHER)

(VIDENSKAPSSELSKAPETS SKRIFTER. I. MAT.-NATURV. KLASSE. 1921. No. 9)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
I KOMMISSION HOS JACOB DYBWAD
1921

Fremlagt i den mat.-naturv. klasses møte den 3dje juni 1921 ved prof. H. H. Gran.

A. W. BRØGGERS BOKTRYKKERI A/S

INDHOLD.

FORORD.

Høsten 1913 omtalte professor R. SERNANDER Gudbrandsdalens kalktuffer under sine forelæsninger ved Kristiania universitet og opfordret undertegnede til at undersøke dem paany. Imidlertid hadde jeg av konservator P. A. ØYEN faat oplysninger om et par kalktuffer i det trondhjemske, opdaget av hr. MARTIN MOE, Stjørdalshalsen. Og da jeg somrene 1914 og 1915 opholdt mig i denne del av landet, foretok jeg en undersøkelse av forekomstene, som dog gav et lite opmuntrende resultat. Den ene forekomst mellem Olderen og Velvang paa Skatvalhalvøen bestod av jordagtig tuf avsat høit oppe i en stupbrat ur, den anden lokalitet ved Auran (omtalt av ØYEN 1915 l. c. p. 44) opviste kun ubetydelige tufmasser sterkt opblandet med bergartsmateriale. Helt uten interesse var undersøkelsen dog ikke. Den ene av forekomstene viste nemlig i den øvre tilgjængelige del et avbrud, karakterisert ved ansamling av smaa skiferbiter (nedraset forvitringsmateriale). Jeg har tidligere bare omtalt resultatet i en stipendie-indberetning til det Akademiske kollegium, men haaber at komme tilbake til disse kalktuffer ved en anden anledning.

Sommeren 1917 lyktes det konservator ØYEN og overlærer HOLME paa Lillehammer at paavise en ny og høist interessant kalktuf i Gudbrandsdalen, nemlig ved Tingvold og Gillebu i Øier herred, hvor HOLME allerede for mange aar siden opdaget kalktufstykker i en grusavsætning.

Konservator OVE DAHL og undertegnede assisterte senere ved bestemmelsen av det store materiale som ØYEN medbragte fra Øier, og da det lyktes mig at identificere nogen eiendommelige bladavtryk med *Hippophaës rhamnoides,* var min interesse for alvor vakt. Da ØYEN mente at der kunde være en efterhøst at gjøre, specielt i palæofloristisk henseende, bestemte jeg mig næste sommer for at reise til Gudbrandsdalen.

Turen gik først til Otta, hvor jeg haabet at finde en ny tufforekomst, idet fiskeriinspektør A. LANDMARK for en del aar siden hadde iagttat hvite tufskorper og løse biter i de bratte lier ved Kringen, og overfor undertegnede antydet at der maatte være kalkholdige kilder paa stedet. Imidlertid viste det sig at det her bare gjaldt helt ubetydelige forekomster av jordagtig tuf og tynde skorper paa fjeldsiden; saadanne fandt jeg paa 3—4 forskjellige steder mellem Solgjem og Otta paa dalens østside. Efter to dages ophold paa Otta drog jeg til Pillarviken, et stykke oppe i Otta-dalføret (Lalm), hvorfra der i sin tid var indleveret prøve av kalktuf til Universitetets samling. Findestedet laa desværre midt ute i en rugaker, men ved eierens, hr. N. SVEINES elskværdighet fik jeg anledning til at foreta en gravning, som dog bare bragte større og mindre mosetufbiter for dagen, av samme type som de i samlingen opbevarte stuffer. Nogen indgaaende stratigrafisk studie var der saaledes ikke adgang til paa det nævnte tidspunkt. Jeg fortsatte derfor til Sørem i Vaage, hvor hr. gaardbruker SØREM i sin tid hadde fundet løse blokker av en haard kalktuf i nærheten av en nedlagt husmandsplads (Gulbrandheimen) paa Ottas anden bred, vis à vis Sørem. Jeg fandt ogsaa ganske rigtig stedet og et par tufblokker, som laa i en gammel stenmur. Men trods ihærdige undersøkelser i dalsiden omkring pladsen var det ikke mulig at opdage nogen tuf. Enten maa de nævnte blokker, som i sin tid blev fundet nede i stranden, være blit transportert med elven under isløsningen fra et eller andet sted høiere oppe i dalen, eller de maa skrive sig fra fjeldet høit over Gulbrandheimen. Tuffen var tildels breccieagtig med smaa biter av forskjellige bergarter, men uten tydelige fossiler. Antageligvis skriver den sig fra en lokal forekomst av ubetydelig utstrækning.

Efter disse undersøkelser, som heller ikke var særlig opmuntrende, drog jeg ned i Gudbrandsdalen igjen, hvor der ialfald var tuf nok at undersøke. Først stoppet jeg i Kvam for at ta *Leinetuffen* i øiesyn. Av forskjellige uttalelser fra folk som i aarenes løp hadde besøkt Leine, hadde jeg faat det indtryk, at der nu for tiden bare var ubetydelige rester igjen av denne tuf, væsentlig løse biter i de øvre jordlag og avfald fra Blytts store indsamlinger i 1891. Desto større var derfor min overraskelse, da jeg efter et par resultatløse prøvegravninger fik op en grøft som aabenbarte et overordentlig vakkert og sammenhængende profil. Resultatet var dog en smule forvirrende, idet jeg istedenfor én *Dryas*-førende horisont, saaledes som Blytt omtaler, fandt to saadanne med et mellemliggende bladtuflag. Mægtigheten av de enkelte horisonter var ogsaa helt anderledes end Blytts profiler viste. Av en gammel mand i Kvam, som i sin tid hadde hjulpet Blytt med gravearbeidet, fik jeg nøiagtig vite hvor disse profiler var optat, og det lyktes mig dernæst at konstatere at den undre del av tuffen paa dette sted var saaledes som av Blytt beskrevet. Imidlertid var *Dryas*-laget og den øvre del av tuffen fjernet, saa paa dette punkt var jeg like klok. Da jeg denne sommer fortrinsvis hadde tænkt at arbeide i Øier, kunde jeg ikke ofre mere tid paa Leine, men nøiet mig med at medføre et stort materiale fra de forskjellige lag i profilet.

Ved *Gillebu* i Øier foretok jeg indgaaende stratigrafiske studier paa en række punkter og med positivt utbytte. Ogsaa *Hippophaës's* vertikale utbredelse i tuffen blev nøiagtig undersøkt. Herfra medbragte jeg ogsaa en stor samling med haandstykker, som blev underkastet en foreløbig granskning efter hjemkomsten til Kristiania.

Vaaren 1919 bestemte jeg mig for alvor til at grave op hele Leine-tuffen paany, idet jeg haabet at der maatte kunne findes et mellemled som forbandt Blytts profiler med mit eget. Jeg bestemte mig for at grave en lang „skyttergrav" gjennem tuffen og opta nøiagtige profiler hele veien for at komme paa det rene med om forekomsten virkelig var saadan som Blytt hadde beskrevet den. Jeg fandt dette absolut nødvendig, da der fra forskjellige hold overfor mig blev hævdet at man ikke maatte stole for meget paa en saa subjektivt farvet fremstilling som Blytts. Til disse undersøkelser fik jeg likesom foregaaende aar et bidrag av Rathkes legat, hvorfor jeg her fremfører min bedste tak.

I slutten av juni 1919 drog jeg atter til Gudbrandsdalen. Først gjorde jeg en avstikker til Ransverk i Vaage, hvor der ifølge hr. gaardbruker Sørem skulde findes kalktuf nær Mysuholet sæter mellem Ransverk og Lemonsjoen. Sammen med hr. Jens Tronhus undersøkte jeg terrænget omkring den nedlagte sæter, men vi fandt kun litt drypstensagtig vakkert krystallinsk kalk, som var meget løs, ved foten av en bergvæg i skogen. — Derefter drog jeg til Leine i Kvam, hvor jeg i løpet av de følgende uker, assistert av hr. Paul Røen, fik opkastet en ca. 20 m. lang og 1,5—2 m. dyp sammenhængende grøft paa langs av bakkeskraaningen, desuten en hel del tverprofiler. Alt i alt blev ca. 25 saadanne nøiagtig analysert og opmaalt og et meget rikt fossilmateriale indsamlet.

Arbeidet gav meget tilfredsstillende resultater og bød paa flere overraskelser. Saaledes fandt jeg meget snart rester av en helt ny tufhorisont ovenpaa furutuffen, som bragte en række nye momenter ind i diskussionen. Det viste sig ogsaa at de forskjellige tuflag hadde sit maksimum paa helt forskjellige punkter indenfor avsætningens omraade. Litt efter litt lyktes det mig at forfølge de temmelig komplicerte stratigrafiske forhold inden Leinetuffen og at sammenstille disse til et sammenhængende profil.

Efter indbydelse av professor R. Sernander tilbragte jeg høstterminen 1919 paa det plantebiologiske institut i Uppsala, og medbragte hele mit store kalktufmateriale til nærmere granskning. Institutets vakre samlinger av svensk kalktuf blev stillet til min disposition, likesom professor Sernander paa alle mulige maater bistod mig med litteratur og oplysninger om svenske tufforekomster, skaffet mig sammenligningsmateriale fra herbariene o. s. v., kort sagt lettet mit arbeide paa al tænkelig vis. I løpet av høsten hadde jeg den tilfredsstillelse at kunne avsløre næsten alle de mange apokryfiske ting og kuriositeter som Leinetuffen indeholdt. Stor nytte hadde jeg av den vistnok først av Nathorst anvendte kollodiummetode, som senere Halle har praktisert med udmerkede resultater. Paa de avtryk som skal undersøkes, dryppes en liten draape kollodium, som naar den er indtørket danner en fin hinde, der avløses forsigtig. De første avtryk er altid daarlige paa grund av forurensninger og luftblærer, men efterhaanden blir de brukbare og kan under mikroskopet avsløre de fineste epidermis- og andre struktureiendommeligheter (spalteaapninger, haardannelser etc.) av stor betydning for bestemmelsenes paalidelighet.

I januar og februar 1920 opholdt jeg mig i Stockholm og gjennemgik med professor Th. Halle Riksmuseets pragtfulde kalktufmontrer i den palæobotaniske samling, likesom professor Halle elskværdigst gav mig tilladelse til at gjennemgaa hele museets store samlinger bl. a. fra Benestad i Skaane og fra de jemtlandske lokaliteter. Samtidig drev jeg litteraturstudier ved Vetenskapsakademiens bibliotek og fik hos statsgeolog dr. L. von Post information i mikroskopisk bestemmelse av vore skogtrærs pollen. Derefter reiste jeg atter til Uppsala, hvor jeg forblev til slutten av mars maaned og bearbeidet resten av mine samlinger.

Jeg vil her faa lov til at rette en varm tak til min ærede lærer og ven professor Rutger Sernander i Uppsala, som gjorde opholdet der uforglemmelig for mig, og for den store interesse han viste overfor mit arbeide. Likesaa vil jeg faa lov til at takke Växtbiologiska Institutionens amanuensis fil. lic. G. E. Du Rietz for hans hjælpsomhet og elskværdighet!

Overfor professor dr. Svante Arrhenius og dr. Olof Arrhenius ved Nobelinstitutet for fysikalsk kemi, som paa alle mulige maater hjalp mig under mit besøk i Stockholm, vil jeg fremføre en dypt følt tak, likesaa overfor professor dr. Th. Halle og dr. L. von Post.

Efter gjennemgaaelsen av samlingene og efterat jeg foreløbig hadde opgjort mig en mening om de undersøkte kalktuffer, fandt jeg det ønskelig endda en gang at ta findestedene i øiesyn, for at stille min egen opfatning paa prøve — en fremgangsmaate som efter min mening gir de bedste garantier for resultatenes paalidelighet.

I oktober 1920 tilbragte jeg nogen herlige høstdager i Kvam og fik bl. a. gravet op et profil som hvad interessant opbygning angaar, slog alle de tidligere studerte av marken. Jeg avla ogsaa et kort besøk ved Gillebu i Øier. I slutten av maaneden reiste jeg op til Faaberg og besaa kalktuffen ved Nedre

Dal, og efterpaa til Biri, for at lete efter den av Blytt i sin tid undersøkte tuf ved Onset. Desværre lyktes det mig ikke med sikkerhet at gjenfinde lokaliteten; men en anden forekomst, som forresten bar spor efter gravning, viste sig at indebære mange træk av interesse.

Av ovenstaaende redegjørelse vil det fremgaa at undertegnede har tat sin opgave meget alvorlig, og ikke skydd noget middel som kunde bringe klarhet over kalktufproblemene. Jeg gik til undersøkelsene indpodet med adskillig skepsis, ikke mindst overfor Blytts studier og teorier. Og den mening som under arbeidets gang litt efter litt har presset sig frem hos mig, er ikke resultatet av nogen paavirkning i denne eller hin retning.

Clements har i et av sine verker kaldt Blytts teori for et „stormcentrum" i nordisk kvartærforskning, og ikke uten grund. Jeg har ogsaa selv hat en levende følelse av, at det at delta i den kvartærgeologiske diskussion er ensbetydende med at utæske kritiken, hvis man da ikke vælger den fremgangsmaate at skrive et arbeide saa upersonlig at læserne ikke paa et eneste punkt øiner forfatterens ansigt. Men da bør man helst ikke sætte sit eget navn under.

Kanhænde vil denne bok ogsaa bringe vind i seilene. Da kalktuffene for Blytts bevissthet stod som vigtige støttepunkter for hans teori, vil man forstaa at denne avhandling bevæger sig indenfor et alt andet end nøitralt gebet.

En ting er imidlertid sikker, og det er, at herefter skal man ikke behøve at diskutere spørsmaalet om hvorledes Gudbrandsdalens kalktuffer er opbygget. Den deskriptive side av saken, som jo er den primære, er ved disse undersøkelser bragt lykkelig i havn. Man kan ikke skyte sig ind under saadanne paaskud som at stratigrafien er mangelfuldt undersøkt, at forholdene er uklare o. s. v. Allerede dette er et fremskridt. Saa faar man stille de forskjellige tolkningsmuligheter op mot hinanden og vælge den, som paa den mest naturlige maate besvarer alle de spørsmaal som reiser sig i det foreliggende tilfælde, og som samtidig ikke kommer i konflikt med andre forskningsomraader. Dette har jeg da efter bedste evne forsøkt at gjøre.

Til slut vil jeg faa lov til at takke konservator P. A. Øyen for den interesse han har vist overfor mine undersøkelser, og for alt det interessante han paa de mange ekskursioner i aarenes løp har vist mig og mine studiekamerater. Jeg har i nærværende avhandling forsøkt at ta et personlig standpunkt til kalktufproblemene, og min opfatning avviker paa enkelte punkter ganske meget fra Øyens. Det kan imidlertid aldrig være til skade for en sak at den blir kritisk belyst fra flere sider.

Professor J. Schetelig har været saa elskværdig at hjælpe mig med bergartsbestemmelser og litteraturoplysninger. Konservator dr. Hjalmar Möller, Riksmuseet, Stockholm, har bestemt en del kalksamlende moser fra Biri, og docent F. Økland, Aas, har bestemt mit materiale av landsnegler. Avdøde fil. lic. Helmer Olivecrona, assistent ved Norges Landbrukshøiskole, Aas, har undersøkt en del Cyanophycé-prøver fra Biri. Ogsaa dr. Nils Odhner, Riksmuseet, Stockholm, har hjulpet mig med det systematiske bestemmelsesarbeide. Til alle disse videnskapsmænd vil jeg faa lov til at rette en ærbødig og hjertelig tak for udmerket assistance, likeledes til Videnskapsselskapet i Kristiania, som har bekostet trykningen av dette arbeide.

Kristiania i mai 1921.

Rolf Nordhagen.

SPECIEL DEL.

I. Kalktuffen ved Leine i Kvam.

A. Topografi og vegetation i nutiden.

I Kvam (anneks til N. Fron) i Gudbrandsdalen gjør Laagen en skarp bøining, idet den først løper ret mot øst, derefter mot syd-sydvest. Dalen har her karakter av en gryte eller et avlangt traug med saagodtsom al bebyggelse samlet paa nordsiden, og hvor elven bøier om, paa østsiden, hvilket dels beror paa ekspositionen mot solen, dels paa det bedre jordsmon paa nordsiden.

Fra nord kommer elven Veikla eller Vindeaaen fossende ned mot hoveddalføret. Denne elv og sidebækken Borju avgrænser tilsammen en mægtig landtunge, som fra Tunsbergfjeldet (944 m. o. h.) falder jevnt, men meget brat av mot dalbunden i syd. Oppe i skraaningen ligger her de gamle Leine-gaarder med sine brunsorte, solsvidde tømmerhus og de store, men tungbrukte jorder. Jordsmonnet er meget frugtbart, hvilket skyldes de kolossale moræneavleiringer som i form av et kalkholdig ler med større og mindre blokker, ofte i tætpakkede lag, dækker hele skraaningen fra Veikla og helt op til mellem 6 og 700 m. o. h., ovenfor Leinegaardene. Til trods for den voldsomt sterke insolation i sommermaanedene lider bønderne her ikke saa meget paa grund av tørke som man skulde vente, netop takket være lermassene, som holder paa vandet.

Disse lerbakker under Leine har været ganske skjæbnesvangre for bygdens befolkning. I tidenes løp har der gang paa gang gaat kjæmpemæssige skred langs Veikla, og store masser av den oprindelige morænefylding har skyllet ut over dalbunden i syd, som av denne grund er ganske komplicert opbygget. Den største katastrofe skedde i aaret 1789, det store ulykkesaar i Gudbrandsdalens nyere historie, da „ofsen" eller den store vandflom herjet overalt i dalen[1]. Den dag idag fortælles det om hvorledes folk reddet sig opover Leinebakkene i hui og hast for at undgaa skredene. De vedføiede fotografier gir et litet indtryk av hvorledes topografien arter sig paa stedet i nutiden. Morænemassene dækker dalsiden temmelig langt opover Veiklas dalføre og har over store strækninger form

[1] Cfr. HELLAND: Norges land og folk. Kristians amt. Bind I.

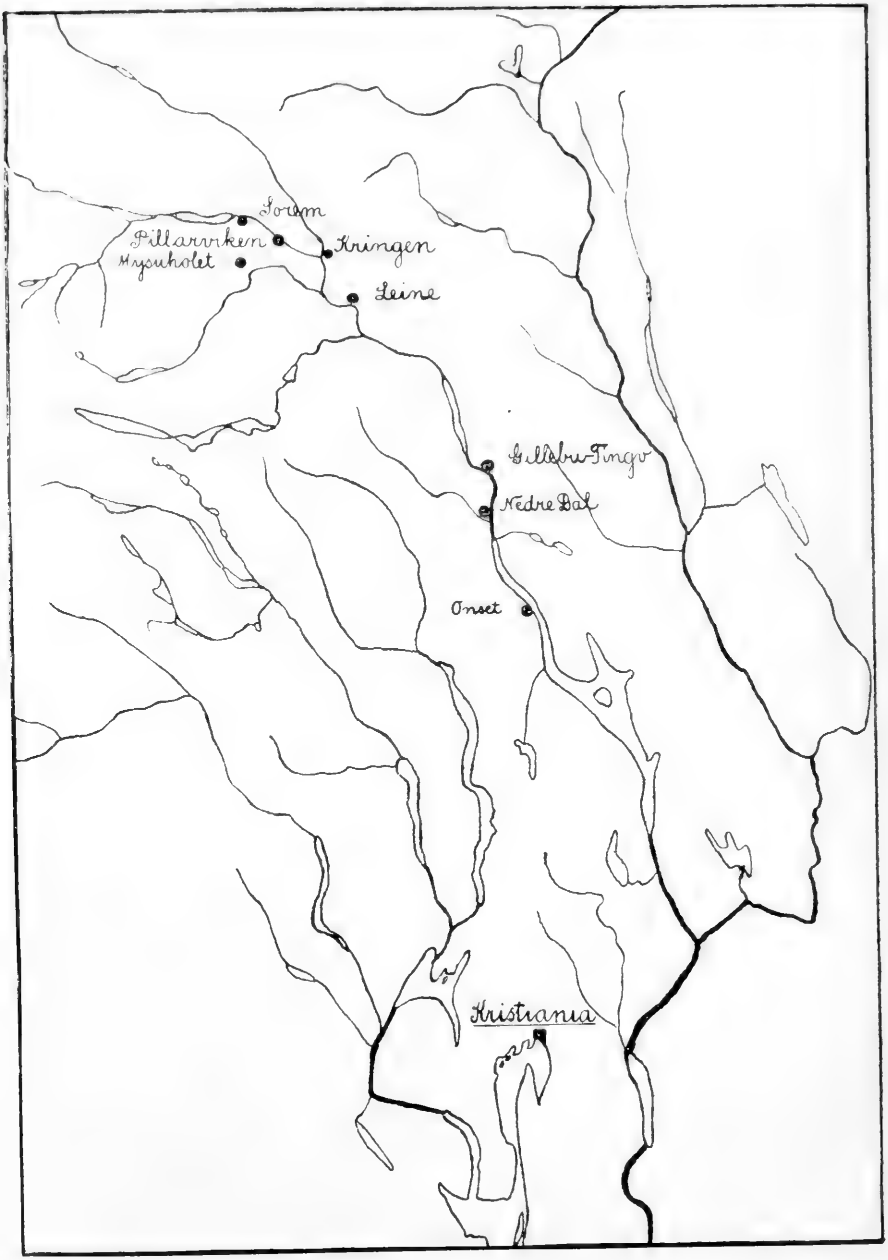


Fig. 1. Kart over de undersøkte kalktuffer i Gudbrandsdalen. 1: 2 000 000.

av længderygger orientert lodret paa elven. Disse rygger er adskilt ved rendeformige smaadaler, som markerer de steder hvor skredene har gaat som værst. Ogsaa paa Veiklas østlige bred gjenfindes lignende lerbakker og længderygger, men i mindre maalestok. Alting tyder paa at Veiklas dalføre i tidligere tider har været sterkt opfyldt av moræneraassene, og at elven efterhaanden har gravet sig ned og forskjovet sig i vestlig retning. Saaledes fortæller traditionen at man i „gamle dager" paa gaarden Veikle fik vand fra kalktufkilden hoit oppe i Leinebakkene, ved hjælp av trærender. Husene paa Veikle laa dengang lavere end i nutiden, men selv under denne forutsætning vilde det i vore dager være umulig at lede vandet paa den nævnte maate. Det hele forutsætter at lerbakkene hadde et meget slakkere forlop og skraanet jevnt ned mot Veikla, som antageligvis ogsaa gik mere ost og nærmere gaarden end nu for tiden. Et andet fænomen som peker i samme retning, er navnet „Fagervold" paa en liten plads ved foten av Leinebakkene (sees paa fig. 3). Ingen vilde nu for tiden falde paa at kalde denne eiendom med et saadant smukt navn; jordveien er alt andet end fager. —

Fig. 2. Lerbakkene ostenfor Leine, mellem Roen og Knipen. Utsigt mot nord fra jordet paa Veikle. Elven Veikla loper i dalens bund (fra hoire).
Juli 1919. Nordhagen fot.

Ogsaa sidebækken Borju har foranstaltet lignende katastrofer. Ifolge gaardbruker Ole O. Knipen, Roen, skal der mellem Leine og gaarden Krok ha ligget en eiendom som er helt forsvundet ved jordskred. Ogsaa i vore dager gaar der hver vaar i snelosningen smaa skred i bakkene, hvilket forøvrig ikke forhindrer folk i at dyrke dem op.

I lerbakkene kommer grundvandet frem paa en række steder som iskolde kilder, specielt nord for gaarden Roen og op for pladsen Knipen. At moræneleret er sterkt kalkholdig kan man straks se paa den rike vegetation i dalsiden; specielt er *Gymnadenia conopea*, som i juli er sterkt fysiognomisk fremtrædende paa fugtig bund, en god kalkbundsindikator. I denne del av Gudbrandsdalen har vi adskillige kalkforende bergarter[1], og det er da disse som i forste række har leveret materialet til moræneleret i Leinebakkene. Man finder ogsaa kalksten blandt blokkene i leret.

Det er for saavidt ikke merkelig, at vi her ogsaa finder flere kilder som i tidens løp har avsat store mængder med kalktuf. Paa det vigtigste tuffindested dannes der i nutiden ringe mængder med mosetuf. Dette er ogsaa tilfældet paa en lokalitet nede i Borjus cañon; her dækker tykke kaker av mosetuf (*Mollia æruginosa*) bergvæggen over en kortere strækning. Ifølge Bjørlykke (1905 l. c. p. 213) skal der i denne dalside anstaa „kalk-

[1] Cfr. Bjørlykkes store arbeide (1905). Aarstallene henviser til litteraturlisten bakerst i boken.

holdig sparagmit", altsaa en slags kalksandsten, og jeg skulde tro at det netop er denne som danner underlaget for den nævnte mosetuf. — Ved pladsen Knipen, hvor der findes store kalktufblokker i jorden langs en bæk ovenfor kjøreveien, har jeg ikke set nogen recent tufdannelse.

Om den bekjendte Leinetufs opdagelse har baade Blytt og Øyen (1920 l. c.) i sine respektive avhandlinger skrevet saa pas indgaaende at jeg her ikke skal gaa nærmere ind paa det kapitel. Forinden jeg gaar over til at skildre tuffens stratigrafi, skal jeg imidlertid omtale vegetationen paa og omkring findestedet, da dette er av stor betydning for de følgende avsnit og de plantegeografiske ræsonnementer som der er fremført.

Fig. 3. Styrtningene nedenfor gaarden Roen (som ligger nederst i Leinejordene). Orekrat, klynger av bjerk og xeromorfe græssamfund. Nederst sees pladsen „Fagervold". Nede i dypet løper Veikla. Utsigt mot nordvest fra Veikle, juli 1919. Kalktuffen ligger ovenfor billedets høire hjørne. Nordhagen fot.

Man skal i vort land med dets magre jordsmon lete længe efter en dalside som hvad vegetationens yppighet angaar, kan maale sig med disse bakker i Kvam. Det næringsrike og jevnt fugtige substrat sammen med den gunstige eksposition (den sterke heldning mot syd og sydøst) har fremkaldt en makeløs frodighet, specielt i de høiereliggende lier op for Knipen. Man finder her udelukkende eutrafente og mesofile, langs bækkene mere hydrofile plantesamfund, bestaaende av løvtræer, græs og urter. Lyngsamfund og andre oligotrafente typer med økonomisk husholdning ser man ikke antydning til. Imidlertid har vegetationen paa de før omtalte længderygger og bratte lerbakker ned mot Veikla til en viss grad et xeromorft anstrøk, paa grund av den sterke avrending og den voldsomme insolation i sommermaanedene.

Det vigtigste skogdannende træ indenfor det angjældende omraade i nutiden er graaôren (*Alnus incana*)[1], dernæst bjerk (baade *Betula odorata* og *B. verrucosa*). Nordenfor Knipen er det mest lav oreskog i dalsiden og litet bjerk. Her er terrænget mere jevnt og ikke saa opdelt i rygger som længer syd, vistnok ogsaa mere fugtig. Nedenfor Leine og Roen der-

[1] Nomenklaturen er den samme som i Blytt-Dahl: Haandbog i Norges Flora. Kristiania 1906.

imot spiller bjerken en ganske stor rolle. Oreskog og krat er her meget almindelig i alle forsænkningene mellem lerryggene, mens bjerken i form av en meget aapen skog eller bare isolerte trægrupper ynder de mere torre rygger, dog kun hvor disse er stabile. De bratteste lerbakker er fuldstændig blottet for al vegetation, og de mindre bratte bærer en hoist eiendommelig og svakt xeromorf græsvegetation, som ikke er helt sluttet og uten bundskikt av moser, hvilket altsammen beror paa substratets sterke skraaning og derav følgende instabilitet. Særlig om vaaren synes der altid at ske glidninger langs ryggenes overflate. Dette er vel ogsaa aarsaken til at bjerk og or har saa vanskelig for at vokse op og danne veritabel skog paa stedet. (Cfr. fig. 2 og fig. 3). Et moment som ogsaa maa tages i betragtning her, er den forholdsvis korte tid som er hengaat siden den store katastrofe under hvilken disse bakker blev utformet (1789). Forøvrig gjor kulturpaavirkning sig sterkt gjældende. Liene anvendes som havnehager for kjorne, tildels ogsaa som utslaatter, og folk har av denne grund næsten overalt hugget ut og lysnet op i lovskogene. Foruten or og bjerk er selje (*Salix capræa*) meget almindelig; desuten findes *Salix nigricans*, *Rhamnus Frangula*, *Ribes rubrum* og *Lonicera Xylosteum*, men temmelig sparsomt. *Myricaria germanica*, som har stor utbredelse i Kvam langs Laagen, og som ogsaa gaar et stykke opover Veiklas dalføre, optrær i nogen faa individer langs skraaningene ved veien op for Knipen.

Naar undtages *Lonicera Xylosteum* og *Betula verrucosa*, finder man merkelig nok ingen av vore mere kuldskjære løvtrær og busker paa stedet; de har alle sin nordgrænse længer syd i dalen. Dette er i og for sig ganske paafaldende, idet vi nemlig blandt græssene og urtene finder flere utpræget sydlige typer repræsentert (cfr. det følgende). Imidlertid maa jo de urteagtige planter som holder sig nærmere jorden og nyder godt av vinterens beskyttende snedække, ha lettere for at klare sig end trær og busker. Desuten opvarmes de nedre luftlag sterkest, saa de lave planter er ogsaa gunstigere stillet hvad sommervarmen angaar. Forøvrig kan jeg vanskelig tænke mig en lokalitet som bedre skulde egne sig for xerotherme relikter end denne dalside, hvor varmen f. eks. i juli maaned ofte er ganske uutholdelig. Der er en svak mulighet for at lerskredene kan ha ødelagt eventuelle saadanne trær og busker, men om dette vet vi ikke noget med sikkerhet.

Gran og furu mangler ogsaa fuldstændig i skraaningene ved Leine og Knipen. Først i storre hoider op mot Tunsbergfjeldet og længer nord i Veiklas dalføre ser man naaletrær, men ingen skog. Dette fænomen er utvilsomt ikke oprindelig, men beror paa uthugst. Ifølge oplysninger fra folk paa stedet har man ogsaa hist og her fundet stubber og rotter, som peker i samme retning. Dog vil jeg præcisere, at vi har ingensomhelst grund til at anta at der i historisk tid har været sammenhængende naaleskog i disse lerbakker. Den nuværende løvtrævegetation (or og bjerk) paa stedet er ikke av saa recent natur som man kanske til en begyndelse skulde tro. Derom bærer kalktuffen tydelige vidnesbyrd.

Ved gaarden Krok, like syd for Leine, paa sydsiden av Borjubækken, træffer vi virkelig granskog. Dog er jordsmonnet her mere grundt og stenblandet, tildels med opragende berg.

Vis à vis Leine, i skraaningen ovenfor gaarden Veikle opunder Hillingen, er der i nutiden meget vakker furuskog. Men her er undergrunden av en helt anden natur, tør og stenet, antageligvis utvaskede moræneavleiringer og nedraset forvitringsmateriale.

Det ligger utenfor denne avhandlings ramme at skildre alle de associationstyper som udmerker dalskraaningene ved Leine. Jeg skal dog for fuldstændighetens skyld nævne en del karakteristiske eksempler.

Om vi begynder med de mindst stabile, men vegetationsklædte lerbakker, saa møter vi her en eiendommelig type, som i første række kjendetegnes ved en masseoptræden av *Calamagrostis Epigeios*, et Calamagrostidetum Epigææ. Herav findes flere varianter, baade artsrikere og artsfattigere. I synokologisk henseende udmerker typen sig ved en meget svak eller oftest ingen mulddannelse. Plantedækket er ikke helt sluttet; et bundskikt av moser er flekvis antydet, men mangler gjerne helt. Dette beror sikkerlig altsammen paa substratets lite stabile karakter: overflatelagene er antageligvis baade vaar og høst, og vistnok ogsaa efter heftige regnskyl, i bevægelse (cfr. fig. 3). Økologien ligner i visse henseender forholdene hos den av Blomquist beskrevne „Högbuskformation" (Svensk Bot. Tidskrift Bd. 5. 1911) fra det sydlige Sverige, hvor lignende edafiske faktorer er virksomme og bl. a. forhindrer virkelig skog i at vokse op paa lokalitetene. Den sterke insolation og uttørring av overflatelagene i sommertiden præger ogsaa vegetationen i nogen grad, og skaper en viss likhet med klippesamfund, f. eks. de skrindmuldete skiferbakkers i Kristianiafeltet og ved Mjøsen. I Tyskland har man fænomenet endda mere utpræget i de saakaldte „pontische" eller „sonnige Hügel" (Graebner 1909).

I den følgende tabel er sammenstillet to analyser, den første fra lerbakken ved Borju (10×10 m.^{2}), den anden fra en av de bratte skraaninger nordøst for Røen (10×30 m.^{2}) (sees paa fig. 3). Tallene angir artenes dækningsgrad indenfor ruten (Hult-Sernanders 5-gradige skala), den 6te oktober 1920.

	I	II
Calamagrostis Epigeios	III—IV	IV
Dactylis glomerata	II	III
Festuca ovina	I	II
Agrostis vulgaris		I

	I	II
Poa alpina	I	I
Poa pratensis		I
Brachypodium pinnatum		I
Carex ericetorum		I
Androsace septentrionale		I
Anthyllis vulneraria	I	I
Arenaria serpyllifolia		I
Artemisia vulgaris		I
Astragalus alpinus	I	I
Calamintha Acinos	I	II
Centaurea Scabiosa	I	II
Chrysanthemum Leucanthemum		I
Draba incana		I
Erigeron acer		I
Galium verum	I	
Hieracium umbellatum	I	
Hieracium sp.	I	
Knautia arvensis	I	I
Lotus corniculatus	I	I
Melandrium rubrum		I
Pimpinella Saxifraga	I	
Potentilla argentea		I
Ranunculus polyanthemos	I	
Rubus saxatilis		I
Rumex Acetosella		I
Sedum annuum		I
Silene venosa	I	II
Stenophragma Thalianum		I
Thalictrum simplex	I	I
Trifolium medium		I
Trifolium pratense	I	
Vicia cracca		I
Viola arenaria		I
Viola canina		I
Viola collina		I
Viola tricolor		I
Rosa cinnamomea	I	I
Betula verrucosa (2 m.)	I	I
Alnus incana (busk)		I
Hypnum rugosum		I
Thuidium abietinum		I

Tabellen viser en eiendommelig blanding av plantegeografiske typer, sydlige og nordlige om hinanden.

Andre associationer møter os paa skraaninger som er mere stabile, og som derfor tillater en tættere, sluttet plantevekst. Det følgende eks. (5 × 10 m.²) viser en association fremdeles bestaaende av græs og urter, men uten *Calamagrostis Epigeios*; isteden kommer andre arter til, først og fremst *Festuca ovina*. *Calamagrostis Epigeios* ynder aabenbart det mere urolige substrat. Med sine svære krypende rhizomer passer den jo ogsaa udmerket der.

Festuca ovina	III	*Knautia arvensis*	I
Calamagrostis arundinacea	II	*Lathyrus pratensis*	I
Dactylis glomerata	I	*Lotus corniculatus*	II
Briza media	I	*Pimpinella Saxifraga*	I
Poa alpina	I	*Plantago media*	II
Poa pratensis	I	*Potentilla verna*	I
Agrostis vulgaris	I	*Rubus saxatilis*	I
Achillea Millefolium	I	*Rumex Acetosella*	I
Androsace septentrionale	I	*Sedum annuum*	I
Antennaria dioica	I	*Silene venosa*	I
Campanula rotundifolia	I	*Solidago Virgaurea*	I
Carex ericetorum	II	*Trifolium medium*	I
Centaurea Scabiosa	I	*Trifolium repens*	I
Cerastium vulgatum	I	*Trifolium pratense*	I
Erigeron acer	I	*Veronica saxatilis*	I
Fragaria vesca	I	*Vicia cracca*	I
Galium verum	I	*Viola arenaria*	I
Hieracium umbellatum	I	*Viola canina*	I
Hieracium Pilosella	I	*Viola collina*	I

Thuidium abietinum III—IV

Desuten stod der en enslig *Betula verrucosa* (ca. 5 m. høi) og en *Alnus incana* (2—3 m. høi), samt en busk av *Rosa cinnamomea* indenfor prøveflaten.

Ogsaa *Brachypodium pinnatum* kunde være associationsdannende paa mere stabil bund.

Som et eks. paa orekrat fra forsænkningene mellem ryggene kan følgende prøveflate (5 × 5 m.²) anføres:

Alnus incana (4—5 m.)	IV	*Triticum caninum*	I
Betula odorata (5 m.)	I	*Carex capillaris*	I
Salix capræa (3 m.)	II	*Aconitum septentrionale*	I
Aera cæspitosa	V	*Cirsium heterophyllum*	I
Dactylis glomerata	I	*Equisetum arvense*	I
Phalaris arundinacea	I	*Geranium silvaticum*	I

Rubus idæus	I	*Tussilago Farfara*	III
Thalictrum simplex	I	*Trifolium pratense*	I
Ulmaria pentapetala	I		
Urtica dioica	I		

I kalktuffens hoide, ca. 520 m. o. h., er der ingen antydning til ras eller spor efter at der har gaat ut lerskred. Disse ophorer paa et lavere nivaa — heldigvis, kan man si; for ellers var der nok ikke levnet spor av denne merkelige forekomst. I den nævnte hoide indtar dyrket mark en meget bred plads og avveksler med lyse, forholdsvis lave bjerkehager, hvis bundvegetation fleresteds avslaaes til fôr. Disse aapne bjerkeskoger paa sterkt heldende bund er utvilsomt i sin nuværende skikkelse i hoi grad betinget av kulturen. De alternerer paa fugtigere bund med orekrat, som fleresteds opviser en bundvegetation av hoie græs og urter saa makelost frodig at man kan skjule sig i den.

I disse bjerkehager og langs veikantene finder man en del interessante arter. Folgende eks. (5×5 m.^{2}) vil vise dette.

Betula odorata	V	*Knautia arvensis*	I
Brachypodium pinnatum	IV	*Lotus corniculatus*	I
Calamagrostis arundinacea	III	*Origanum vulgare*	I
Anthoxanthum odoratum	I	*Plantago media*	I
Festuca ovina	I	*Pimpinella Saxifraga*	I
Poa nemoralis	I	*Rubus saxatilis*	I
Carex sp. (steril)	I	*Solidago Virgaurea*	I
Achillea Millefolium	I	*Trifolium medium*	I
Brunella vulgaris	I	*Veronica serpyllifolia*	I
Chrysanthemum Leucanthemum	I	*Vicia cracca*	I
Dracocephalum Ruyschiana	I	*Viola canina*	I
Euphrasia sp.	I	*Viola collina*	I
Fragaria vesca	I	*Hylocomium triquetrum*	II
Galium verum	I	*Hypnum* sp.	I
Geranium silvaticum	I	*Peltigera canina*	I
Hypochoeris maculata	I	*Cladonia* sp., basalskjæl	I

Kombinationen: *Brachypodium pinnatum, Calamagrostis arundinacea, Origanum vulgare, Dracocephalum Ruyschiana, Trifolium medium, Viola collina* er overmaade interessant ved sin sydlige, xerotherme karakter. *Brachypodium pinnatum* har her sin nordgrænse i Skandinavien (61° 40'), og *Dracocephalum Ruyschiana* er her nær sin nordgrænse (Dovre)[1]. I denne forbindelse fortjener ogsaa følgende arter at nævnes: *Androsace septentrionale, Calamintha Acinos, Carex ericetorum, Centaurea Scabiosa, Dianthus*

[1] Fig. 42 og fig. 43.

deltoides, Verbascum nigrum, (Veronica verna), Viscaria viscosa o. fl.[1]. En del av disse er allerede nævnt tidligere i tabellene, de øvrige optrær ogsaa i Leinebakkene, med undtagelse av *Veronica verna*, som jeg har fundet ved Veikle. Disse arter danner ikke nogen absolut ensartet floristisk gruppe, men er allesammen av sydlig type og varmekjære.

I skarp kontrast til disse staar de fjeldplanter som vi træffer paa de samme lokaliteter: *Astragalus alpinus, Veronica saxatilis, Draba incana.* Disse er allerede omtalt ovenfor. Men hertil kommer: *Oxytropis lapponica, Saxifraga aizoides, Poa cæsia* og *Gentiana nivalis*, som jeg har fundet paa et par steder, og *Primula scotica*, som Blytt iagttok i 1891[2].

Fig. 4. En del av skiferklippene ovenfor Leine med græs-urtesamfund, hvori indgaar de i teksten omtalte fjeldplanter. Midt i billedet *Aconitum*. Utsigt mot nordost, Veiklas dal tilhøire med gran- og furuskog. Juli 1919. Nordhagen fot.

Sommeren 1919 opdaget jeg nogen skiferklipper i ca. 700 meters høide, ovenfor Leinegaardene, som viste sig at være et rent asyl for fjeldplanter. Fra dette sted, men sikkerlig ogsaa fra de høiereliggende fjeldpartier i nord og nordvest (som dog var meget fattigere paa arktisk-alpine arter paa grund av haardere sparagmiter), skriver antagelig de nævnte fjeldplanter sig. Og deres forekomst i lerbakkene lavere nede (4—500 m. o. h.) beror efter min mening først og fremst paa de eiendommelige konkurrenceforhold som her gjør sig gjældende; vegetationen er jo flere steds meget aapen og spredt, og av og til blotlægges mindre arealer ved nye ras, hvilket gir fjeldplantene en chance til at hævde sig overfor alle de andre, som paa de vanlige lokaliteter i lavlandet formaar at utkonkurrere dem. Den manglende eller ytterst spredte trævekst sammen med den heldige eksposition gjør vel ogsaa sit til at fjeldplantene, som hyppig er fotofile, trives i disse sollyse bakker. Hertil kommer da som et meget vigtig moment den korte avstand op til de nævnte skiferklipper, hvorfra frø og frugter meget let maa kunne føres

[1] Ifølge Blytt (l. c. p. 29) findes ogsaa *Avena pubescens* og *Erysimum hieraciifolium* ved Leine.

[2] l. c. p. 28. Her nævnes ogsaa *Oxytropis lapponica* og *Saxifraga aizoides.*

nedover bakkene baade med vand og vind (f. eks. om vinteren)[1]. Ogsaa substratets kalkgehalt influerer sikkert. Flere av de anførte planter er kalkyndende og gaar ogsaa andre steder i Gudbrandsdalen ned i dalbunden paa kalkholdige bergarter (f. eks. ved Otta og i Sel).

Denne merkelige blanding av sydlige xerotherme planter og arktisk-alpine arter er altsaa et fremtrædende træk i det plantegeografiske helhetsbillede som møter os i disse fantastiske lerbakker. Dog maa det skarpt fremhæves at fjeldplantene kvantitativt set spiller en helt underordnet rolle. Kun *Astragalus alpinus* formaar at gjøre sig fysiognomisk gjældende paa enkelte mindre flekker. — Som vi senere skal se, fortæller kalktuffen os at det motsatte har været tilfældet i længst forsvundne tider.

Da de ovenfor nævnte skiferklipper i 700 m.s høide og deres vegetation vil bli trukket ind i flere av de vigtigste ræsonnementer i nærværende avhandling, blir det her nødvendig at fæste opmerksomheten ved enkelte hovedtræk i deres plantevekst. Klippene ligger ovenfor gaarden Hagen, omtrent 200 m. høiere end kalktuffen, og bestaar av løse, smuldrende skifre. Bjørlykke omtaler herfra en graa, skruklet fyllit med kvartskirtler med bølgende skifrighetsfald og høiere oppe en skruklet, graagrøn skifer med fald mot N. NO.; den fører undertiden kalkholdige sandstenslag (1905 l. c. p. 215). Følgende floraliste vil gi et indtryk av hvilken besynderlig konstellation av arter disse klipper huser (6te juli 1919):

Aconitum septentrionale
Alectorolophus minor
Antennaria dioica
Anthyllis vulneraria
Arabis hirsuta
Arctostaphylos uva ursi
Botrychium Lunaria
Brunella vulgaris
Calamagrostis arundinacea
Calluna vulgaris
Carex capillaris
Carex ericetorum
Carex ornithopoda
Carex sparsiflora
Cotoneaster integerrima
Cystopteris fragilis
Dianthus deltoides
Euphrasia sp.
Fragaria vesca
Festuca ovina
Galium boreale
Galium uliginosum
Gentiana Amarella
Geranium silvaticum
Hieracium Pilosella
Knautia arvensis
Melica nutans
Origanum vulgare
Parnassia palustris
Pinguicula vulgaris
Plantago media
Polygonum viviparum
Phegopteris Robertiana
Potentilla Tormentilla

[1] Om denne nedvandring er av forholdsvis recent natur, eller har paagaat gjennem geologisk set langvarige tidsrum, kan vi foreløbig ikke avgjøre. Dog er det neppe tvil om at lerskredene og de derigjennem skapte edafiske tilstande har begunstiget nedvandringen. Cfr. forøvrig den generelle del.

Potentilla verna.
Rubus idæus.
Saxifraga adscendens.
Sedum annuum.
Silene rupestris.
Vaccinium vitis idæa.
Verbascum nigrum.
Veronica officinalis.
Vicia cracca.
Viola collina.
Woodsia rufidula.

Antennaria alpina.
Astragalus alpinus.
Cerastium alpinum.
Cetraria nivalis.
Draba hirta.
Draba incana.
Gentiana nivalis.
Gentiana tenella.
Juncus trifidus.
Phyllodoce coerulea.
Poa alpina.
Poa cæsia.
Sagina Linnæi.
Selaginella spinulosa.
Veronica saxatilis.

Ved en bæk i nærheten av klippene notertes bl. a.:

Juncus triglumis.
Salix cfr. *arbuscula* (bastard?).
Salix lapponum.
Salix reticulata (meget sparsom).
Saxifraga aizoides.
Saussurea alpina.
Thalictrum alpinum.

En saa fantastisk kombination som paa den ene side *Verbascum nigrum, Origanum vulgare, Calamagrostis arundinacea* og *Juncus trifidus, Antennaria alpina, Gentiana tenella* og de andre fjeldplanter paa den anden, har jeg ikke set noget andet sted i vort land, ialfald ikke søndenfjelds. Kun i det indre av Nordland fylke, paa kalk og dolomit, har jeg iagttat lignende, tilsyneladende paradoksale artskonstellationer.

Klippene er i vore dager fuldstændig træbare, med tyndt jorddække sterkt opblandet med fyllitmateriale. De synes ogsaa at være sterkt utsat for vinden, og bærer sandsynligvis om vinteren et ubetydelig snedække. Ovenfor klippene følger et mere plataaagtig omraade, bestaaende av haardere bergarter (tildels overdækket) med lyngvegetation (associationer av *Empetrum nigrum, Calluna, Phyllodoce, Vaccinium-arter, Arctostaphylos alpina,* tildels med lav *Juniperus*). Her notertes *Pulsatilla vernalis* og *Lycopodium alpinum.*

I 850 m.s høide saaes følgende fjeldplanter ved en bæk: *Bartschia alpina, Betula nana, Cerastium trigynum, Juncus biglumis, Ranunculus hyperboreus, Salix glauca, S. herbacea, S. lanata, S. lapponum, S. myrsinites, S. reticulata* (sparsom). Opunder Tunsbergfjeldet findes lave, spredte gran- og furu-individer, granen oftest som lave, vindtørre avlæggergrupper. Begge to gaar saa godt som helt op til fjeldets top (944 m. efter rektangelkartet). I 900 m.s høide vokste *Turritis glabra* og *Saxifraga Cotyledon* sammen. Ellers er Tunsbergfjeldet meget plantefattig og trivielt paa grund av de haarde sparagmiter hvorav det er opbygget. Ingensteds finder man en saa rik flora som paa fyllitklippene længer nede, ja en hel del arter syntes udelukkende at være knyttet til disse. Antageligvis vil Torgerkampen, et fjeld som ligger 5—6 km. længer vest, vise sig rikere end Tunsbergfjeldet; Bjørlykkes oplysninger om bergartene tyder paa det.

Mine floristiske optegnelser, som blev revidert under et nyt besøk 17 juli 1919, er i flere henseender bemerkelsesværdige. Saaledes mangler *Dryas octopetala* fuldstændig paa fyllitklippene og ogsaa høiere oppe. Hovedhensigten med min ekskursion til fjeldene ovenfor Leine var netop at opspore *Dryas*; men til trods for en ihærdig leting var den ikke til at opdage. Da kalktuffen som bekjendt indeholder *Dryas* i kolossale masser i en bestemt horisont, er det nævnte faktum meget overraskende og gir os et tydelig vink om hvilke store forandringer vegetationen her i Kvam har undergaat i aartusenernes løp. Skiferklippene og deres vegetation gir os vigtige holdepunkter og angrepspunkter i den følgende diskussion. Som jeg senere skal forsøke at klargjøre, er det ingen tvil om at *Dryas* dengang kalktuffen var tæt bevokset med denne art, ogsaa dominerte paa de angjældende klipper, som efter de erfaringer jeg har gjort med hensyn til denne dvergbusks livskrav rundt omkring i Norges fjeldtrakter, skulde synes at være ideelle som voksested netop for *Dryas octopetala*. En nøiere gjennemgaaelse av den anførte floraliste gir ogsaa fingerpek i denne retning. Hvor langt indover fjeldet vi maa gaa i vore dager for at finde den nærmeste *Dryas*, vet vi foreløbig ikke.

Vegetationen paa selve tuffindestedet er i nutiden ikke naturlig, men sterkt kulturpaavirket. Tuffen ligger nederst i et brat jorde under den østligste av Leinegaardene. Kilden kommer ret frem av jorden under en stor stenrøis, som antageligvis er meget gammel (fra den tid da jorden i nærheten blev ryddet), og herfra fører et litet bækkeleie med spredte klynger av vidjebusker og bjerk nedover bakken, som en stripe mellem to dyrkede enger, og fortsætter gjennem en ny stenrøis over i orekrat længer nede. I stenrøisens omgivelser hvor bunden er mest tør, vokser et krat av *Betula verrucosa* og *B. odorata*, samt litt *Salix capræa*, *S. nigricans* og *Rosa cinnamomea*. Markvegetationen langs bækken er nu ødelagt av kreaturtraakk og gravninger, likesom ogsaa den primitive kjørevei som passerer paa skraa over tuffindestedet, har influert paa omgivelsene (cfr. fig. 5 og 6). Græs og urter danner et slags dække nedover bakken, men uten synderlig orden. Følgende arter optræer indenfor kalktufomraadet:

Aconitum septentrionale, *Aera cæspitosa*, *Agrostis stolonifera*, *A. vulgaris*, *Alectorolophus minor*, *Alchimilla officinalis*, *Anthyllis vulneraria*, *Artemisia vulgaris*, *Brachypodium pinnatum*, *Briza media*, *Brunella vulgaris*, *Calamagrostis arundinacea*, *Campanula rotundifolia*, *Carex capillaris*, *C. flava*, *C. panicea*, *Carum Carvi*, *Centaurea Scabiosa*, *Cerastium vulgatum*, *Chrysanthemum Leucanthemum*, *Cirsium heterophyllum*, *Crepis paludosa*, *Dactylis glomerata, Equisetum arvense, E. pratense, Euphorbia Helioscopia, Euphrasia officinalis, Festuca ovina, F. rubra, Fragaria vesca, Galium palustre, G. uliginosum, Geum rivale, Gymnadenia conopea, Hieracium umbellatum, Juncus bufonius, Knautia arvensis, Lathyrus pratensis, Leontodon autumnalis, Linum catharticum, Lotus corniculatus, Molinia coerulea, Phalaris arundinacea, Pimpinella Saxifraga, Plantago media, Poa alpina, Polygonum viviparum, Potentilla anserina, Potentilla Tormentilla, Ranunculus acer, R. repens, Rubus saxatilis, Silene venosa, Solidago Virgaurea, Thalictrum simplex, Trifolium medium, T. pratense, Triglochin palustre, Tussilago Farfara, Ulmaria pentapetala, Urtica dioica, Vicia cracca, V. sepium, Viola tricolor.*

Forskjellige ting tyder dog paa at oprindelig en *Carex panicea*-association av eutrafent og hydrofilt præg har behersket bækkens nærmeste omgivelser. Længer nede i bakken, i tuffens periferi, optrær nemlig saadanne plantesamfund over en kortere strækning. For at belyse dette har jeg i nedenstaaende tabel opført analyser av to proveflater, hver paa ca. 4 m^2, fra dette sted:

	1	2		1	2
Carex panicea	II—III	IV—V	*Alectorolophus minor* . .	I	—
Juncus lamprocarpus . .	IV	I	*Brunella vulgaris*	I	—
Aera cæspitosa	I	II	*Cirsium heterophyllum* .	—	I
Agrostis vulgaris	—	II	*Mentha* sp. (steril) . . .	I	—
Phalaris arundinacea . .	—	I	*Parnassia palustris* . . .	—	I
Phleum pratense	—	I	*Polygonum viviparum* .	I	—
Carex flava	I	—	*Ranunculus acer*	—	I
Juncus compressus . . .	—	I	*Thalictrum simplex* . . .	—	I
Triglochin palustre . . .	I	II	*Tussilago Farfara* . . .	I	I
Equisetum arvense . . .	I	II	*Ulmaria pentapetala* . .	—	I

I det første eksempel fandtes ogsaa *Hypnum filicinum* III med nedtil halvveis forkalkede skud. Denne moseart optrær ogsaa høiere oppe hvor vandet silrer utover den blottede tufoverflate. — Hvis vegetationen fik anledning til at falde tilbake til naturtilstanden, vilde utvilsomt *Alnus incana* indfinde sig saaledes som længer nede i bakken, og et orekrat omgi tufkilden, med litt bjerk paa de tørrere flekker.

B. Stratigrafiske undersøkelser.

Som resultat av en række barometermaalinger i juli 1919 fremgaar det at kalktuffen ligger 232 m. høiere end Slettens landhandleri nede i dalbunden. Da dette maa antages at ligge et par meter høiere end Kvam station (287,7 m. o. h.), skulde kalktuffens høide over havet bli ca. 520 m. Blytt angir ca. 500 m. (496 m. efter barometermaaling), men dette er utvilsomt for lavt. I oktober 1920 medførte jeg et andet barometer samtidig med at lufttemperaturen bestemtes ved hjælp av slyngetermometer. Resultatet blev 232 m. over dalbunden, altsaa nøiagtig middeltallet av fjoraarets maalinger.

Lerbakkene paa tuffindestedet skraaner fra vest mot øst, dog ikke ganske jevnt. Heldningsvinkelen er i gjennemsnit 15—20°; dog kan den lokalt være betydelig større[1]. Hvor stor utstrækning tuffen har, kan ikke siges med sikkerhet. Avstanden mellem mit nordligste og sydligste profil er ca. 15 m.; paa begge disse steder skraaner tuffen indunder dyrket mark, som forbød

Fig. 5. Fra tuffindestedet ved Leine. Utsigt mot nordøst. Tilhøire kjøreveien. Foto 5te oktober 1920 (efter grøftens gjenkastning).

videre gravning. Imidlertid skulde jeg anta at tuffen ganske sikkert har hat en utstrækning i denne retning (ↄ: tvers paa skraaningen) som er dobbelt saa stor som det opgitte tal. Avstanden mellem mit høiestliggende profil (indunder den før omtalte stenrøis) og mit laveste, maalt langs efter skraaningen (ↄ: vest—øst), er ca. 20 m. Opad synes tuffen at kile ut ganske snart, men nedad synes dens grænser slet ikke at være naadd. Under opdyrkningen av den omgivende mark synes store tufmasser at være brutt op av jorden; saaledes ligger der svære tufblokker (hvorav en som er 1,5 m. × 1 m. × 0,30 m.), hovedsakelig bestaaende av mosetuf, paa en stenrøis længer nede i bakken. Disse blokker skriver sig uten tvil fra tuffens undre lag. Ogsaa de løse tufstykker

[1] Paa længdeprofilet (fig. 11) er heldningen i tuffens øvre del noget overdrevet for at undgaa altfor store knæk og bølger i lagrækken (paa grund av den forskjellige høide- og længdemaalestok).

som har ramlet længer nedover lien og ligger spredt hist og her i orekrattet, skriver sig vel fra en eller anden nydyrkningsperiode eller oprenskning av bækkeleiet. Der er ialfald i den del av tuffen som jeg har undersøkt, intet tegn til ras eller utglidninger. Dog er det mulig at saadanne kan ha foregaat længer nede.

De forskjellige tuflag viser sig i det store og hele tat at være omtrent paralelle med bakkens skraaning; men der er en mængde smaa avvikelser i forskjellige retninger, saa stratigrafien er ganske komplicert. Den kalktufavsættende kilde kommer ret ut av bakken like i tuffens overkant, og nogen store variationer i dens løp har netop av denne grund ikke indtraadt i tidenes løp. Imidlertid har de enkelte karakteristiske tuflag sin største tykkelse paa helt forskjellige punkter indenfor omraadet, hvilket kunde tyde paa at bækken saa at si har pendlet frem og tilbake indenfor en cirkelsektor med tufkildens „dagaapning" som centrum, ialfald til en viss grad. Dette er bare naturlig, da jo en saadan kalkdannende kilde stadig fylder op sit eget leie og derved tvinger sig selv over i et nyt løp. Imidlertid kommer her ogsaa et andet og meget vigtig moment til, som Blytt først opdaget, nemlig at kalktufavsætningen ved Leine ikke har været kontinuerlig, men intermitterende; dette vil fremgaa av den følgende utredning. Og det er ganske klart at en stans i avsætningen ledsaget av forvitring og mulddannelse i høi grad maa virke bestemmende paa kildens fremtidige løp, naar den atter begynder sin kalkdannende virksomhet. — Overfor enkelte tufavsætninger med tydelige avbrud i avsætningen og derav følgende muldstriper eller forvitringshorisonter, har man gjort gjældende at dette kunde skyldes det forhold, at kilden periodevis har tat et helt nyt løp. For Leinetuffens vedkommende kan imidlertid dette ræsonnement ikke gjøres gjældende, da kilden som nævnt kommer ret ut av jorden i tuffens overkant. Det vilde ialfald være høist ubegripelig hvorledes denne kilde, hvis den under de to avbrud i avsætningen som tuffen viser, hadde et andet løp, atter kunde indfinde sig præcis i det gamle underjordiske løp og komme frem i dagen nøiagtig paa det gamle sted, ikke bare én gang, men gjentagne ganger.

I Gudbrandsdalens tuffer kan man i likhet med hvad Sernander har vist for svenske kalktuffers vedkommende (1916 l. c.), adskille *sedimentære* og *sedentære* lag. Hvis et lag viser sig at bestaa av løse blader, kvister og andre avkastede plantedeler som vandet har bundfældt, og som senere litt efter litt er forkalket, eller av rent fysikalsk utfældt fossilfri tuf, faar man en sedimentær avsætning. I andre tilfælder derimot kan tuffens overflate være dækket av en sammenhængende, rotfæstet, levende vegetation, som ogsaa gradvis kan forkalkes. Man faar da en veritabel autokton dannelse, en fossilificert vegetation in situ, en sedentær avsætning. I praksis kan det undertiden være vanskelig at holde disse to typer ut fra hinanden; saaledes kan visse mosetuffer og cyanofycé-tuffer være saa kompakte og strukturløse at de sterkt minder om fysikalsk utfældt, sedimentær tuf[1]. Men i almindelighet er de sedentære lag meget karakteristiske, med ortotropt orienterte skud og andre sikre kjendetegn. For utredningen av vegetationens historie er den slags horisonter meget vigtige, idet man her kan finde rester av urteagtige planter, som jo visner sukcessivt ned uten bladfældning og under vanlige omstændigheter raatner væk meget raskt, og som derfor helt naturlig mangler i sedimentære lag. Et par av Leinetuffens lag er i denne henseende meget interessante. Meget ofte begynder en kalktufavsætning med sedentære lag (mosetuf) og fortsætter som sedimentær avleiring. Men dette er slet ikke altid tilfældet, hvilket vil fremgaa av profilene i nærværende avhandling. Imidlertid gir ogsaa de sedimentære lag i Leinetuffen utvilsomt et adækvat billede av vegetationen paa stedet, netop fordi kilden kommer ut av jorden og saaledes ikke kan ha transportert plantedeler langveisfra. Dog vil selvfølgelig den slags ting kunne ske under sneløsningen eller i flomtider.

Fig. 6. Den øvre del av Leinetuffen. Kilden kommer frem av jorden øverst mellem buskene, som skjuler stenrøisen. Billedet er tat efter groftens gjenkastning. Nordhagen foto, 6te oktober 1920.

Som i forordet nævnt lykkedes det mig med bistand av en gammel mand som i 1891 assisterte Blytt, at utfinde nøiagtig det sted hvor Blytt optok sine to profiler[2]. Disse laa like i nærheten av hinanden i overkanten av den gamle bygdevei som skraar over tuffen. Blytts profiler kan meget smukt indpasses i min serie og utfylder et hul i denne.

For fuldstændighetens skyld, og for at man skal faa det rigtige indtryk av hvor lovmæssig tuffen er opbygget, skal jeg i det følgende beskrive alle de opmaalte og undersøkte profiler. Fremstillingen vil ogsaa vise hvilke fuldstændig misvisende resultater en mere overfladisk undersøkelse kunde ha ført til, idet en hel del av tuffens mere perifere profiler tilsynelatende

[1] Jeg agter ved en anden anledning at komme tilbake til spørsmaalet om kalktuffenes genesis. I de senere aar har tyske forskere tildels git vigtige bidrag til tufutskillelsens mekanik.

[2] Manden fortalte ogsaa at da „han kom ned til det tredje laget i tuffen, fandt Blytt en plante som han kaldte Dryen (ↄ: Dryas)".

er himmelvidt forskjellige fra de mere centrale i tuffens hovedparti, mens de i virkeligheten meget harmonisk indordner sig under disse.

I nedenstaaende utredning av profilene er disse inddelt i flere serier efter sin beliggenhet i forhold til den store grøft som blev gravet paa langs av bækken. Først kommer en venstre serie, optat nedenfra og opad bakke paa grøftens venstre (ɔ: søndre) side. Den tar sit utgangspunkt i Blytts profil, som er det nederste i serien, og ender opunder stenrøisen, hvor tuffen antageligvis kiler ut ganske snart.

Tilsvarende hertil faar vi en høire serie paa grøftens motsatte side, ogsaa nedenfra og opad. Endelig har jeg en serie paa tvers av bækken, tverserien, fra syd mot nord, som ender i profilet av 1920. Alle disse er optat ovenfor den nævnte kjørevei, som gaar paa skraa henover tuffindestedet. Som profiler nedenfor veien beskrives et par vigtige grøfter optat længer nede i bakken; de ligger i ca. 20—25 meters avstand fra det øverste profil i venstre serie.

Længdeprofilet[1] (fig. 11) er konstruert paa grundlag av venstre serie og profilene nedenfor veien, tverprofilet (fig. 12) ved hjælp av tverserien og venstre serien.

Som „Alnus-tuf" betegnes den allerøverste, tidligere ukjendte tufhorisont eller rester av denne. „Furutuf", „Dryastuf" og „bladtuf" er tildels de samme betegnelser som Blytt anvendte. Dog omfatter Blytts bladtuf eller „birketuffen" ogsaa den underliggende mosetuf, som hænger sammen med birketuffen. Jeg foretrækker dog at betegne denne som „mosetuf". Ved „undre Dryashorisont" forstaaes en sedentær horisont i bladtuffens underkant (mosetuffens øvre del), som tidligere ikke er beskrevet fra Leinetuffen; den mangler ogsaa i enkelte profiler og er av meget mindre dimensioner end den høiere oppe i lagrækken forekommende „Dryastuf". Ved „rød lere" forstaaes den høist eiendommelige, i visse profiler skrikende røde lere som optrær umiddelbart under den laveste mosetuf, og som over hele tufomraadet bedækker den underliggende morænelere, som benævnes „blaa lere".

For alle profilers vedkommende gjælder at lagfølgen beskrives nedenfra og opad (kronologisk orden).

Venstre serie.

Profil I (Blytt 1891).

I. Jøkeller med vandreblokker.
II. Jernholdig ler uten forsteninger indtil 0,03 m.
III. {Gulgraa skifrig birketuf (uten furu) 0,45 m.
IV. {Heri er som nævnt indbefattet mosetuffen paa bunden (Blytt l. c. p. 7).

[1] Profilet benævnes her længdeprofil fordi det er optat langs med bækken (tverprofilet tvers paa bækken). Geologisk set er længdeprofilet i grunden et tverprofil; men da stratigrafien ved Leine er ytterst komplicert, kan man her ikke tale om „strøk" og „fald" i vanlig stratigrafisk betydning.

V. {Gulgraa, tildels jordagtig Dryastuf (med furu) indtil 0,03 m.
Grønliggraat ler uten forsteninger 0,04 m.

VI. Graahvit furutuf 0,58—0,68 m.

VII. Muldjord 0,10—0,15 m.

Forøvrig henvises til Blytts egen beskrivelse av de forskjellige lag (1892 l. c.).

Profil II.

I. Blaa lere, ukjendt mægtighet.

II. Rød lere ca. 3 cm.

III. Mosetufkompleks.

A. 10 cm. graagrøn, slagg- eller koralagtig mosetuf, brunfarvet paa undersiden, med avtryk og hulheter efter *Equisetum variegatum.*

B. 10 cm. rødlig mosetuf.

C. 5—8 cm. hvitagtig kalkgrus (mosetufbiter).

IV. Bladtuf, 25 cm., planskifrig, med blader av *Betula odorata, Populus tremula, Salices.*

V. Dryastuf, 3 cm., løs og smuldrende med massevis av *Dryas*-blader og stammer[1].

VI. Furutuf, 18—20 cm., sterkt forvitret, med masser av *furunaaler,* blader av *Vaccinium vitis idæa.* Øverst muldblandet.

VII. Muldjord, 20—25 cm. med stener og smaa fragmenter av *Alnus*-tuf, med blader av *Alnus incana.*

Sammenlignes dette profil med Blytts, som laa ca. 2 m. længer nede i bakken, ser man at lagene er præcis de samme, men mægtigheten er helt anderledes. Den slags variationer møter os imidlertid overalt indenfor tuffens omraade.

Profil III.

I. Blaa lere.

II. Rød lere, noget grusblandet med smaa skiferfragmenter, samt en stor, raatten skiferblok midt i grøften.

III. Mosetuf, ca. 10 cm., nederst med *Equisetum variegatum* og utydelige bladavtryk (*Salix* sp.), porøs og slaggagtig. Hænger sammen med overliggende.

IV. Bladtuf, 15 cm., grønbroget, vakkert laget, med *bjerk, asp, Salices.*

V. Dryastufkompleks, ca. 15 cm., danner nederst en skorpe ovenpaa bladtuffen. Tuffen var eiendommelig sinteragtig, i vaat tilstand rødfiolet, i tør tilstand kridthvit og lite egnet til at opbevare fossilavtryk. Dog fandtes en række blader (13) av *Dryas octopetala, furunaaler* og et par blader av *Betula odorata.* Øverst fandtes en hvitagtig, lerlignende sone, bestaaende av opsmuldret tuf med mindre, fastere biter, utvilsomt et forvitringslag, op til 10 cm. tykt.

[1] *Dryas octopetala* er en dvergbusk med træagtig stamme.

VI. Furutufkompleks, 30 cm.; nederst en veritabel forkalket furustok (grov gren eller fragment av en stamme), som var løs og smuldrende (raatten)! Ellers temmelig løs furutuf, tildels jordagtig; de faste stykker med umaadelige masser av *furunaaler*.

VII. Muldjord med røtter, 15—20 cm.

Profil IV.

I. Blaa lere.

II. Rød lere, typisk.

III. Mosetufkompleks.

A. 10 cm. hullet, slaggagtig, graagrøn mosetuf, med *Equisetum variegatum* og huller efter smaa kvister og pinder (*Salices*?). Lokalt fandtes en liten linseformig, hvit lermasse ovenpaa denne mosetuf.

B. 7—10 cm. mosetuf, øverst med den undre Dryashorisont utviklet, med blader og stammer av *Dryas* (middels mængde), *Equisetum variegatum*, bladfragment av *Betula odorata*, en levermos som antageligvis er en *Pellia* sp., et eiendommelig avtryk som muligens er *Tofieldia palustris*, samt *snegler*.

IV. Bladtuf, 10—15 cm., meget vakker og planskifrig med de vanlige *løvblader* i stor mængde.

V. Dryastufkompleks, temmelig komplicert bygget.

A. Underst antydning til mosetuf ovenpaa bladtuffen, 2—3 cm.

B. Graagrøn Dryastuf, med uhyre masser av *Dryas*blader og stammer, desuten et blad av *Salix reticulata* og et bladfragment av *bjerk*, ca. 5 cm. mægtig.

C. En tynd, 1,5—2 cm. mægtig sedimentær horisont, grønlig av farve med: *Dryas* (temm. sparsom), *furu* (flere store og brede naaler), *bjerk* (bladfragmenter), *Salix arbuscula* (mange blader), *Salix capræa* (1 bladfragment), *asp* (bladfragmenter), *Pyrola minor* (et par blader), samt en stor *fuglefjær*.

D. 1—1,5 cm. hvit kalkgrus (forvitringshorisont).

VI. Furutufkompleks, ca. 45 cm. Nedtil tildels litt fin mosetuf, dels furutuf med mange naaler og blader av *Salix arbuscula* (det eneste sted i furutuffen hvor denne art er fundet!). Derover vanlig furutuf, som opad viser antydning til en sedentær sone. Øverst løs og jordagtig (forvitret) furutuf.

VII. Muldjord, 20 cm., med rester av *Alnus*-tuf og en eiendommelig krøllet tuf (mosetuf?).

Dette profil er interessant derved, at vi her for første gang møter en ganske indviklet bygget Dryastuf, et fænomen som de følgende profiler ogsaa viser.

Profil V.

I. Blaa lere.
II. Rød lere, typisk.
III. Mosetufkompleks.
A. 5—7 cm. hullet slagg-tuf, normal.
B. 5—10 cm. mosetuf, lysere av farve, øverst mot bladtuffen med en antydet undre Dryashorisont (*Dryas*-blader, *Equisetum variegatum*, utydelige *løvblader*).
IV. Bladtuf, 20 cm., normal.
V. Dryastufkompleks.
A. 5—7 cm. grønlig Dryastuf med masser av *Dryas*-rester, aldeles kaotisk.
B. 2—3 cm. lagdelt horisont, med avvekslende grønlige og gulhvite lag, indeholdende: *Dryas* (flere blader), *Salix arbuscula* (et litet blad), *Pyrola minor* (3 blader), *furu* (flere store naaler), *bjerk* (mange blader, hunrakler), *asp* (bladfragmenter), *Carex* sp. (en liten plante med 3 blader). Alt dette tyder paa at tuffen har baaret en meget sparsom vegetation paa dette sted, og laget er halvt sedentært, halvt sedimentært. — Allerøverst viser denne horisont sig at være belagt med en ytterst tynd, hvit skorpe av kalkgrus, som gjerne løsner sig av idet stykkene hakkes løs.
C. Meget eiendommelig løs sone, kun paatruffet tydelig i dette profil, 3 cm. mægtig. De smaa klidbrød-lignende tufstykker ligger (især nedtil) i et fint, hvitt kalksmuldr og indeholder massevis av ytterst fine furunaaler samt mange *Dryas*-blader, desuten et blad av *Salix arbuscula* og et fragment av *bjerk*. Som nærmere utredet i det følgende, er dette lag en forkalket, destruert førne ɔ: sterkt opraatnet barnaalavfald, som danner raahumus i skogbunden. Antageligvis er det dette lag som i visse profiler danner forvitringshorisonten øverst i Dryaskomplekset (cfr. foregaaende profil).
VI. Furutufkompleks, 40 cm.; nedtil med massevis av store furunaaler og mange blader av *Vaccinium vitis idæa*; underflaten er altid fri og hænger aldrig sammen med foregaaende horisont. Derover et mere løst furutuflag, optil mere kompakt tuf.
VII. Muldjord, 25 cm., med *Alnus*-tuf og krøllet, forvitret, grov tuf.

Profil VI.

Dette er i virkeligheten optat midt i grøften, men medtages av forskjellige grunde her.

I. Blaa lere.
II. Rød lere.
III. Mosetufkompleks.

A. 5 cm. slaggagtig tuf, normal.
B. 4 cm. hvitlig, grovt mosetufgrus.
C. 5 cm. mosetuf, øverst med nogen blader av *Dryas*, altsaa antydet undre Dryashorisont.

IV. Bladtuf, ca. 10 cm., normal.

V. Dryastufkompleks.
A. 7 cm. grønliggraa kaotisk Dryastuf, med uhyre masser av *Dryas*-rester, bl. a. pragtfulde stammer med paasittende bladrester, en blomst i frugtstadium; videre et par *furunaaler* samt fragment av *bjerkeblad*.
B. 3 cm. lagdelt sone med *Dryas* temmelig sparsom (som i foregaaende profil).
C. 3 cm. løs, smuldrende, klidagtig tuf, med fine furunaaler og litt *Dryas* (som i foregaaende profil, men mere opsmuldret og løs).

VI. Furutufkompleks, 40 cm., som i foregaaende profil.

VII. Muldjord, 25 cm., med biter av *Alnus*-tuf.

Dette profil er interessant idet bladtuffen her er paa vei til at kile ut over mot grøftens høire side. Dette fænomen blir nærmere omtalt under „høire serie".

Profil VII.

I. Blaa lere.

II. Rød lere.

III. Mosetufkompleks.
A. 7 cm. hullet slaggagtig, graagrøn mosetuf (normal).
B. 5 cm. kalkgrus, bestaaende av mosetufstykker.
C. 5 cm. undre Dryashorisont, med *Dryas*-blader og løvblader.

IV. Bladtuf, 10 cm., normal (*bjerk, asp, Salices*).

V. Dryastufkompleks, ca. 15 cm.
A. 8 cm. ren Dryastuf, tildels et eneste smuldr av *Dryas*.
B. 2 cm. lagdelt øvre sone, med furunaaler og sparsom Dryas (cfr. foregaaende profiler). Øverst et tyndt, hvitt grusagtig belæg med nogen furunaaler.
C. 5 cm. løst lag, tildels bare fint kalkgrus, men med biter av den samme klidagtige tuf som i de foregaaende profiler.

VI. Furutufkompleks, 20—25 cm., meget løst, øverst jordagtig og sterkt forvitret; ellers normal furutuf.

VII. Muldjord med *Alnus*-tuf, 20 cm.

Profil VIII.

I. Blaa lere.

II. Rød lere.

III. Mosetufkompleks, ca. 20 cm., præcis som i profil VII.

IV. Bladtuf, ca. 10 cm., normal.

V. Dryastufkompleks.
  A. 8 cm. ren Dryastuf som i profil VII.
  B. 2 cm. lagdelt øvre sone som i p. VII.
  C. 5 cm. grønbrun, gruset lere, som gik over i foregaaende profils kalkgruslag (C), og som utvilsomt er et forvitringsprodukt herav.
VI. Furutufkompleks.
  A. 20 cm. meget løs og smuldrende mosetufagtig furutuf.
  B. 20—25 cm. furutuf, bestaaende av en række mindre lag: 1. 4 cm. sprød, men tæt gul tuf, meget fin i bruddet, med faa furunaaler. Muligens av sedentær natur. 2. 1,5 cm. kulførende sort stripe. 3. 2 cm. graagul jordagtig tuf. 4. 2 cm. sort kuljord. 5. graagul jordagtig tuf, ca. 10 cm.
  C. 15 cm. løs, sterkt forvitret furutuf.
VII. Muldjord, 20 cm., med *Alnus*-tuf.

Profil IX.

I. Blaa lere.
II. Rød lere.
III. Mosetufkompleks.
  A. 7 cm. hullet slaggagtig tuf, normal.
  B. 8 cm. rødlig mosetuf, haardere.
  C. 4—5 cm. mosetuf med bladrester (*bjerk, asp, Salices*).
  D. 3—4 cm. undre Dryashorisont, med mængdevis av Dryasblader og flere stammer samt en frugtstand, bladfragment av *bjerk* og *Salix* sp. og foliøs levermos (cfr. *Pellia* sp.).
IV. Bladtuf, ca. 8 cm., meget vakkert planskifrig, typisk.
V. Dryastufkompleks.
  A. 3 cm. typisk Dryastuf, kaotisk.
  B. 2—3 cm. laget sone med *furu, bjèrk, Dryasblader*.
  C. 3 cm. løst lag, med smaa tufstykker indeholdende *Dryas* og *furunaaler*.
  C. 1,5 cm. hvitagtig lere.
VI. Furutufkompleks.
  A. ca. 3 cm. mosetuf med furunaaler.
  B. 5—7 cm. graagul, tæt, men fin og sprød furutuf, muligens sedentær, med forholdsvis faa furunaaler, blader av *Vaccinium vitis idæa*, ledstykker av *Equisetum hiemale* og en kurv av *Cirsium heterophyllum*, samt blader av en mindre urt (utydelige).
  C. 30—35 cm. temmelig løs, men tydelig skiktet furutuf, delvis tufjord, med mængdevis av *furunaaler, bark,* flere *kongler* samt *tyttebærblader*.
VII. Muldjord, ca. 20 cm., med *Alnus*-tuf.

Profil X.

Dette profil er det første som blev undersøkt (1918), og det avslutter venstre serie op mot stenrøisen.

I. Blaa lere, ukjendt mægtighet.

II. Rød lere, 4 cm.

III. Mosetufkompleks, ganske komplicert sammensat:

A. 5—6 cm. hullet graagrøn mosetuf, normal, med *Equisetum variegatum* som vanlig.

B. 2—3 cm. rødlig, haardere mosetuf.

C. 1 cm. smal, rød lere med smaa sandkorn, ligner fuldstændig den røde lere paa bunden, og er antageligvis bare en saadan som bækken har gravet ut litt høiere oppe og ganske lokalt skyllet ut over mosetuffen nedenfor.

D. 5—6 cm. mosetuf, optil mere sedimentær.

E. 4 cm. skifrig, fossilfattig tuf, halvt sedentær, ialfald nedtil mosetufagtig, med grønbrogete lag avvekslende med gulagtige; *bjerk* (blader, rakleskjæl, *Salices* (bladfragmenter), *Equisetun variegatum.*

F. 3 cm. opsmuldret mosetuf, øverst hvitagtig kalklere.

G. Undre Dryashorisont, 4—5 cm., med mængdevis av *Dryas*blader, stammer, en blomst i frugtstadiet, *Salix arbuscula* (1 blad), *bjerk* (flere store blader).

IV. Bladtuf, 8—10 cm., skifrig, normal, med *bjerk, asp. Salices* (bl. a. en mindre form, muligens *S. phylicifolia*), desuten et par store *Dryasblader.*

V. Dryastufkompleks:

A. 2 cm. løs, smuldrende Dryastuf, normal.

B. 2 cm. graabrun jordagtig stripe, tildels sortfarvet av kul, over mot foregaaende profil mere hvitagtig lere, som var temmelig seig. Et par smaa tufbiter viste *furunaaler* (tversnit).

VI. Furutufkompleks:

A. 4—5 cm. graagrøn furutuf med mængder av barnaaler, desuten et par blader av *Vaccinium uliginosum.* Paa ett sted litt mosetuf.

B. 4—5 cm. graagul, skjør og fin furutuf, tildels med avvekslende graagrønne og mere gulgraa lag, indeholdende huller efter *kvister, furunaaler, Cirsium heterophyllum* (4 kurver, blomsterstilker, store bladfragmenter), *Tofieldia palustris* (flere vifteformige bladrosetter), *Fragaria vesca* (1 blad), *Pyrola minor* (mange blader, samt en hel plante med paasittende blader), *Equisetum* sp., *moser,* samt avtryk av en lavart, vistnok *Parmelia physodes.* Utpræget sedentær horisont.

B. 1—2 cm. kulstripe.

C. 30—40 cm. furutuf, noget varierende, med *furu*naaler, kvister, bark, kongler i stor mængde, *tyttebær*blader, samt *Vaccinium uliginosum* (flere blader).

VII. Muldjord, 20—25 cm., med store biter av *Alnus*-tuf og mindre stener.

Profilet udmerker sig ved bladtuffens ringe mægtighet; den holder her paa at kile ut og viser flere avvikende træk (f. eks. sparsomme Dryasblader). Den undre Dryashorisont under bladtuffen opnaar her sin største mægtighet, mens Dryastuffen gir indtryk av at være sterkt forvitret og reducert. Endelig byr furutuffen paa flere interessante træk, specielt den sedentære horisont med urteagtige planter, hvorav flere aldrig før er fundet fossile i kvartære avleiringer.

Høire serie.

Denne serie, som løper paralelt med den venstre, men paa grøftens anden (ɔ: nordre) side, viser først fire profiler som stemmer helt overens med venstre-serien, men avsluttes opad med 4 utkilingsprofiler. Bladtuffen og Dryastuffen kiler nemlig ut mot nord og nordvest i forhold til grøftens midtlinje; men utkilingssonen ligger nærmere midtlinjen i tuffens øvre del end længer nede i bakken, hvor først tverprofilet overskjærer utkilingssonen (cfr. dette). Man kan ogsaa uttrykke det samme paa den maate, at bladtuffen og Dryastuffen nu for tiden optrær i en skaalformig, men uregelmæssig omgrænset fordypning, men forsvinder til sidene, hvor imidlertid baade den underliggende mosetuf og de overliggende tuflag (furutuf og Alnus-tuf) fortsætter, tildels med stor mægtighet. Bladtuffens „centrum“ ligger der hvor Blytt optok sit profil, altsaa like ovenfor kjøreveien; her opnaar den sin største tykkelse.

Imidlertid er der flere sikre beviser paa at bladtuffen engang i tiden (ɔ: da dens dannelsestid var avsluttet) har overdækket et meget større areal end den nu gjør, men at den senere igjen er vitret ned i stor utstrækning, forinden furutuffen begyndte at dannes. Jeg kommer tilbake til dette betydningsfulde punkt under beskrivelsen av tverprofilet, som er meget oplysende i saa henseende.

Profil XI.

I. Blaa lere, ukjendt mægtighet.
II. Rød lere, ca. 3 cm.
III. Mosetufkompleks:
   A. 10 cm. graagrøn, hullet, slagg eller koralagtig mosetuf, brunfarvet paa undersiden, med avtryk og hulheter efter *Equisetum variegatum.*
   B. 10 cm. løs mosetuf, brytes let istykker.
   C. 5 cm. mosetuf med blader av *Dryas*; undre Dryashorisont. Hænger sammen med underliggende saavelsom med overliggende lag.
IV. Bladtuf, ca. 20 cm., planskifrig og med mængder av løvblader *(Betula odorata, Populus tremula, Salices).*
V. Dryastuf. Av denne fandtes her bare spor aller øverst i bladtuffens overkant (*Dryas, Salix arbuscula* (mange blader og 2 ♀-rakler), *Pinus*

silvestris (naaler), *Betula ordorata* (bladfragmenter), *Populus tremula* (do.) samt flere tvilsomme avtryk).

VI. Furutuf, ca. 25 cm., temmelig løs og opstykket. Kolossale masser av *Pinus silvestris*-naaler og andre rester. I midten antydning til en mosetufagtig horisont med løvbladfragmenter. Øverst muldblandet forvitret tuf.

VII. Muldjord med rotter av den nuværende vegetation, 20 cm., og med med smaa biter av forvitret *Alnus*-tuf med blader av *Alnus incana*.

Profil XII.

I. Blaa lere.

II. Rød lere, normal.

III. Mosetufkompleks:

A. 10 cm. slaggagtig, hullet mosetuf, normal.

B. 20 cm. lysere mosetuf.

IV. Bladtuf, ca. 25 cm., meget løst skifrig, tildels bladet eller skjællet; typisk.

V. Dryastufkompleks:

A. 6 cm. kaotisk Dryastuf med masser av blader og stammer, desuten flere *furunaaler* og fragmenter av *bjerkeblader*. Lokalt var den fin og med klidagtig struktur (kanske fin mosetuf).

B. 2 cm. smal lersone op mot furutuffen.

VI. Furutuf, her utviklet som en stor kompakt tufblok, 20—25 cm. tyk, som syntes at ha glidd litt fremover paa grund av gravningen nedenfor, som ophævet mottrykket fra denne kant. Øverst meget forvitret.

VII. Muldjord med *Alnus*-tuf rikelig, 30—40 cm.

I dette profil mangler den undre Dryashorisont, i likhet med hvad tilfældet var i Blytts profiler. En del av profilet sees paa fig. 7.

Profil XIII.

I. Blaa lere.

II. Rød lere.

III. Mosetufkompleks:

A. 5 cm. graagrøn slagg-tuf med *Equisetum variegatum*; typisk.

B. 15 cm. mosetuf, i den øvre del med grønbrogete lag indeholdende *bjerkeblader*, *Salix*-blader og *Dryas* meget sparsomt (kun 2 blader).

IV. Bladtuf, 25 cm., overordentlig vakker og fossilrik, nedtil smuldrende, finskifrig.

V. Dryastufkompleks:

A. 5—8 cm. ren Dryastuf med masser av *Dryas*-rester, *Salix reticulata* (2 blader), *Salix herbacea* (1 blad), *S. arbuscula* (blader), *furunaaler* (sparsomt, kun et par naaler set), desuten *insektrester* (bakkropsringer) og flere utydelige avtryk.

B. 2 cm. lagdelt, mere sedimentær sone med *bjerkeblader, asp, Salices,* hvoriblandt *S. arbuscula* og kanske *S. phylicifolia, furunaaler* (sparsomt), *Dryas*blader (sparsomt).

C. 1,5—2 cm. gruset kalklere.

VI. Furutufkompleks.

A. 4 cm. løs furutuf med masser av naaler og smaa tyttebærblader.

B. 10 cm. sinteragtig, løs, fossiltom tuf (kun med træbiter).

C. 30 cm. furutuf, temmelig løs og øverst sterkt forvitret. Nedtil litt mosetuf.

VII. Muldjord, 15 cm.

Profilet er ganske interessant derved, at det viser den samme antydning til tredeling av Dryastufkomplekset som vi saa i venstre-seriens centrale profiler. Dryastuffen var her særlig artsrik og pragtfuldt utviklet.

Fig. 7. Profil XII. Meiselen staar nederst fast i den røde lere og markerer mosetufkompleksets tykkelse. B—B = bladtuffen, hvis skifrighet sees ret over meiselen. Papirkorsene avmerker Dryastufkomplekset. Øverst den kompakte furutuf. Juli 1919. Nordhagen fot.

Profil XIV.

I. Blaa lere.

II. Rød lere.

III. Mosetufkompleks.

A. 10 cm. slaggagtig mosetuf, normal.

B. 4 cm. hvit lere.

C. 10 cm. vakker mosetuf.

IV. Bladtuf, 25 cm., meget vakker; typisk.

V. Dryastufkompleks.

A. 5—7 cm. kaotisk Dryastuf med mængder av *Dryas*rester (blader, stammer, en knop eller blomst i begyndende frugtstadium, „anatomiske" tversnit), *Salix reticulata* (3—4 blader), *S. arbuscula, bjerk, asp, Equisetum variegatum, furunaaler* (meget sparsomt). Nedtil litt løs, fin mosetuf.

B. 2—3 cm. lagdelt sone med *bjerk, asp, Salix capræa, S. reticulata* (6 blader), *S. arbuscula, S. cfr. phylicifolia, Dryas, Pinus silvestris* (flere store naaler).

C. 1,5 cm. hvitagtig til chokoladefarvet tuflere (gruset kalklere).

VI. Furutufkompleks.

A. 2 cm. utpræget sone med smuldrende tuf, tætpakket av furunaaler og med smaa fine blader av *Vaccinium vitis idæa* samt fragmenter av *Salix*-blader.

B. 2 cm. lerlignende stripe.

C. 7—8 cm. hvitagtig sinter-tuf, fossilfattig, men med *furu*naaler, tildels meget løs og opsprukket.

D. 15 cm. mosetufagtig furutuf.

E. 30 cm. kompakt furutuf, tre plater over hinanden, øverst sterkt forvitret. Rik paa fururester.

VII. Muldjord, 20 cm. med mange smaa biter av *Alnus*-tuf allerøverst.

Profilet er meget fuldstændig og viser en mægtig furutuf med ganske komplicert bygning.

Profil XV.

I. Blaa lere.

II. Rød lere.

III. Mosetuf, 10 cm. hullet slaggagtig mosetuf, typisk.

IV. Mangler }
V. Mangler } cfr. næste lag.

VI. Furutufkompleks.

A. 10—15 cm. løs sone, tildels brunlig lere med smaa tufstykker fuldproppet med furunaaler og med smaa tyttebærblader, desuten mosetufrester. Svarer utvilsomt til den underste del av furutuffen i foregaaende profil, som her synes at være opknust under vegten av den overliggende mægtige furutuf og trykket ned i en leragtig masse (forvitringsprodukt av bladtuffen).

B. 30—40 cm. haard, sammenhængende furutuf, fossilrik, meget kompakt og tung.

C. 25 cm. forvitret løs furutuf, tildels tufjord.

VII. Muldjord, 30 cm., med *Alnus*-tuf og andre utydelige tufrester.

Vi møter her det første utkilingsprofil hvor baade bladtuffen og Dryastuffen er forsvundet; antageligvis er den leragtige substans et forvitringsprodukt herav. Profilet kan meget let forfølges over til grøftens venstre side, og her kommer baade bladtuf og Dryastuf til som en kile fra venstre, men forsvinder indunder fututuffen tilhøire i grøften, saaledes som nærværende profil viser.

Profil XVI.

I. Blaa lere.

II. Rød lere.

III. Mosetuf, 5 cm. hullet slaggtuf, typisk.

IV. 1,5 cm. hvitt kalkgrus.

V. Kaotisk kompleks, 20 cm.; brungrøn tuflere med tufstykker, indeholdende *Dryasblader, furunaaler*; et stykke indeholdt *bladtufrester* øverst og mosetuf nederst. Øverst furutufstykker.

VI. Furutufkompleks, 30—35 cm., øverst løsere og forvitret, nedtil mere kompakt og haard tuf.

VII. Muldjord med tufbiter, 20 cm.

Dette profil er meget instruktivt, idet det viser os de sidste smuldrende rester av den utkilende bladtuf og Dryastuffen.

Profil XVII.

I. Blaa lere.
II. Rød lere.
III. Mosetufkompleks.
A. 3 cm. grønlig, gruset stripe.
B. 5 cm. hullet mosetuf, typisk.
C. 5—7 cm. forvitret rødlighvit mosetuf; tildels gruset, hvit kalklere.
IV. V. Brungrøn, gruset tuflere, 8—10 cm., med *Dryastuf*stykker (ogsaa *furunaaler* i disse) med mængder av *Dryas*rester, fragmenter av *bjerk* og *asp* (sparsomt), *snegler*. Furunaalene var temmelig tynde og fine.
VI. Her kom først en lerstripe, som nedtil var sterkt rød og optil blaalig, 3—5 cm. Derefter fulgte 30 cm. furutuf, som i foregaaende profil, med *furu*rester (naaler, kongler), en *Salix*-rakle o. a.
VII. Muldjord. 20 cm. med *Alnus*-tuf.

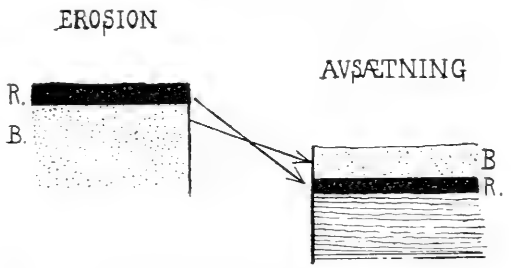


Fig. 8. Skematisk tegning av en stratigrafisk inversion. B = blaa lere. R = rød lere.

Dette profil supplerer foregaaende paa en udmerket maate. Imidlertid er lerstripen VI (under furutuffens nederste del) ganske gaadefuld. Vi har her nemlig akkurat det omvendte av hvad vi finder paa bunden av tuffen, nemlig rød lere og derefter blaa. Dette fænomen kan ikke forklares paa anden maate end at bækken dengang furutuffen skulde begynde at dannes, maa ha gravet sig ned til de underste lerlag paa et sted hoiere oppe i bakken (hvor kanske ogsaa mosetuffen var vitret ned). Den har da selvfølgelig først erodert i den røde lere som ligger øverst, og atter avsat denne længer nede, derefter i den underliggende blaa og placert denne oppaa den røde længer nede i bakken. Dog synes baade dette erosionsfænomen og avsætningsfænomen at ha været ganske lokalt (vi møter det atter i næste profil). — Denne stratigrafiske inversion tyder paa ganske sterk vandføring i bækken i begyndelsen av furutuffens tid (cfr. fig. 8).

Dette profil er forøvrig et ukilingsprofil av det under venstre serie omtalte profil VI, som var optat midt i grøften. Fotografiet (fig. 9) med forklaring viser dette.

Profil XVIII.

I. Blaa lere.
II. Kun antydet rød horisont, som røde flammer i overkanten av den blaa lere.
III. Mosetufkompleks.
A. 5 cm. grønlig hullet mosetuf, normal.

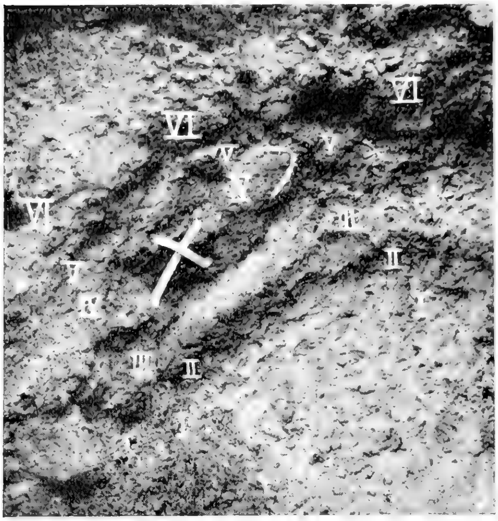


Fig. 9. Billedet viser en del av profil VI tilvenstre og dets utkiling over mot profil XVII tilhøire. I = blaa lere, II = rød lere (hvis mørke farve sees paa billedet), III = mosetuffen, IV = bladtuffen, som kiler ut paa det sted som er betegnet med >. Papirkorset markerer ogsaa bladtuffen. V = Dryastuffen; tilhøire er denne ogsaa avmerket med et kors. VI = furutuffen. Lagene skraaner sterkt mot iagttageren. Juli 1919. Nordhagen fot.

B. 5—8 cm. mosetuf-kalkgrus, tildels leragtig.
IV. } 5 cm. brun, gruset tuflere
V. } med Dryastufstykker.
VI. A. 5—6 cm. lere; nederst 1—2 cm. skrikende rød lere, øverst 4 cm. blaalig, sandet lere (samme fænomen som i foregaaende profil).
B. 10—12 cm. kalkgrus, hvitagtig.
C. 30 cm. furutuf, temmelig løs og forvitret.
VII. Muldjord, 20 cm., med tufbiter.

Profilet stemmer helt med foregaaende; det danner dets forlængelse opad og grænser op mot stenrøisen, avslutter altsaa høire serie.

Bladtuffen kiler altsaa ut opad bakken og over til høire; i det øverste profil i venstre serie fandtes den fremdeles, men var her, som vi har set, av ringe mægtighet (8—10 cm.) og kiler vel ogsaa ut opunder stenrøisen paa dette sted.

Tverserien.

Denne begynder med profil IV i venstre serie og passerer profil XV i høire serie, hvortil henvises. Derefter følger endda længer tilvenstre (ɔ: nordligere) følgende profil.

Profil XIX.

I. Blaa lere.
II. Rød lere.
III. Mosetuf, 5 cm. hullet slaggagtig tuf, normal.

IV. } mangler. Isteden optrær 10 cm. brunlig olivenfarvet *tuflere* med smaa
V. } mosetufbiter.

VI. Furutufkompleks; mægtig og avvekslende.

A. 8—10 cm. mosetuf med *furunaaler* og *kongler*.

B. 30 cm. haard, tildels flinthaard furutuf med mængdevis av fururester, desuten *Vaccinium vitis idæa*, *Salices* o. a. Især nedtil tydelig lagdelt og meget haard.

C. 20 cm. løs jordagtig tuf med et mere sammenhængende, sprødt lag, som mindet om den sedentære sone i profil IX og X.

VII. Muldjord, 20 cm. med *Alnus*-tuf i store stykker, desuten et stykke av en bladrik furutuf, som indeholdt talrike *furubar*, blader av *asp*, *bjerk* (vistnok *B. verrucosa*), *Salix* sp., *Sorbus Aucuparia* (1 bladfinne), *tyttebær*, samt nogen valkformige, glatte forhøininger, som muligens skriver sig fra blaagrønne alger (cyanofycé-tuf).

Dette profil viser de samme forhold som profil XV, med en utkilende bladtuf. Furutuffen derimot opnaar her omtrent sin største mægtighet (cfr. næste profil).

Profil XX.

Danner en fortsættelse av foregaaende over mot venstre.

I. Blaa lere.

II. Rød lere, typisk.

III. Mosetuf, 20 cm., slaggagtig, med *Equisetum variegatum* og thalløse levermoser (*Marchantia polymorpha*); normal.

IV. } Brun, jordagtig rand, 3 cm. med smaa flate *bladtuffragmenter* (*Betula*
V. } *odorata*, diverse blader og rakleskjæl), som var sterkt brunfarvet paa oversiden. Derover 5 cm. grønlig sandblandet tuflere.

VI. Furutufkompleks, tilsammen ca. 70 cm.

A. 10 cm. løs furutuf, vistnok mosetuf, med sparsomme furunaaler.

B. 10 cm. grønbroget, valket furutuf med masser av fururester.

C. 15 cm. meget haard mosetufagtig furutuf med sparsom *furu*, *Salix*-blader samt *løvblad*-fragmenter. Tildels meget kompakt og plateformig.

D. 10 cm. furutuf, normal type, med et eneste kaos av naaler og andre rester av *furu*.

E. 20 cm. løs, forvitret og jordblandet furutuf.

VII. Muldjord, 20 cm., med smaa tufbiter.

Profilet er i flere henseender et av de interessanteste i hele tuffen. Bladtufrestene i den brunlige jordstripe laa meget smukt paa rad bortover, i naturlig stilling (skifrigheten orientert paralel med bakkens overflate, som her næsten var horisontal over en kortere strækning). De er utvilsomt de sidste rester av en tidligere bladtuf, som er vitret ned forinden furutuffens dannelse blev paabegyndt. Den grønlige lere er ogsaa tydelig et forvitringsprodukt.

Furutuffen derimot har paa dette sted sit maksimum hvad mægtigheten angaar og udmerker sig ved en række med stratigrafisk forskjelligartede horisonter. Fig. 10 viser et fotografi av profilet.

Profil XXI.

Dette blev optat høsten 1920 og ligger hele 9 m. nordenfor profil XX. Mellem dem ligger der, saaledes som antydet paa tverprofilet (fig. 12) en

Fig. 10. Profil XX. Nederst ved vandpytten sees mosetuffen (III). Derpaa følger den brune rand (IV) med bladtufrestene, og den grønlige tuflere (V). Øverst sees furutuffen (VI), som fortsætter ovenfor billedets rand. Juli 1919. Nordhagen fot.

stenrøis og bjerkekrat. Overensstemmelsen mellem dette profil og de gravninger som jeg foretok nedenfor kjøreveien, er ganske slaaende (cfr. nedenfor), og de er alle sammen meget forskjellige fra tuffens øvrige profiler derved, at *Alnus*-tuffen her er paafaldende mægtig utviklet, mens den jo ellers kun er tilstede i form av mindre stykker øverst i jordlaget. Rækkefølgen i profil XXI var saaledes:

I. Store stener i bunden.

II. Mosetuf, ca. 10 cm., nedtil rustfarvet paa undersiden og slaggagtig, graagrøn med *Equisetum variegatum*. Den stemmer helt overens med bundlaget ellers i tuffen. Øverst mere rødlighvit og tæt mosetuf.

III. Kaotisk kompleks, bestaaende av graaagtig tufjord med talrike løse tufstykker, 8—10 cm.

A. Nederst mot mosetuffen fandtes smaa *bladtufstykker*, sterkt forvitret; typiske.

B. Høiere oppe fandtes større og mindre stykker (op til 20×20×7 cm.) av *furutuf*, typisk, med masser av *bar*, mange store *kongler*, *tyttebærblader*, dverggrener av *asp*; de var sterkt forvitret og brune i overflaten (planche IV, fig. 1).

C. Jordagtig stripe, ca. 3 cm., med biter av trækul.

IV. Alnustufkompleks, 90—95 cm.

A. 25 cm. blekt rødlig tufjord (bleke) med en del mindre fastere stykker, som let knuses mellem fingrene. De bestod vistnok av mosetuf med en del utydelige planteavtryk (græsstraa). Øverst fandtes en svakt antydet kulstripe.

B. 8—10 cm. mosetuflag, meget sprødt og porøst, med blader av *Alnus incana*, *Salix* sp., dverggrener, vedbiter, ledstykker av *Equisetum hiemale*. I sin øvre del var dette lag sterkt rustfarvet, særlig i profilets høire del, mere utydelig i den venstre del, hvor de overliggende lag var haardere. Rustsonen bør muligens tolkes som et podsolfænomen (cfr. det følgende). 20—25 cm. haardere mosetuf fulgte ovenpaa rusthorisonten, uten avbrytelse i lagrækken. Denne tuf var grovere og mere kaotisk end foregaaende og stemmer helt overens med Alnus-tuf fra muldlaget i andre profiler; den var temmelig fossilfattig (*Alnus incana*, *Salix* sp., *græsblader*, *moser*); enkelte partier sinteragtige.

C. 20—25 cm. løs, blekeagtig tufjord med haardere biter, graalighvit av farve, øverst meget hvit og fin.

D. 12 cm. muldblandet tufjord med haardere biter.

V. Muldjord med røtter, 5 cm.

Alnustuffens lag viste et fald paa ca. 30° mot øst-nordøst og ligger, som fig. 12 viser, i en slags mulde ovenpaa den forvitrede furutuf.

Profilets allerunderste del stemmer helt overens med tuffens øvrige profiler, og likesom i foregaaende profil træffer vi her restene av en forvitret bladtuf oppaa mosetuffen. Men, man kunde fristes til at si, det sensationelle moment ligger i den forvitrede furutuf som her møter os, og som aabenbarer en diskordans mellem furutuffen og Alnustuffen. Dette fænomen kunde man forøvrig slutte sig til paa forhaand, da restene av Alnustuffen i de øvrige profiler altid ligger ovenpaa furutuffen, og fordi der aldrig er iagttat nogen overgang mellem furutuf og Alnustuf, som har helt forskjellig struktur, farve og fossilindhold.

Men nærværende profil viser til evidens at paa dette sted var furutuffen vitret ned til et løst kaos av muldblandet tuf forinden Alnustuffen begyndte at dannes. Antageligvis har furutuffen paa dette sted været mindre mægtig end i de foregaaende profiler i tverserien. Flere ting tyder paa at foregaaende profil markerer furutuffens maksimum, og at den derfra har skraanet noget til begge kanter (baade nordover og sydover). Dog er det ikke mulig at rekonstruere furutuffens oprindelige utseende. Vi har før set at den i saagodtsom alle profiler er meget løs og forvitret optil, og antageligvis har den overalt været mægtigere end nu, selv om dette ikke kan siges med bestemthet.

Tverprofilet viser os saaledes hvad jeg allerede indledningsmæssig fremhævet, at i Leine-tuffen har de forskjellige horisonter n u f o r t i d e n sit maksimum paa helt forskjellige steder. Bladtuffens ligger i en mulde længst syd ved bækken, furutuffens ligger litt nordligere og Alnus-tuffens maksimum endda længer mot nord. Imidlertid vil de følgende profiler nedenfor veien vise at Alnustuffen ogsaa har et maksimum længer nede i bakken i en lignende mulde, hvor ogsaa furutuffen er høist reducert.

Profilet er videre meget oplysende om selve *Alnus*-tuffen. Vi ser at den gjennemgaaende har en ytterst løs, tildels blekeagtig karakter, og at den i vertikal retning opviser en række forskjellige lag, videre at den er meget mægtig sammenlignet med tuffens øvrige hovedlag. Det er sikkerlig oretuffens løse, smuldrende natur som er hovedaarsaken til at den gjennemgaaende er meget sterkt reducert over store arealer paa tuffindestedet.

En speciel omtale fortjener den rustfarvete stripe indenfor mosetuflaget. Jeg har ovenfor antydet at dette fænomen muligens er av sekundær natur, en utfældning som har foregaat efter Alnustuffens dannelsesperiode. Som nævnt var den meget utpræget i profilets venstre del, men over til høire blev den mere utvisket; her var den overliggende tuf temmelig haard. Hadde vi her hat en autokton jernholdig tufhorisont, burde man ha ventet at den var lik overalt. Det er derfor mulig at rusthorisonten er et saakaldt podsolfænomen, og motsvarer den anrikningshorisont av jernforbindelser som optrær i en mængde jordbundsformer under en overliggende saakaldt blekjord. Podsolprofil utvikles bedst i granskoger med tykt lag av raahumus øverst (Tamm 1920 l. c.). Imidlertid pleier et kalkholdig underlag, særlig hvor det er skraanende, at fremkalde en helt anden jordbundstype uten tydelig podsolering (Hesselmann 1917 l. c. p. 397—411). Som substrat for vegetationen betragtet, er jo en kalktufforekomst, specielt under perioder hvor avsætningen paagaar, meget fugtig, og man skulde ogsaa av denne grund ikke vente at finde podsolering; en saadan proces synes nemlig, efter hvad man vet, ikke at foregaa paa meget fugtig bund (cfr. Tamm l. c. p. 55). Den omtalte rusthorisont i Alnustuffen ligger imidlertid netop indenfor en del av Leinetuffen som nu for tiden er meget tør (ca. 10 m. fjernet fra det nuværende bækkeleie), saa av denne grund var podsolering nok mulig. Dog vover jeg ikke at uttale noget herom med sikkerhet, men nøier mig med at gjøre opmerksom paa forholdet.

Profiler nedenfor veien.

Under selve kjøreveien og i dens nærmeste omgivelser var det selvsagt umulig at foreta nogen gravninger (bl. a. paa grund av bækkens mulige ødelæggelser hvis den kom i et nyt leie). Mit første profil nedenfor veien ligger ca. 2 m. fra veikanten.

Profil XXII.

I. Blaa lere.

II. Rød lere.

III. Mosetufkompleks, tilsammen 20 cm., utviklet som en sammenhængende bænk, som nedtil var hullet og slagget (typisk). Øverst fandtes en sone med talrike blader av *Salix arbuscula*, bladfragmenter av *Betula odorata* samt en ♀-rakle av samme, *Equisetum variegatum*. Svarer uten tvil til den undre Dryashorisont i de øvrige profiler, men mangler altsaa *Dryas*.

IV. Bladtuf, 25—30 cm., normal, men med talrike *Salix*-blader foruten *bjerk* (blader, rakleskjæl) og *asp*. Vakkert skifrig, optil løs.

V. VI. } Derefter fulgte en 10—15 cm. mægtig løs, kaotisk sone med

A. Bladtufbiter nederst (i bladtuffens overkant).

B. Et vakkert stykke Dryastuf, meget forvitret, men med 15 bladavtryk paa overflaten, desuten en stammedel og et bjerkeblad.

C. Forvitrede furutufstykker med masser av naaler samt tyttebærblader; typisk.

VII. Alnustufkompleks, 15—20 cm., meget løst, tildels jordagtig, med større og mindre fastere stykker indeholdender *Alnus*-blader rikelig; typisk.

VIII. Muldjord, 30 cm. nedtil med *Alnus*-tuf, hvorav flere store stykker.

Dette eiendommelige profil ligner i flere henseender meget det nordligste i tverserien. Bl. a. er furutuffen her ogsaa tydelig vitret ned, ja vitringen har øiensynlig grepet endda dypere om sig, helt ned i bladtuffens øvre del. Dryastufstykket er specielt værdifuldt; det viser nemlig at forvitringsproduktene ligger ganske i sin naturlige orden paa hinanden, og vidner om at her ogsaa har været en veritabel Dryastuf paa stedet, saaledes som høiere oppe i tuffen. Endelig er *Alnus*-tuffen ganske godt opbevaret.

Profil XXIII.

Optat ca. 3 m. nedenfor foregaaende.

I. II. } Runde stener i grøftens bund.

III. Mosetufkompleks.

A. 15 cm. normal mosetuf med *Equisetum variegatum*.

B. 5 cm. grønbroget horisont med *Salix arbuscula*, græsstraa etc., nøiagtig som i foregaaende profil.

IV. Bladtuf, ca. 15 cm. med massevis av *Salix*-blader, vistnok mest *S. caprea*, ellers typisk. Optil løs og forvitret.

V. } Løs sone, 15 cm., bestaaende av kul og muldblandet tufjord med tal-
IV. } rike furutufstykker (7—8 cm. tykke), desuten biter av en merkelig kornet, sammenkittet grustuf uten fossiler. Nederst pladeformige bladtufbiter.

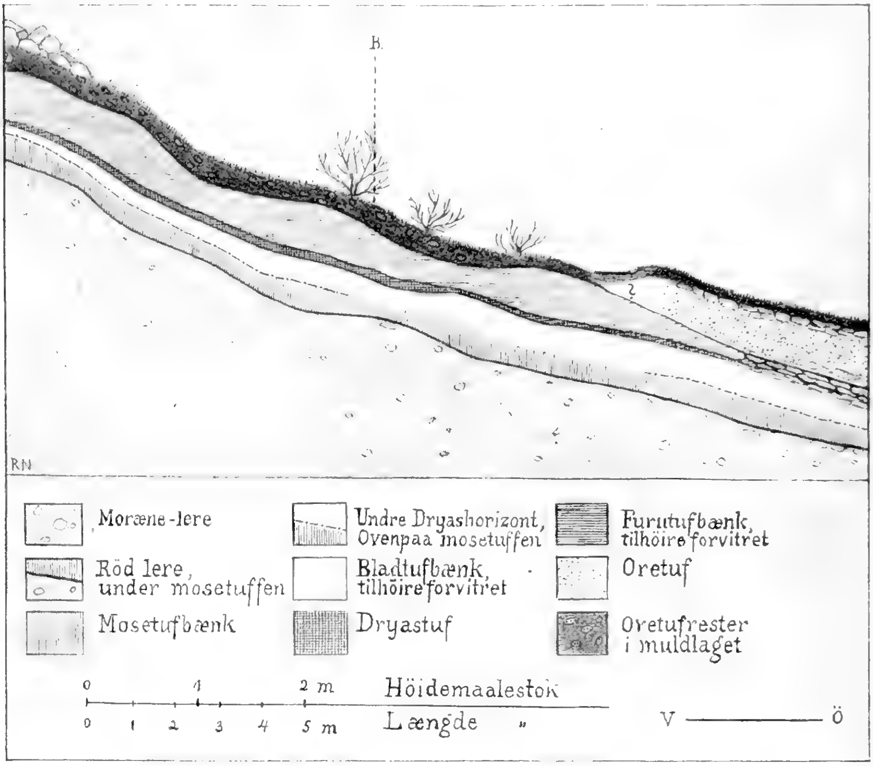


Fig. 11. Længdeprofil, Leine. B angir tverprofilets beliggenhet.

VII. Alnustufkompleks, 25—30 cm., graagul blekeagtig tuf med haardere stykker, især nedad.

VIII. Muldjord, 30 cm., med store biter av *Alnus*-tuf nederst.

Sammenholdes disse to profiler, som er temmelig like, med tverseriens nordligste profil, gir det hele et ganske interessant billede av av *Alnus*-tuffens forekomstmaate. Den har sin største mægtighet der hvor fututuffen er mest forvitret, og hvor der av denne grund er muldeagtige fordypninger i tuffens øvre del. Det er da ganske naturlig at den her er bedst bevaret; men kanske har den ogsaa paa disse steder oprindelig været mægtigere end paa alle andre punkter inden omraadet. Hvor meget der atter er vitret bort over størsteparten av tuffens areal, er det umulig at avgjore; de i muldlaget forekommende tufrester er av flere typer (*Alnus*-rikere og -fattigere, mosetufagtige, krøllet-cyanofycé-lignende o. s. v.) og er tydelige vidnesbyrd om, at selv paa de punkter hvor denne øverste tufhorisont nu er ytterst reducert, har der engang været flere vertikale facies.

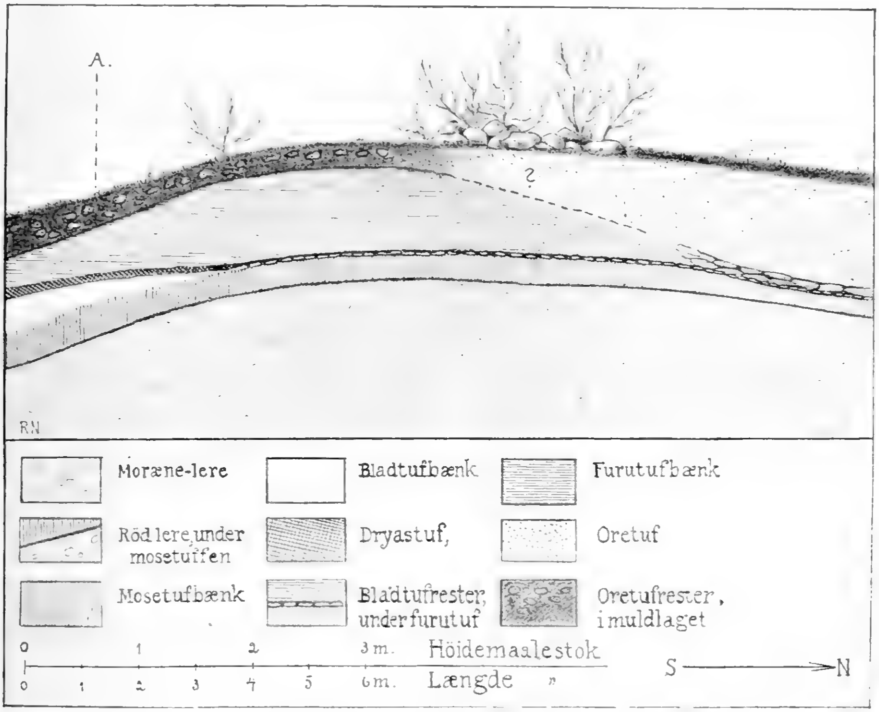


Fig. 12. Tverprofil, Leine. A angir længdeprofilets beliggenhet.

Alle disse tre perifere profiler, som ved første øiekast ser hoist paradoksale ut, og som for en iagttager der ellers var ubekjendt med tuffens stratigrafi, vilde være ganske problematiske, indordner sig i virkeligheten meget smukt i helhetsbilledet. Saalænge det ytterste profil i tverserien var ukjendt, kunde man nok staa tvilende overfor litt av hvert. Men da overensstemmelsen er saa slaaende i disse ytterpunkter av tufomraadet, baade nordover og østover, hvilket fig. 11 og fig. 12 tydelig viser, blir det endelige resultat av denne stratigrafiske detaljstudie, at kalktuffen ved Leine har en strengt lovmæssig, klar og oversigtlig opbygning, som ikke kan misforstaaes.

C. Oversigt over Leinetuffens stratigrafi.

Efter at ha skildret alle de mange enkeltprofiler, skal jeg nedenfor gi en samlet oversigt over tuffen[1] og diskutere de enkelte horisonter nærmere.

Den blaa lere.

Under kapitlet „isavsmeltningen i Gudbrandsdalen" vil spørsmaalet om moræнemassenes oprindelse og alder bli nærmere berørt. En række av kjendsgjerninger taler for at de er avsat av en bræ fra nordvest, antageligvis under en periode med lokalglaciation i det centrale Norge (*Portlandia*-nivaaet).

De snegleformer som det lykkedes mig at fremfinde i den blaa leres øvre del, *Vitrina pellucida* (MÜLL.), *Conulus fulvus* (MÜLL.) samt *Limnæa truncatula* (MÜLL.)[2] er ikke særlig oplysende i klimatologisk henseende. Det er altsammen temmelig ubikvisite former, som baade kan tyde paa et alpint og et subalpint klima.

Den røde lere.

Denne horisont er saa eiendommelig at den fortjener den største opmerksomhet fra geologenes side. Den er i gjennemsnit 3 cm. tyk, undertiden tykkere, men ofte ogsaa tyndere. I sin mest typiske form er den meget sterkt rød, næsten skrikende, og forbauser altid ved sin tilsynekomst under den laveste mosetuf. I fugtig tilstand er den noksaa plastisk, undertiden sees litt tilblandet sand (blaalige kvartskorn bl. a.). I motsætning til den underliggende blaa leres overflatelag indeholder den nu ingen opbevarte snegler.

At den røde lerhorisont er et forvitringsprodukt av den blaa moræнelere, er hævet over enhver tvil. Og det skyldes kalktuffen, som har lagt sig som et beskyttende skjold over den, at den her er bevaret, mens den ellers overalt er forsvundet.

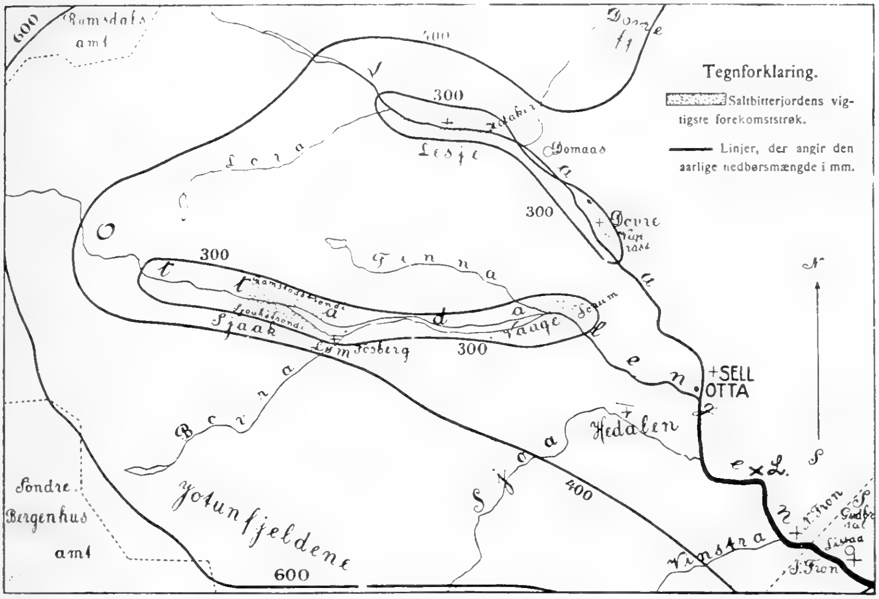
I jordbundslæren adskiller man som bekjendt flere typer av forvitring efter de klimatiske forhold. I et relativt humid klima faar man jordbundstyper karakterisert ved en utpræget opløsning og bortførelse av opløselige forvitringsprodukter fra de øverste markskikt, altsaa en utvaskning og absolut ingen ophobning i overflatelagene. I motsætning hertil staar den aride type, hvor der netop paa grund av klimatiske forhold sker en ansamling av forvitringsprodukter i overflaten. Hovedforskjellen mellem disse to klimatiske typer,

[1] ØYEN har i sit arbeide om kalktuffene kommentert BLYTTS oprindelige beskrivelse paa en række punkter. Imidlertid er disse supplerende oplysninger tildels noget misvisende, hvilket nærværende stratigrafiske oversigt godtgjør. De grunder sig paa studiet av BLYTTS efterlatte samlinger alene, ikke paa nye iagttagelser paa findestedet.

[2] Den sidstnævnte art er bestemt av dr. NILS ODHNER, Stockholm.

som selvfølgelig ikke er skarpt adskilt, ligger i forholdet mellem nedbør og fordampning; i et humid klima mottar marken mere vand end den avgir ved fordampning, og overskuddet synker ned og bortfører ustanselig visse forvitringsprodukter. I et arid klima derimot er der likevegt, eller oftest en stor deficit paa grund av den intense fordampning, hvilket bevirker den nævnte akkumulerende virksomhet i overflatelagene (cfr. Ramann 1911, Hesselmann 1917 p. 397).

Alting tyder paa at lerbakkene ved Leine i tidsrummet efter den sidste isbræs tilbakerykning har været gjenstand for en intens oksydation og



Kartskisse over nordre Gudbrandsdalen, visende de vigtigste forekomststrøk av saltbitterjord. 1 : 750 000.

Fig. 13. Tallene angir nedbørhøiden i mm. L = Leine i Kvam. (Five 1911).

anden kemisk omdannelse i overflaten under ganske særegne forhold. At klimatet har været ytterst kontinentalt, kanske likefrem arid, er meget sandsynlig.

Det er i denne forbindelse meget interessant at den øvre del av Gudbrandsdalen i nutiden hører med til de nedbørfattigste egne i hele det sydlige Norge, med under 400 mm. aarlig nedbørhøide. De stationer som ligger nærmest Kvam, er Botn i Sel med 332 mm. og Steinfinsbø i Hedalen med 325 mm. I Skjaak gaar nedbørhøiden ned til 254 mm. (Metorol. Institut l. c.).

Som vistnok Bjørlykke først har gjort opmerksom paa, har vi i disse strøk ogsaa i nutiden en virkelig arid jordbundstype, nemlig „saltbitterjorden“ i Vaage, Skjaak, Dovre og Lesje (1911 l. c.). Denne er specielt studert av I. Five, som har skrevet en meget interessant opsats om saltbitterjorden, dens utbredelse og økonomiske betydning (1911 l. c.).

„Saltbitteret“, skriver FIVE, „som viser sig paa jordoverflaten i den varme og tørre aarstid, enten som skorpe, klumper eller kruster, *bestaar hovedsagelig av gips* (svovlsur kalk); men indeholder ogsaa adskillig *bittersalt* (svovlsur magnesia), som gjør, at det smaker bittert. Desuten kan det være smaa mængder av *alkaliesulfater*, samt en del *klorider*.“ „Saltbitteret holdes *opløst i jordvandet*, som bevæger sig i jordens porer. *Denne bevægelse vil i den varme og regnfattige forsommer* (tildels ogsaa utover høstparten) *væsentlig være i opadgaaende retning*. De foran nævnte salte følger med i opløst tilstand helt til jordoverflaten. Naar saa vandet dunster væk *utfældes saltene* (saltbitteret) i en av de før nævnte former“ (l. c. p. 23). Vedføiede kartskisse er hentet fra FIVES arbeide og viser saltbitterjordens utbredelse samt nedbørkurver. Kalktuffens beliggenhet er avmerket med L. i kartets sydøstre hjørne. — Aarsakene til denne merkelige jordarts dannelse maa ifølge FIVE søkes i de klimatiske forhold: „et *utpræget indlandsklima* med varm sommer og kold vinter — og *liten nedbør*, specielt i vaarmaanederne“ (l. c. p. 9, hvor en række tabeller belyser forholdene). BJØRLYKKE omtaler ogsaa aride „hardpan“-dannelser og saltjorder fra de øvre deler av vore østlandske dalfører i „Norges jordbundsprovinser og klimatiske hovedstrøk“ [1].

Den „fossile jordbund“ under kalktuffen er efter min mening et tydelig og værdifuldt vidnesbyrd om at de kontinentale forhold var i endda høiere grad potensert i disse længst forsvundne tider. Kanske sterke føhnvinder kan ha bidradd til at paaskynde oksydationsprocessene. Desuten har utvilsomt den heldige eksposition og derav følgende sterke insolation og opvarmning stimulert de kemiske omsætninger. Imidlertid sier det sig selv at en saadan forvitringshorisont ikke opstaar i en haandvending, men kræver tid til sin dannelse. — Nogen anden forklaring paa fænomenet kan for tiden ikke gives. Saavidt jeg vet, foreligger der i litteraturen ingen oplysninger om tilsvarende fænomener fra andre strøk i Skandinavien, som kan gi angrepspunkter for en mere indgaaende diskussion [2].

Om lerbakkene ved Leine under denne periode var vegetationsklædt eller ikke, kan ikke siges med bestemthet, da alle tydelige organiske rester mangler. Undertiden synes den røde lere at indeholde mere brunlige partier, som muligens er destruerte levninger av plantevekst; dette kunde jo tyde paa en meget spredt vegetation. Et andet moment som fortjener opmerksomhet, er det faktum, at den underste, slaggagtige mosetufhorisont er brunfarvet paa undersiden og her fleresteds bærer tydelige avtryk efter kvister og mindre grener (*Salices*?). Men disse kan ogsaa først ha ind-

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1 Naturforskermøtets forhandlinger 1916. Kristiania 1918, p. 522—523.

2 Den røde lere minder baade om „terra rossa“ og lateritdannelser; men da disse opstaar i varme klimatomraader, er det vanskelig at trække nogen mere indgaaende sammenligning.

fundet sig paa stedet da kalktufkilden begyndte at sprudle frem av bakken[1].

Flere ting tyder med bestemthet paa at den røde lere ved Leine ikke er et rent lokalklimatisk fænomen, men av mere generel natur. Kalktuffen ved Gillebu i Øier længer syd i Gudbrandsdalen viser nemlig det samme fænomen. Her er, som vi senere skal se, tuffens underlag meget sterkt oksydert og rikt paa jernforbindelser, hvilket bl. a. ogsaa har hat tilfølge at selve tuffens bundlag tildels er mørkt brunt eller chokoladefarvet, mens lagene høiere oppe har den vanlige graagule tuffarve (cfr. Øyen 1920, p. 285).

Mosetufkomplekset.

Den første kalktufhorisont som møter os ved Leine, er en mosetuf. Og den underste del av denne, som er meget karakteristisk, gjenfindes i samtlige profiler, har altsaa en sammenhængende utbredelse over hele omraadet.

Denne mosetuf er hullet, porøs og uren, og kan betegnes baade som slaggagtig og koralagtig. Mosetufstrukturen er meget utvisket paa grund av forkalkningen, men aabenbarer sig ikke sjelden paa brudflater, hvor mosens blader ofte sees. Farven er i fugtig tilstand eiendommelig graagrøn, og temmelig mørk. Hovedmassen utgjøres muligens av en *Amblystegium*-art, men det er ikke mulig at konstatere dette med nogen sikkerhet. Dog kan det ikke være *A. falcatum*, da denne art, som høiere oppe i tuffen er almindelig, er meget grovere. Tuffen viser en paafaldende likhet med stuffer fra subarktiske lag i tuffen ved Hemrike i Lerdala, Västergötland (Sernander 1916, l. c. p. 141, Växtbiologiska Institutionens kalktufsamling).

Som før nævnt er mosetuffens underside rødfarvet av den underliggende lere. Men ogsaa selve den først dannede kalktuf er flheresteds meget sterkt jernholdig og rødfarvet, desuten forurenset med kvartskorn. Paa undersiden, men ogsaa høiere oppe, er der avtryk og hulrum efter flere middels grove træpinder (muligens trærøtter), hvorav en del var 1 cm. i diameter; et grovt, men mere tvilsomt, halvcylindrisk avtryk var 3,5 cm. i diameter. Muligens skriver de sig fra *Salix*-busker, da jeg andre steder i tuffen har fundet utydelige smaa *Salix*-blader (som minder litt om *S. phylicifolia* eller *S. arbuscula*). Ellers egner denne porøse mosetuf sig meget daarlig for opbevaring av blader og andre urteagtige plantedeler. — Gjennem næsten hele mosetuffens masse findes nogen smaa hvite, tynde rørlignende fragmenter, som skriver sig fra *Characéer* (planche I, fig. 10). De viser den største likhet med saavel svenske characé-holdige tuffer som recent characé-kalk fra bunden av gotlandske sjøer (Växtbiologiska Institutionens i Uppsala samling av organogene kalkdannelser). Nogen artsbestemmelse er

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[1] Kilden har tydeligvis virket eroderende i begyndelsen og skyllet væk en del av den røde lere (cfr. mosetuffens underste, jernholdige parti) og fjernet opløselige salter i denne.

ikke mulig, neppe engang nogen sikker slegtsbestemmelse; dertil er fragmentene altfor lite utpræget. I Skandinavien findes der baade *Chara* og *Nitella*-arter som gaar ganske høit over havet (RABENHORST l. c.).

Ellers er *Equisetum variegatum* ytterst karakteristisk for denne underste mosetuf. Overalt træffer man avtryk og hulheter efter dens stængler, ofte i tætte masser. Av landsnegler fandtes *Conulus fulvus* MÜLL.

Alt i alt maa man anta at lerbakken ved Leine ved tufavsætningens begyndelse har været klædt med en svulmende, meget fugtig mosmatte indenfor det av bækken overrislede omraade. I denne mosmatte har der vokset *Marchantia polymorpha* (cfr. profil XX), *Characéer*[1] og *Equisetum variegatum*; muligens var der et krat av *Salices* (ialfald har træer eller busker været tilstede), eller kanske spredte vidjebusker. Desuten kan man være sikker paa at en række med græs og urter ogsaa har holdt til paa stedet (f. eks. subalpine *Carices*, *Epilobium*-arter o. s. v.), saaledes som tilfældet er med den subalpine kildevegetation i nutiden.

Ovenpaa dette aller underste sedentære tuflag kommer der i flere profiler mere kompakte, grovere mosetuffer, som hovedsakelig synes at være dannet av *Amblystegium falcatum* (BLYTT 1892 l. c.). Andre steder findes mere sprøde smuldrende mosetufpartier. Farven er gjennemgaaende rødlig eller gulhvit i motsætning til den underste graagrønne bænk (renere kalk). I de øverste profiler IX og X i venstre serie møter vi et ganske komplicert bygget mosetufkompleks. Her kommer nemlig øverst en halvsedimentær, av avvekslende grønlige og gule lag bestaaende sone med tydelige bladrester av *Betula odorata*, *Populus tremula* og *Salices*, hvilket viser at disse trær og busker har været tilstede næsten helt fra tufavsætningens begyndelse. At de mangler i det allerunderste lag (cfr. dog kvistavtrykkene), kan som ovenfor antydet bero paa at denne sedentære, porøse horisont ikke egner sig for opbevaring av myke eller flate, avfaldne plantedeler.

En ganske stor overraskelse møter os i dette sedentære mosetufkompleks's aller øverste parti, nemlig den undre Dryashorisont. Denne mangler i flere profiler, specielt i den del av tuffen hvor BLYTT foretok sine undersøkelser, hvilket jeg selv ved mine gravninger har erfaret. Og nedenfor kjøreveien finder vi heller ikke *Dryas* paa dette sted i lagrækken, men en smal horisont med anrikning av *Salix arbuscula*, som dog utvilsomt korresponderer med den undre Dryashorisont høiere oppe i bakken. Dette nivaa er for saavidt av en anden valør end den høiereliggende „Dryastuf", som for det første er meget mægtigere og markert, og som desuten er av helt generel natur.

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[1] Eventuelt i mindre kulper med aapent vand. I naturparken ved Sylene findes *Nitella opaca* paa denslags lokaliteter i 700 m. høide.

Den undre Dryashorisont er dog i flere henseender meget interessant. Den lærer os for det første at arter som *Dryas octopetala, Salix arbuscula* og andre *Salices, Betula odorata, Equisetum variegatum* og *Pellia* sp. vokste ved Leine paa dette tidspunkt, altsaa en blanding av alpine og subalpine arter.

Blytt fremhæver i sit arbeide ganske sterkt at de arktiske planter mangler i den undre halvpart av tuffen, netop fordi, som vi har set, den undre Dryashorisont ikke findes i hans profiler. Og for ham maatte da de arktiske planters pludselige masseoptræden i Dryastuffen synes end mere paafaldende. Dog har han tydeligvis studset over forholdet; han skriver nemlig om *Dryas* og de øvrige arktiske arter: „de mangler ikke blot i den overliggende furutuf, men merkelig nok ogsaa i den underliggende tuf — — —“ (1892 l. c. p. 6).

Nu vet vi imidlertid at saa ikke var tilfældet; vi maa derimot anta at lerbakkene under mosetuffens tid har hat en blanding av alpine og subalpine arter.

Imidlertid er *Dryas*, som jeg i det følgende kommer til at diskutere nærmere, en dvergbusk med xerofil bygning, som ynder tør bund, specielt løse, smuldrende skifre og kalkbund. Den undre Dryashorisont er derfor, saavidt jeg kan forstaa, et tegn paa en mindre oscillation i tufkildens vandføring. Enkelte partier av omraadet er blit mindre fugtige end før, og her har bl. a. *Dryas* kommet ind. Dette synes specielt at ha været tilfældet alleroverst i venstre serien, nær kildens utspring (profil IX og X). Andre partier har ikke gjennemgaat nogen forandring paa dette tidspunkt, men opviser den samme svulmende, vanddrukne mosmatte som før. Nedenfor veien synes *Salix arbuscula* at ha dominert lokalt.

Mosetufkompleksets sedentære natur potenseres saaledes opad, hvor det kulminerer i den undre Dryashorisont. Men derefter synes tufkilden at ha svulmet ganske voldsomt op, og den følgende tid viser os utpræget sedimentære tuflag.

Bladtuffen.

Dette utpræget sedimentære kompleks er saa karakteristisk at man kan kjende det igjen selv i ganske smaa biter. Skiktningen er meget markert, ofte er tuffen likefrem skjællet-skifrig. Planterestene ligger tydelig klappet paa hinanden; det ser ut som om de alle sammen er blit tvunget over i horisontal stilling (eller rettere paralel bakkens overflate) og har lagt sig paa hinanden etagevis[1]. *Betula odorata, Populus tremula, Salices* (*S. capræa, S. glauca, S. hastata, S.* cfr. *nigricans, S.* cfr. *phylicifolia*) forekommer her i umaadelige kvantiteter; enkelte partier av tuffen bestaar ikke av andet

[1] Om dette simpelthen skyldes en rolig bundfældning i vandet eller dets raske strømning, kan neppe avgjøres med sikkerhet. Bladene synes ialfald at ha hat tid til at „ordne sig“ inden de blev forkalket (cfr. Gillebu-tuffen, hvor forholdet er et andet).

end forkalkete bladrester. Desuten fandt BLYTT i sin tid et blad av *Ribes rubrum*, samt tvilsomme bladfragmenter av *Alnus incana*. Efter opdagelsen av Alnus-tuffen ved Leine har jeg et rikholdig materiale av *Alnus incana*-blader i alle mulige størrelser, og sammenlignes de av BLYTT omtalte fragmenter med de sikre oreblader, ser man at overensstemmelsen er meget svak. Jeg tror at det kun er fragmenter av nogen store bjerkeblader; derom vidner baade hovednervene og det fra oreblade̲ne avvikende anastomóse-net mellem disse. Makroskopiske furures̲ter mangler totalt; hundredevis av haandstykker er undersøkt, men med negativt resultat. Derimot indeholder bladtuffen furu-pollen, som først av Dr. G. HOLMSEN paavist i haandstykker fra BLYTTS samling[1]. Da jeg i en anden forbindelse kommer til at diskutere spørsmaalet om furuens første optræden i Gudbrandsdalen[2], skal jeg her nøie mig med at præcisere, at vi vel maa anta at *Pinus silvestris* under denne periode levet i dalen, men at den av klimatiske aarsaker har været løvtrærne helt underlegen[3]. Naar tre forskjellige tufdannelser paa rad nedover dalen fra Kvam til Lillehammer (cfr. Gillebu og Nedre Dal) viser nøiagtig samme fænomen, saa kan man ikke længer tale om tilfældigheter. Man staar da overfor en lovmæssighet som kræver en tilfredsstillende forklaring. Spørsmaalet om pollenets langflugt kommer jeg senere tilbake til; hvor stor vegt man vil tillægge denne feilkilde, er foreløbig i høi grad en trossak. — Forekomsten av furupollen i bladtufbænken er imidlertid et interessant fænomen, som fortjener vor største opmerksomhet. Det forandrer imidlertid ikke opfatningen av bladtuffen som et distinkt palæofloristisk ledenivaa i Gudbrandsdalens kalktuffer.

De forvitrede bladtufrester som det lykkedes mig at fremfinde i utkilingsprofilene baade i høire serie og i tverserien, viser med al ønskelig tydelighet at bladtuffen engang har overdækket saagodtsom hele omraadet. Dog er det mulig, at dens mægtighet altid har været størst der hvor den nu har sit maksimum, og at tykkelsen har avtat fra

[1] Jeg har senere gjort pollenanalyser av kalktuf og iagttat forskjellige ting som er av interesse. For at undgaa feilkilder har jeg vasket tufstykkene meget omhyggelig og finknust dem og vasket tufpulveret paany. Dette er absolut nødvendig, idet saagodtsom al tuf er poros og indeholder forurensninger i alle hulrummene (avsat av nedsivende vand). Man har ingen garanti for at disse forurensninger skriver sig fra det samme tidsrum som selve kalktufsubstansen; de kan være yngre. Ved Leine er hele tufavsætningen gjennemfiltrert av vand, og under gravearbeidet har man stadige ubehageligheter av kilden. — Jeg har fundet at efter en meget omhyggelig knusning og utvaskning indeholder selve kalktuffen bare smaa mængder av pollen, tildels minimale (oplosning i fortyndet saltsyre, efterpaa kokes bundfaldet med kalilut). I enkelte prøver finder jeg ikke spor av pollen. — Kalktuffen ved Gillebu er ogsaa uhyre let tilgjængelig for nedsivende regnvand og for strømninger i grundvandet.

[2] Cfr. den generelle del.

[3] Forekomsten av *Hippophaës* ved Gillebu og de biologiske fænomener som knytter sig til denne, peker ogsaa i samme retning. Cfr. den generelle del.

dette punkt og til sidene. — I det øverste profil i venstre-serien indeholdt bladtuffen et og andet *Dryas*blad, men uhyre sparsomt. Dette beviser at planten ogsaa under bladtuffens tid har eksistert langs tuffens overkant. Ellers er bladtuffen paafaldende ensformig og artsfattig uten variationer, hverken i vertikal eller horisontal retning. Kun nedenfor veien er der antydning til en ophobning av *Salix*-blader (*S.* cfr. *nigricans*).

Som helhet betragtet tyder bladtuffen paa stor vandføring i bækken. Dette gjælder sedimentære lag i sin almindelighet. Noget brud mellem det underliggende mosetufkompleks og bladtuffen eksisterer ikke. De danner tilsammen en serie med den sterkeste tufdannelse til slut; dog er der som tidligere omtalt antydning til mindre oscillationer i fugtighetsforholdene i periodens begyndelse.

Dryastuffen.

At denne merkelige og utpræget sedentære horisont maatte vække Blytts store interesse da han første gang fik øie paa den, er let forstaaelig. Og dog synes Dryastuffen i Blytts profiler ikke at ha været saa pragtfuld som fleresteds i de ovenfor beskrevne serier, hvor man faktisk kan ta ut det ene store stykke efter det andet som ikke bestaar av andet end Dryasrester.

Dryastuffen har en meget karakteristisk graagrøn farve[1], specielt i fugtig tilstand. En undtagelse fra denne regel møter vi i profil III, hvor tuffen var rødlighvit eller svakt fiolet og eiendommelig sinteragtig (ujevn, vortet og knutet og med paralelle tynde, bølgende lag). Muligens har her cyanofycéer lokalt været virksomme ved kalkutskillelsen. Paa enkelte punkter har Dryastuffen karakter av en mosetuf (cfr. Blytt 1892 p. 11; her omtales en recent mosetuf av *Hypnum filicinum* fra Bardodalen i Tromsø amt, som ifølge Blytt viser stor likhet med visse partier av Dryastuffen).

Tuffindestedet ved Leine maa under denne periode ha frembudt et ganske enestaaende syn. Bakken maa paa forsommeren ha været et eneste hav av blomstrende *Dryas*. Det vedføiede fotografi av Dryas i fuldt flor fra Hesjehompan i Saltdalen gir et indtryk av hvorledes markvegetationen saa ut. Nu er *Dryas* en utpræget xerofil plante, og da kalkkildens nærmeste omgivelser utvilsomt har været fugtigere end den øvrige del av bakken, ialfald til visse aarstider, maa man nødvendigvis anta at *Dryas* har været likesaa frodig, ja sandsynligvis endda frodigere rundt omkring tuffindestedet, hvor man jo overalt har den kalkholdige jordbund.

De forholdsvis sparsomme rester av bjerk, asp og andre løvfældende lignoser samt de spredte furunaaler tyder paa en meget spredt og aapen trævekst. *Dryas* er en utpræget lyselskende plante, som ikke taaler over-

[1] Dette skyldes tuffens urene karakter. Furutuffen er derimot paafaldende ren kalk og gir tildels intet residuum ved opløsning i saltsyre.

skygning, og dens masseoptræden forutsætter med bestemthet at der ikke har eksistert nogen tæt sammenhængende skog paa stedet, saaledes som under bladtuffens tid. Som vi senere skal se, utdør *Dryas* ganske tydelig ved Leine som en følge av furuskogens tiltagende tæthet i den efterfølgende tid.

Efter alt hvad vi vet om artens utbredelse i skandinaviske fjeldtrakter i nutiden, maa *Dryas octopetala* karakteriseres som utpræget xerofil og kalkyndende (cfr. A. Cleve 1901 l. c., Schroeter: Das Pflanzenleben

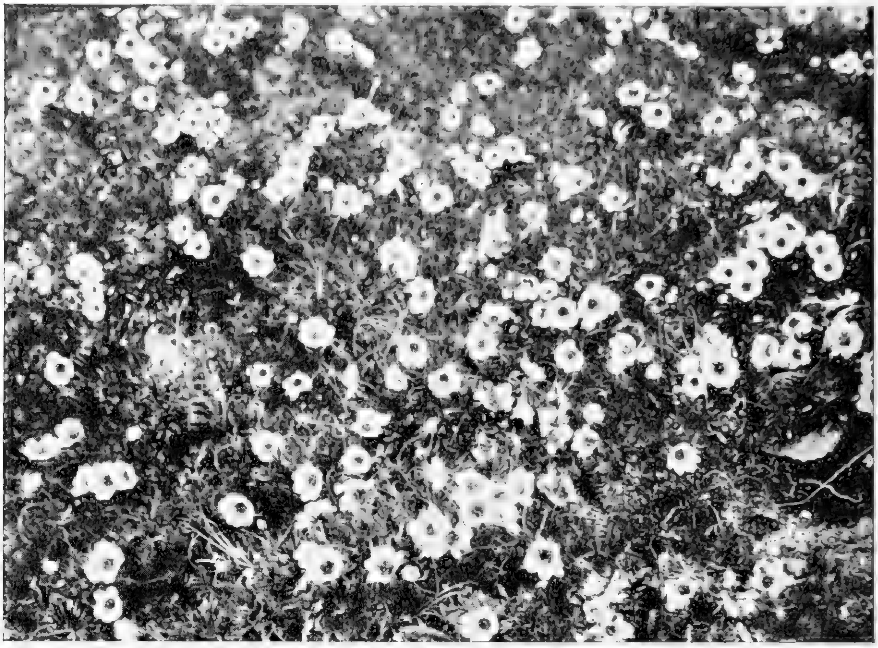

Fig. 14. Dryadetum octopetalae paa kalkberg. Hesjehompan, Saltdalen i Nordland. Juli 1920. Nordhagen fot.

der Alpen 1908 p. 182). Som Blytt altid fremhævet i sine plantegeografiske arbeider, er den knyttet til løse, smuldrende skifre (særlig kalkholdige) og kalkbergarter. Den elsker en varm og i vegetationsperioden tør jordbund og optrær her associationsdannende. Svenske forskere adskiller ofte en lavrik og en mosrik „Dryas-hede"; men dette skille er temmelig tvilsomt og lar sig ikke altid gjennemføre i praksis, ialfald i visse strøk av den skandinaviske fjeldkjæde (cfr. Samuelsson 1916, hvor forholdene ved Finse omtales; i naturparken ved Sylene har jeg konstatert det samme). I det nordlige Norges kalk og dolomitstrøk, f. eks. mellem Ranen og Sulitjelma, er Dryadeta octopetalae meget utbredt og synes her at være mere ekstremt xerofile end sydpaa (cfr. ogsaa Fries 1913, Tengwall 1920 l. c.).

Ved Leine har man hat det særsyn, at et Dryadetum optrær som undervegetation i en meget lysaapen skog (om samfundet som helhet fortjente navnet skog, er et spørsmaal hvorom der kan disputeres). Sidste sommer iagttok jeg en motsvarighet hertil ute i naturen, nemlig i Junkersdalsuren i Salten, Nordland. Som en følge av eiendommelige edafiske forhold (stadige jordras og ophobning av talusmateriale fra de stupbratte styrtninger i uren) er skogen her fleresteds meget aapen og indskrænker sig til smaa trægrupper (furu og løvtrær, særlig bjerk). Store matter av *Dryas* dækker her flekvis den kalkrike, ujevne bund[1].

Av de øvrige i Dryastuffen fundne arter indgaar *Salix reticulata*, *S. herbacea*, *Pyrola minor* og *Equisetum variegatum* allesammen i de av mig statistisk undersøkte Dryadeta i naturparken ved Sylene (i Sør-Trøndelag fylke). *Salix reticulata* er, som Blytt fremholdt (l. c. p. 5), en plante „som paa vore fjelde trofast pleier at ledsage Dryas" ; man burde ogsaa ha ventet at *Thalictrum alpinum* og *Carex rupestris* hadde været tilstede. Disse er imidlertid ikke fundet fossile.

Sammenlignes nu denne sedentære horisont med den underliggende bladtuf, er kontrasten sterkt iøinefaldende[2]. Under Dryastuffens tid maa bækkens vandføring være svundet betydelig ind, og antageligvis har bækken været helt uttørret i sommertiden. Den tætte, xerofile Dryasmattes tilstedeværelse kan ikke forklares paa anden maate. Periodevis har vel bækken silret utover marken og avsat kalktuf, men ikke til stadighet.

Undersøker vi de profiler nærmere hvor Dryastufkomplekset har sin største mægtighet, finder vi flere komplikationer. Saaledes tyder den i en række profiler forekommende ganske tynde, lagdelte og halvsedimentære horisont som er avsat ovenpaa Dryasmatten, paa en mindre opsvulmning i bækkens vandføring, dog ikke stor nok til at fordrive den sedentære vegetation (*Dryas*, *Salix reticulata*, *Pyrola minor*, *Carex* sp.).

Den alleøverste del av komplekset er atter meget karakteristisk. I saagodtsom alle profiler møter vi her en opsmuldret, forvitret, tildels leragtig sone med enten utydelige tufrester eller smaa biter indeholdende *furu* og *Dryas*. I Blytts profiler fandtes et virkelig grusblandet kalkler (4 cm. mægtig), utvilsomt et forvitringsprodukt; de i palæontologisk museums kalktufmonter utstillede prøver fra Blytts samling viser dette. Av undertegnedes profiler er f. eks. nr. III og X alleøverst ved stenrøisen meget oplysende. Paa sidstnævnte sted fandtes en 2 cm. tyk graabrun jordagtig stripe, som over mot profil IX antok natur av seig lere, ovenpaa den opsmuldrede Dryastuf. Under oprenskning av dette profils nordligste del viste Dryastuffen sig at være aldeles brun og forvitret

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[1] Merkelig nok syntes *Carex rupestris*, en av *Dryas's* trofaste ledsagere, at taale beskygning meget bedre end *Dryas*. Den optraadte i Junkersdalsuren fleresteds i skogbunden (paa meget tørre steder) i store masser.

[2] Dog maa det specielt fremhæves at der mellem bladtuffen og Dryastuffen ikke er spor av brud eller diskontinuitet i lagfølgen i de fuldstændige profiler.

paa overflaten. — Alle utkilingsprofilene i høire serie og i tverserien er i denne forbindelse ogsaa meget værdifulde. Her viser Dryastuffen sig at være ytterst forvitret eller mangler helt, samtidig med at ogsaa den underliggende bladtuf er vitret ned til ubetydelige rester. Isteden finder man brunlige eller olivenfarvete lerstriper paa disse tufhorisonters plads i lagfølgen.

Dette faktum kan ikke forklares paa anden maate end ved den antagelse, at under en periode forut for furutuffens dannelse og efter bladtuffens tilblivelse, har kilden svundet saa sterkt ind at der over visse arealer av tuffens overflate ingen avsætning har foregaat, men tvertimot en forvitring av den tidligere dannede kalktuf. Utkilingsprofilene og de øvrige „fuldstændige" serier taler her et samstemmig sprog, som ikke kan fortolkes paa mere end én maate. Om der til en begyndelse blev avsat Dryastuf over hele tuffens omraade, vet vi ikke med sikkerhet. Det er meget mulig at der f. eks. i profil XX og XXI i tverserien, hvor ingen Dryasrester er opbevaret, aldrig har været nogen tufavsætning under denne periode, men kun forvitring. — Det karakteristiske Dryastufstykke som blev fundet nedenfor kjøreveien (profil XXII), viser at der ogsaa foregik kalkdannelse længer nede i bakken. Men alt i alt lar grænsene for Dryastuffens oprindelige horisontale utbredelse sig ikke fastsætte med sikkerhet.

Der er, som vi har set, antydning til en tredeling i Dryastufkomplekset. Men det allerøverste lag er gjerne vitret ned, undertiden ogsaa det midterste, halvsedimentære; dog er det ikke sikkert at dette har været avsat overalt[1].

Profil V i venstre serie og dets naboprofiler opviser enkelte træk av speciel interesse. Her er nemlig det allerøverste lag i Dryaskomplekset bedst opbevaret og ytterst eiendommelig. Man finder her en ca. 3 cm. mægtig overordentlig fin og sprød horisont, som jeg ovenfor har betegnet som „klidagtig", fordi den har en viss likhet med det saakaldte klidbrød (som indeholder hveteklid). Den er meget porøs og aabenbarer ved nøiere eftersyn en utallighet av fine kanaler. Disse skriver sig fra meget tynde furunaaler, saa tynde og korte at hvis man ikke saa det karakteristiske halvmaaneformete tversnit og den typiske gruppering i naalepar, kunde man staa tvilraadig overfor deres natur. Da furunaalene baade i furutuffen og i det underliggende lag var store, brede og kraftige, fik jeg den tanke, at de ovennævnte fine avtryk maatte skrive sig fra sterkt opraatnede furunaaler, hvor grønvævet var forsvundet og kun den centrale karstrengagtige del med omgivende skeder var tilbake. Ved undersøkelser i furuskogen ovenfor gaarden Veikle i Kvam, kunde jeg konstatere at denne tydning var

[1] Øyen skriver (1920 l. c. p. 253) at Dryastuffen er tredelt med et egte Dryaslag i midten og et overgangslag nedad mot birketuffen og et opad mot furutuffen. Dette er, som mine profiler viser, ikke ganske rigtig.

rigtig. Skogbunden var her tæt dækket av nedfaldne recente naaler (saakaldt „fald-forna" efter SERNANDERS terminologi 1918 l. c). Disse var uforandret, store og brede. Men dypere nede blev de sukcessivt forandret, mere og mere myke og tynde, og til slut fandtes en raahumus bestaaende av tæt sammenfiltrede eller sammenklæbede fine naaler, hvor bare de forvedede elementer endnu holdt stand mot forraatnelsen. Naalene var ofte brukket over paa tvers i kortere stykker, og hele massen hadde den mest slaaende likhet med den i kalktuffen forekommende horisont. *Dryas octopetala*'s blader er ogsaa som bekjendt læragtige og „eviggrønne" og motstaar meget længe forraatnelsen, hvilket man kan iagtta paa gamle eksemplarer ute i naturen, som altid har en mængde indtørrede, gamle blader sittende paa stammene.

Denne merkelige lille tufhorisont utdyper saaledes paa en udmerket maate billedet av naturforholdene paa stedet under den tid da kilden var meget reducert. Den viser os at furuskogen maa ha tyknet til; fjeldplantene gaar sin undergang imøte under den tiltagende beskygning; de sidste Dryasblader møter os her. Og kalkavsætningen synes at ha foregaat ytterst trægt; barnaalene har hat tid til at raatne op og danne raahumus og er efterhaanden langsomt forvandlet til en sprød, smuldrende og porøs tuf. Antageligvis markerer profil V og de tilstøtende profiler, som dog er mindre utpræget, det eneste sted indenfor tufomraadet hvor en fortløpende, men mere og mere utpint avsætning har fundet sted.

Dryastuffen indeholder de første makroskopiske fururester og tilkjendegir dette træslags indvandring paa stedet. Dette beror utvilsomt paa en tiltagen i sommertemperaturen sammenlignet med bladtuffens tid. Under Dryastuffens tid synes lerbakkene ved Leine at ha været tørre og varme i sommermaanedene. Antageligvis har vintrene været strenge. Om Leine dengang laa ved furuens høidegrænse over havet, saaledes som BLYTT antok, eller om træet gik endda høiere tilfjelds, kan ikke avgjøres med sikkerhet. BLYTT fremhæver at furunaalene i Dryastuffen er korte og smalere end i furutuffen, og tyder dette som et tegn paa relativt ugunstige kaar. Imidlertid viser den halvsedimentære horisont (midt i Dryaskomplekset) store, kraftige og brede furunaaler (flere 3,6—4 cm. lange), saa jeg tror ikke at man kan komme til nogen sikre resultater ad denne vei. At furunaalene i den sedentære Dryasmatte er smaa, kan muligens bero paa forraatnelse (cfr. det øverste, klidagtige lag). Forøvrig viser furunaalene i en recent skog meget store variationer, alt efter deres stilling paa grenene og efter beskygningen.

Efter at ha diskutert spørsmaalet om tuflagenes geologiske alder kommer jeg i et følgende kapitel tilbake til de arktiske planterester ved Leine og deres betydning for spørsmaalet om fjeldplantenes utbredelse i Skandinavien i tiden for den postglaciale varmetid.

BLYTT anfører i sit arbeide ogsaa *Cotoneaster vulgaris* fra Dryaslaget ved Leine, dog under tvil; desuten opføres *Betula nana* og *B. intermedia* samt *Arctostaphylos officinalis* som meget usikre. Jeg har selv hat anledning til at se disse avtryk og finder dem ogsaa meget problematiske og utydelige. Og vi gjør derfor rettest i ikke at ta dem med i det plantegeografiske ræsonnement, hvorpaa de forøvrig ikke influerer i nogen avgjørende grad. Forresten er det slet ikke usandsynlig at de kan ha vokset paa stedet[1].

Av landsnegler er følgende arter iagttat i Dryastuffen: *Cochlicopa lubrica* MÜLL., *Conulus fulvus* MÜLL., *Hyalinia radiatula* ALDER og *Pyramidula ruderata* STUDER.

Furutuffen.

Da tufkilden i den efterfølgende tid atter begyndte at vælde frem med stor kraft, var stedet dækket av en dyster furuskog, for at anvende BLYTTS ord. Selv de allerunderste lag viser en enorm mængde med store furunaaler, som danner et eneste løst, forkalket kaos. I et par profiler er der fundet antydning til litt mosetuf underst, men gjennemgaaende har furutuffen et sedimentært præg helt fra bunden av. Den i profil XVII og XVIII forekommende lerstripe (rød og blaa lere), som er skyllet ovenpaa Dryastuffen, tyder vistnok paa sterk vandføring helt fra begyndelsen av (i likhet med det sedimentære præg). Furutuffen er ellers meget ren og rødlig av farve.

Ellers viser profilene adskillige variationer i vertikal retning, uten at egentlig bestemte gjennemgaaende horisonter kan paapekes. Og furutuffen er paafaldende ensformig; store masser av naaler, barkstykker, grener og en mængde furukongler gjenfindes overalt, desuten blader av *Vaccinium vitis idæa*. Den anden art *V. uliginosum* er betydelig sparsommere i sin optræden. Man faar et levende indtryk av at en tæt, dyster urskog av furu har behersket Leinebakkene under denne periode.

I furutuffens øvre del gjenfindes, ialfald i en del av de øverste profiler ved stenrøisen, en sedentær horisont, som frembyr flere træk av interesse. De opbevarte rester av urteagtige planter *(Cirsium heterophyllum, Fragaria vesca, Pyrola minor, Tofieldia palustris)* samt *Parmelia physodes* tyder paa meget rask tufavsætning. De bløte blader av *Cirsium* har ikke engang faat tid til at raatne op, ja de opbevarte kurver bærer tildels forkalkede rester av blomstene i sit indre (planche II, fig. 1). Horisonten er som nævnt meget fin og sprød, tildels mosetufagtig, og fossilfattig, men er antageligvis til en viss grad fysikalsk utfældt tuf. Fossilene tyder paa en mere englignende vegetation i bækkens nærhet under lagets avsætnings-

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[1] Naar ØYEN i sit sidste arbeide opfører *Betula nana, Cotoneaster* og *Arctostaphylos officinalis* for Dryastuffen uten spor av reservationer, er dette efter min mening meget misvisende. Naar BLYTT, som kjendte sine arter ut og ind, satte spørsmaalstegn efter bestemmelsene, har vi ingensomhelst grund til at sløife dem!

tid. Høiere oppe i lagfølgen møter vi imidlertid den samme kaotiske furutuf som længer nede.

Fragaria vesca fortjener særlig opmerksomhet, da den er av en plantegeografisk set, sydlig type. Dog gaar den selv i nutiden paa lokalklimatisk særlig gunstige steder over 1000 m. o. h. i fjeldtraktene (Resvoll-Holmsen 1920 l. c. p. 255).

Tofieldia palustris, som er en typisk fjeldplante, viser at selv under denne periode har der vokset arktisk-alpine arter i Leinebakkene[1]. Dryas synes dog at være helt forsvundet.

Blytts fund av *Mnium punctatum* og *Peltigera canina* „midt i bænken" (l. c. p. 4) tyder paa forekomsten av en lignende sedentær horisont længer nede i bakken.

Av løvfældende trær optraadte følgende under furutuffens tid: *Betula odorata* og *B. verrucosa*, *Populus tremula*, *Salix capræa* (og muligens flere arter) og *Sorbus Aucuparia*. Ingen av disse arter er i klimatologisk henseende særlig oplysende, uten kanske *Betula verrucosa*. Bjerkeblader er vanskelige at bestemme paa grund av artenes store variationsvidde. Dog tror jeg at det av Blytt fremfundne dobbelttandete blad (l. c. p. 12) og et lignende, som undertegnede fandt i et furutufstykke i profil XIX, maa henføres til *Betula verrucosa*. Denne art staar paa grænsen til vore kuldskjære løvtrær og gaar i almindelighet ikke høiere end 4—500 m. o. h. (Blytt-Dahl: Haandbog i Norges Flora 1906). Nordpaa gjør den et stort sprang fra Inderøen til Salten, hvor konservator Ove Dahl og undertegnede fandt den i Junkersdalsuren sommmeren 1920. Desuten kommer den igjen i Øst-Finmarken[2], hvor den er indvandret fra Finland. *Betula verrucosa* og *Fragaria vesca* tyder begge paa at klimatet maa ha bedret sig betydelig siden bladtuffens og Dryastuffens tid. Da *Betula verrucosa*, som Blytt fremholder, i nutiden er nær sin høidegrænse ved Leine (ca. 600 m. o. h.), maa man anta at klimatet under furutuffens avsætningstid ialfald ikke kan ha været strengere end i nutiden[3]. Vi har her en minimumsgrænse som er ganske værdifuld.

Furutuffen har i likhet med bladtuffen oprindelig dannet et sammenhængende lag over hele omraadet. At dens nuværende maksimum (profil XX i tverserien) betegner det sted hvor den ogsaa oprindelig var mægtigst, er meget sandsynlig, men kan ikke bevises.

Furutuffen hviler, som vi har set, diskordant paa Dryastufkomplekset (muligens med undtagelse av profil V, hvor der som ovenfor nævnt er svak antydning til kontinuitet), og viser ingensomhelst tegn til nogen overgangs-

[1] Et eiendommelig avtryk i den undre Dryashorisont tilhører muligens ogsaa denne art (profil IV).

[2] Her er den nylig opdaget av forstmænd.

[3] Hvor høit Leine dengang laa over havet, kan neppe siges med bestemthet, dog vistnok ikke lavere end 4 à 450 m.

sone mot *Alnus*-tuffen. Jeg skulde ogsaa være tilbøielig til at tro at furutuffen ingensteds indenfor det undersøkte omraade opviser sin oprindelige mægtighet; den er overalt meget forvitret øverst, og man savner paa en maate en logisk avslutning av komplekset opad (f. eks. i form av en sedentær sone). — Som helhet betragtet maa furutuffens tid ha været en livlig kalkdannende periode; derom vidner den betydelige mægtighet.

Trækulrestene og de lokale kulstriper indenfor furutuffen paa forskjellige punkter viser, som BLYTT ogsaa nævner, at lynnedslag ikke var nogen sjeldenhet under denne periode. Ogsaa i Alnus-tuffen fandtes kulrester (profil XXI). Disse katastrofer synes ikke at ha influert paa kalkavsætningen i nogen paaviselig grad.

Av landsnegler er følgende arter fundet i furutuffen: *Conulus fulvus* MÜLL., *Hyalinia radiatula* ALDER og *Vitrina pellucida* MÜLL.

Alnus-tuffen.

I likhet med bladtuffen og furutuffen er denne horisont saa karakteristisk i petrografisk henseende at den kan gjenkjendes selv i smaa fragmenter.

Farven er gjennemgaaende brunlig, og tuffen meget grov med store hulrum, bølget og valket og uten tydelig skiktning. Fleresteds har den karakter av grov mosetuf. Følgende arter er med sikkerhet konstatert i oretuffen: *Betula odorata, Alnus incana* (blader, talrike ♀-rakler), *Populus tremula, Salix capræa, Pinus silvestris* (nogen faa, men tydelige naaler), *Equisetum hiemale* (talrike ledstykker), samt grove blader og straa av *græs* og *Carices* og flere sorter *mos.* Enkelte av de løse stykker fra muldlaget viser stor likhet med recente *Cyanofycé*-tuffer[1].

Tuffen gir gjennemgaaende indtryk av at være dannet temmelig raskt (cfr. mangelen paa utpræget skiktning). Profil XXI og de to profiler nedenfor veien, hvor *Alnus*-tuffen var bedst bevaret, viser at kalken tildels har været utfældt som jordagtig tuf, der alternerer med fastere sedentære horisonter. Paa dette punkt stemmer Leinetuffen med en flerhet av de svenske tufforekomster, hvor de alleryngste tuflag meget ofte er ytterst sprøde og sterkt forvitret (SERNANDER 1916 p. 129 og 160). Da rester av oretuffen er fundet over hele det undersøkte areal, viser dette at kilden ogsaa under denne tufavsættende periode har været ganske betydelig og har overrislet hele arealet. Jeg har før paapekt at *Alnus*-tuffen antageligvis har hat sit maksimum i de muldeagtige forsænkninger (op til 95 cm. i profil XXI), selv om dette ikke kan siges med sikkerhet.

Pollenundersøkelser fra en række med haandstykker har bragt for dagen *furu, or, bjerk* og *Salix*-pollen, derimot ikke antydninger til

[1] Følgende snegler er iagttat i Alnus-tuffen: *Cochlicopa lubrica* MÜLL., *Hyalinia radiatula* ALDER, *Pyramidula ruderata* STUDER, *Vertigo alpestris* ALDER, samt *Hydrobia Steini* v. MART.

gran. Da Leinetuffen under denne periode har været dækket av et fugtig orekrat med en englignende, hydrofil eller mesofil bundvegetation (cfr. den recente proveflate som er beskrevet p. 8) og saaledes maa ha frembudt stor likhet med de nutidige forhold i Leinebakkenes fugtigere partier, kunde man ogsaa vente at finde rester efter *gran*, som likeledes optrær i den samme dalside (ialfald ikke mere end 1—2 km. vestenfor tuffindestedet) i nutiden. Men undersokelsen har altsaa git et negativt resultat, hvilket kunde tyde paa at kalktufavsætningen var ophort allerede forinden granen var indvandret til Kvam. Imidlertid utelukker ikke dette negative resultat en mere sporadisk forekomst av gran i bygden. Det er ogsaa mulig, at de partier av Alnus-tuffen som nu tydeligvis er forsvundet, kan ha indeholdt spor efter granen.

Alnus-tuffen er meget interessant derved, at den bygger en bro over til nutiden. Som i indledningen omtalt, er *Alnus incana* fremdeles et meget vigtig skog- og kratdannende træslag i dalskraaningene under Leine og langs Veikla. Man kunde ved forste oiekast tro at dette forhold hovedsakelig var fremstaat som et resultat av kulturpaavirkning (uthugst og oprydning). Men kalktuffen viser os ganske tydelig at nutidsvegetationen har sine rotter langt tilbake i tiden.

Alnus-tuffen utfylder et hul mellem furutuffens tid og nutiden; og det helhetsbillede som vi nu faar av Leinetuffen, er ganske anderledes harmonisk end tilfældet var tidligere da oretuffen ikke var kjendt, og da furutuffen saa at si braastanset, uten spor av overgangsled til stedets recente vegetation.

Hvad der ligger mellem furutuffen og Alnus-tuffen, og hvorledes vegetationen har artet sig paa voksestedet i dette tidsrum, er forelobig hyllet i mørke. Diskordansen og den sterke nedbrytning av furutuffen i tuffens nordre og sydøstlige del (nedenfor veien) viser at tufkilden har stoppet op; der er ingen antydning til overgang mellem furutuf og oretuf. Forvitringen har til og med grepet om sig endda dypere; saaledes er i profilene nedenfor veien baade Dryastuffen og bladtuffens øverste del forvitret. Dog foreligger her en anden mulighet, som ikke bor oversees, nemlig at baade Dryastuffen og de øverste lag i bladtuffen paa dette sted kunde være vitret ned allerede i slutten av Dryastuffens tid (saaledes som i profil XIX og XX); de to forvitringshorisonter skulde altsaa møtes. Forøvrig er den første eventualitet slet ikke udelukket; ti furutuffen kan paa dette sted ha været meget mindre mægtig end hoiere oppe i bakken (det samme ræsonnement gjælder ytterprofilet i tverserien (nr. XXI)).

Jeg skal foreløbig ikke opholde mig nærmere ved denne interessante diskordans, men isteden fæste opmerksomheten ved et andet forhold, som ogsaa er av betydning, nemlig *Alnus*-tuffens forvitring. Det er ganske klart at denne maa ha foregaat mellem tuffens avsætningsperiode og nutiden. I vore dager er tufkilden forholdsvis beskeden og danner som før nævnt ubetydelige mængder av mosetuf hist og her. Vi har altsaa atter en oscillation i denne merkelige kildes kalkdannende virksomhet fra Alnus-tuffens tid og til nutiden, ledsaget av tydelig forvitring. Og denne forvitring har ikke alene forvandlet oretuffen til ubetydelige rester øverst i det stadig voksende muldlag over store deler av tufomraadet, men har ogsaa begyndt at angripe furutuffen, altsaa atter to forvitringsperioder som griper over i hinanden!

Jeg haaber ved denne utredning, som ikke indeholder et eneste postulat, men som er en fuldstændig nøktern diskussion av Leinetuffen ut fra stratigrafiske, genetiske og plantegeografiske synspunkter, at ha vist at denne tuf hører med til vore mest interessante kvartærgeologiske avleiringer. Opbygningen er helt lovmæssig og klar, og de problemer som knytter sig til den, fortjener den allerstørste opmerksomhet og alvorlig drøftelse.

II. Kalktuf ved Gillebu og Tingvold i Øier.

A. Topografi og vegetation i nutiden.

I Øier, som ligger ca. 60 km. sydøst for Leine, gjør Laagen en bøining, som viser en paafaldende likhet med forholdene i Kvam. Den danner nemlig et utpræget S. Paa det sted hvor elven løper ret vest—øst, ligger Tingvold og Tolstad, og her kommer en liten bæk nedover skraaningen fra nord—nordvest og løper ut i Laagen. Bækken render langs en forsænkning mellem den temmelig bratte Skarskampen (fig 15 tilvenstre) og Skjønsbergkampen (tilhøire). Terrænget er her tæt bevokset med naaleskog og tilhører gaarden Gillebu, som ligger straks østenfor. Gillebutuffen ligger omtrent halvveis oppe i lien i ca. 50 meters høide over landeveien ved Tingvold og i alt ca. 240 m. o. h., ifølge Øyens maalinger (1920 l. c.).

Som i indledningen berørt blev tuffen opdaget av Øyen og Holme sommeren 1917, efterat Holme allerede for mange aar siden hadde fremfundet løse kalktufstykker i et grustak ved Tingvold, like i kanten av landeveien. Disse to forekomsters beliggenhet og relation til hinanden vil fremgaa av fig. 16, som gir et meget skematisk billede av forholdene.

Da mine undersøkelser paa stedet i flere henseender gav betydningsfulde resultater, som utvider kjendskapet til tuffens stratigrafi, skal jeg her gi en utførlig fremstilling av denne. Redegjørelsen blir i det hele tat en logisk fortsættelse av den beskrivelse som Øyen tidligere har publicert over denne interessante tufforekomst (1920 l. c.).

Den omtalte bæk, som nu er ganske ubetydelig i sommertiden, har, som fig. 16 viser, ved tilbakeskridende erosion gravet sig et markert leie i dalsidens løse dække, som bestaar av bundmoræne og bræelvgrus. Kalktuffen optrær nu kun som rester paa begge sider av bækken, og er likesom den øvrige del av skraaningen bevokset med naaleskog. Træbestanden i denne utgjøres av gran og furu i blanding, dog mest av den første. Bundvegetationen er fysiognomisk præget av *Hylocomium parietinum* og *H. proliferum*. Særlig den første danner pragtfulde grønne matter

Fig. 15. Grustaket ved Tingvold og Gillebuskogen høiere oppe. Bækken kommer ut av skogen mellem huset og telegrafstolpen og render over til venstre, bakenfor skigarden. August 1918. Nordhagen fot.

mellem stammene. Associationens konstitution vil fremgaa av nedenstaaende analyse, der omfatter 10 prøver à 0,25 m.^{2}; de 5 første er fra bækkens østside, de 5 sidste fra vestsiden. Tallene angir dækningsgraden (HULT-SERNANDERS 5-gradige skala).

	1	2	3	4	5	6	7	8	9	10
Vaccinium vitis idæa	3	3	2	3	3	3	3	2	3	3
Linnæa borealis	2	1	2	2	3	2	2	2	2	1
Calamagrostis arundinacea	1	—	1	1	1	1	1	1	2	2
Fragaria vesca	1	1	1	1	2	1	1	1	1	—
Hylocomium parietinum	5	5	3	3	5	3	5	1	5	5

	1	2	3	4	5	6	7	8	9	10
Hylocomium proliferum	1	1	—	4	1	4	1	4	2	1
Dicranum undulatum	1	—	2	—	1	1	1	1	1	1
Agrostis vulgaris	—	—	1							
Campanula persicifolia	—	—	—	—	—	—	—	1		
Carex digitata	—	1	—	2	1	1	—	1	—	1
Festuca ovina	1	1	2	—	—	—	—	—	1	1
Hieracium sp.	—	—	—	—	—	1	—	2		
Juniperus communis (liten)	—	—	—	1	—	—	1	1	—	—
Lotus corniculatus	1	—	—	—	—	—	—	—	—	—
Luzula pilosa	—	1	—	—	—	—	—	—	—	—
Melampyrum silvaticum	1	—	—	1	—	—	—	1	—	—
Oxalis Acetosella	—	1	—	1	1	—	1	—	1	1
Phegopteris Dryopteris	—	—	—	2	—	—	—	—	—	—
Phegopteris Robertiana	—	—	—	—	—	—	—	1	—	—
Pimpinella Saxifraga	—	—	—	—	—	—	—	1	—	—
Pirola chlorantha	—	—	—	—	—	2	—	1	—	—
Rubus idæus	—	—	—	1	1	—	—	—	—	—
Rubus saxatilis	—	—	—	—	—	1	—	1	1	—
Silene venosa	1	—				—	—	—	—	
Sorbus Aucuparia (liten)	—	—	—	1	—	—	—	—	1	—
Stellaria graminea	—	—	—	—	1			—	—	
Vaccinium Myrtillus	—	1	—	—	—	—	—	—		—
Veronica officinalis	—	1	—	—	1	—	1	1	—	—
Vicia cracca	—	—	—	—	—	1	—	1	—	—
Viola collina	—	1	—	1	—	—	—	1	—	—
Viola Riviniana	—	—	—	—	—	1	—	—	—	—
Viola arenaria	—	—	—	—	—	—	—	—	1	—
Cladonia spp.	—	1	2	—	—	—	1	—	—	—
Cladina silvatica	—	—	—	—	—	1			—	—
Dicranum majus	—	—	—	—	—	—	—	—	—	1
Dicranum scoparium	1	1		—			2	—	—	—
Peltigera aphtosa	1	—	—	1	1	—	1	—	—	—
Polytrichum sp.	1	—	1	—	—	—		—	—	—

Tabellen viser os en tæt *mosmatte* med meget spredt bevoksning av *tyttebær, Linnæa, jordbær* og *Calamagrostis arundinacea.* Av de øvrige arter kan merkes *Oxalis Acetosella, Carex digitata* og *Pirola chlorantha.*

Bækkedalens skraaninger var meget løse og lite stabile. Naaleskogen gaar tildels nedover bratten, men gjennemgaaende ser man her en *aapen vegetation,* som er temmelig vekslende og ganske artsrik:

Antennaria dioica
Arabis hirsuta
Arenaria serpyllifolia
Calamintha Acinos
Echinospermum deflexum
Epilobium montanum
Erigeron acer
Festuca ovina
Galeopsis tetrahit
Galium verum
Hieracium Pilosella
Hieracium spp.
Knautia arvensis
Lathyrus pratensis
Linaria vulgaris
Lotus corniculatus
Melica nutans
Moehringia trinervia
Myosotis arvensis
Origanum vulgare
Phegopteris Robertiana
Phegopteris Dryopteris
Pimpinella Saxifraga
Sedum album
Sedum maximum
Stellaria graminea
Trifolium medium
Trifolium pratense
Verbascum nigrum.
Verbascum Thapsus
Vicia cracca
Viola collina

Artslisten minder delvis om den for Leinebakkene anførte og viser en række sydlige typer.

Bækkedalens bund var tildels ganske fugtig. Her vokste spredte trær og busker: *Alnus incana, Picea excelsa, Prunus Padus, Rhamnus Frangula.* Bundvegetationen bestod av mesofile, tildels hydrofile græs og urter. De kvantitativt fremherskende arter var følgende:

Aconitum septentrionale
Aera cæspitosa
Agrostis vulgaris
Brunella vulgaris
Circæa alpina
Impatiens noli tangere
Knautia arvensis
Leontodon autumnalis
Oxalis Acetosella
Pteridium Aquilinum
Ranunculus repens
Rumex Acetosa
Stachys palustris
Stellaria nemorum
Taraxacum officinale
Trifolium repens
Tussilago Farfara
Ulmaria pentapetala
Valeriana sambucifolia

Desuten fandtes nedenstaaende arter i mindre mængde: *Achillea Millefolium, Alchimilla vulgaris, Anthriscus silvestris, Artemisia vulgaris, Athyrium Filix femina, Caltha palustris, Campanula rotundifolia, Carduus crispus, Carum Carvi, Cerastium vulgatum; Chrysanthemum Leucanthemum, Cystopteris fragilis, Dactylis glomerata, Epilobium montanum, Festuca rubra, Fragaria vesca, Galeopsis tetrahit, Galium palustre, G. uliginosum, Geum rivale, Glechoma hederacea, Hieracium Auricula, Mentha* sp. (steril), *Phego-*

pteris polypodioides, Plantago major, P. media, Poa nemoralis, Poa pratensis, Polygonum viviparum, Ranunculus acer, Rumex Acetosella, Rubus idæus, Silene venosa, Solanum Dulcamara, Stellaria media, Struthiopteris germanica, Trollius europæus, Urtica dioica, Verbascum nigrum, Veronica officinalis, Vicia sepium, Viola canina, V. Riviniana, V. umbrosa. Av mosene i bunden var *Climacium dendroides* en av de mest fremtrædende. — Flere av de opregnede arter er utvilsomt indkommet paa stedet med beitende kreaturer; skogen anvendes nemlig tildels som havnehage.

Fig. 16. Kalktuffen ved Gillebu (K) og dens forhold til gruskeglen ved Tingvold (G). K1 – K1 = kalktuf transportert ovenfra av bækken. Meget skematisk.

Forøvrig er plantevèksten i Øier lite kjendt. De bratte styrtninger under Skarskampen like vest for kalktuffen opviste ganske mange interessante arter, tildels de samme som ovenfor er omtalt fra bækkedalens sider. *Carex muricata, Geum urbanum, Turritis glabra, Viscaria viscosa, Triticum caninum* og *Polygonum dumetorum* anføres her som et supplement til ovennævnte liste. Forekomsten av *Polygonum dumetorum* var ganske overraskende, da denne art tidligere ikke var kjendt længer nord end paa Ringerike i det østenfjeldske Norge. Langs kysten optrær den meget sparsomt inde i fjordene til nordsiden av Trondhjemsfjorden (Fosen 63° 50′).

Efter disse orienterende bemerkninger om vegetationen paa kalktuffen og i dens nærmeste omgivelser, skal jeg gaa over til at beskrive de stratigrafiske forhold.

B. Stratigrafiske undersøkelser.

Kalktuffen i Gillebuskogen er som antydet paa fig. 16 opbevaret paa begge sider av bækken i ca. 50 meters høide over landeveien. Hovedmassen ligger i nutiden paa vestsiden av bækkedalen. Imidlertid maa forekomsten i tidligere tider ha været meget større; man finder nemlig tufrester høiere oppe i lien (antydet paa fig. 16) og længere nede. Paa det nederste med K betegnede sted paa figuren ligger der dog bare løse blokker, saavidt jeg har kunnet se; disse kan tænkes at være fört ovenfra og nedover under en eller anden flomkatastrofe. Avstanden mellem den alleröverste forekomst og den sidstnævnte noget tvilsomme blev ved maaling med staaltraadline fundet at være ca. 90 m., og avstanden mellem de mest perifere tufrester paa bækkens vestside og dens østside (maalt tvers paa bækkens længdeakse) 30 m.

Efter tuffens opdagelse har adskillige personer besøkt findestedet, og efter ytringer som de har latt falde, synes enkelte at ha dannet sig den opfatning av forholdene, at „der er avsat litt tuf paa begge sider av bækken". Imidlertid vil den følgende fremstilling vise at det her ikke er tale om to eller flere selvstændige tufavsætninger, men om restene av én, stor sammenhængende kalktuf, saaledes som Øyen allerede fra første stund av var klar over. Dog maa man selvsagt finde sig i at der blir avkrævet én absolute, haandgripelige beviser naar man fremsætter en saadan antagelse. I denne henseende er nedenstaaende profil av avgjørende betydning.

Profil I paa bækkens østside.

Øyen anfører herfra et profil, som over morænegruset i bunden viser tre tufførende horisonter. I det øverste lag fandtes et stykke med furunaaler, men „paa grund av et antal meterstore blokker stikkende op av morænegruset, blir stillingen av serie 2 og enkelte lag av serie 4 tildels noget dubiøs, idet de begge antar paa sine steder karakteren av koncentriske kalktufkruster omkring blokkeoverflaten" (Øyen l. c. p. 287). For Øyen og Holmé var dette profil meget avgjørende, idet de nemlig paa grundlag av de i gruskeglen ved Tingvold (cfr. fig. 16) fundne løse tufstykker nødvendigvis maatte trække den slutning, at baade et bladtufkompleks og et furutufkompleks maatte eksistere in situ høiere oppe i dalsiden. Bladtuffen fandt de med engang, men av furutuffen saaes bare det ene stykke som er omtalt ovenfor.

Den opgave som undertegnede stillet sig, var da for det første at grave op et stort og helt tydelig profil paa denne side av bækken, og dernæst at lete efter mulige furutufrester. Heldigvis var der like for min ankomst til Øier opkastet en grøft paa stedet for at faa konstatert om tuffen var saa betydelig at den hadde nogen økonomisk betydning. Med utgangspunkt i denne grøft fik jeg oparbeidet et meget vakkert profil, som hadde følgende utseende:

I. Grovt morænegrus med større og mindre blokker av kvartsit, skifre etc. Midt i profilet laa 2 store avrundede blokker. Gruset var brunt og gjennemgaaende sterkt oksydert.

II. Bladtufkompleks, tilsammen 45—50 cm.

  A. Underst kom en 10—20 cm. sterkt jernholdig, rustbrun til chokoladefarvet tuf, som var tydelig lagdelt og temmelig løs og sprød. Paa tuffens underflate masser av *Hippophaës*-blader, ellers *bjerk*- og *Salix*-blader i mængde.

  B. Kaotisk, foldet og valket graagul bladtuf, 20—25 cm., med mængder av *bjerkeblader*, porøs og lakunøs og meget løs.

C. Utpræget lagdelt, fossilfattig, gul tuf, 5—8 cm.; temmelig kompakt med smukt foldede lag, men sprød og let at trænge igjennem. Lagene kan let løsnes fra hinanden og viser sparsomme bjerkeblader *(B. odorata)* paa flaten.

III. Jordstripe, 5—8 cm., bestaaende av brunlig, fin tufblandet jord uten haardere klumper. Optil var den undertiden mere graahvit av farve.

IV. Furutufkompleks, ca. 30 cm.

A. 1,5—3 cm. smukt laget, gul, fossilfri tuf; knækkes let over med

Fig. 17. Profil fra bækkens østside, Gillebu. Nederst moræne, derover bladtuf. Korsene angir jordstripen. Øverst furutuf og muldlag. (Cfr. beskrivelsen i teksten). August 1918. Nordhagen fot.

fingrene. Over denne fandtes en uhyre tynd (0,5 cm.) brunlig stripe.

B. 25—27 cm. furutuf, nedtil eiendommelig konglomeratagtig med bittesmaa grønblaa, avrundede kvartsitbiter, sammenkittet med smaa tufbiter, samt furunaaler, der var fossilificert som tynde rør eller dobbeltrør (naalepar). Derover kom meget løs furutuf med masser av naaler, en kongle, blader av tyttebær (sparsomt) samt bjerkeblader. Tuffen var tildels bølget-knudret og drypstensagtig, altid meget let, porøs og sprød. Paa de fleste punkter var komplekset sammenvitret til et løst, smuldrende kaos av tufstykker.

V. 15 cm. muldjord; øverst 3 cm. humus av Hylocomier.

Fig. 17 viser en del av profilet. Den underste papirremse avmerker „jerntuffens" grænse mot det underliggende moraenegrus; den utfylder ogsaa mellemrummet mellem de to store blokker og kitter disse fast sammen. Papirkorsene er fæstet i jordstripen mellem bladtuffen og furutuffen. Mellem kors nr. 2 og 3 fra venstre markerer en tynd horisontal papirstripe den „knækkelige" tuf underst i furutufkomplekset.

Av billedet og den skematiske figur 18 ser man at alle tuflagene helder østover, hvor de desuten blir smalere. Desuten skraaner alle lag ganske sterkt ret imot iagttageren. Disse stratigrafiske eiendommeligheter beviser at tuffen umulig kan være avsat av en kilde fra øst eller nordøst. Den eneste mulige tydning er den, at

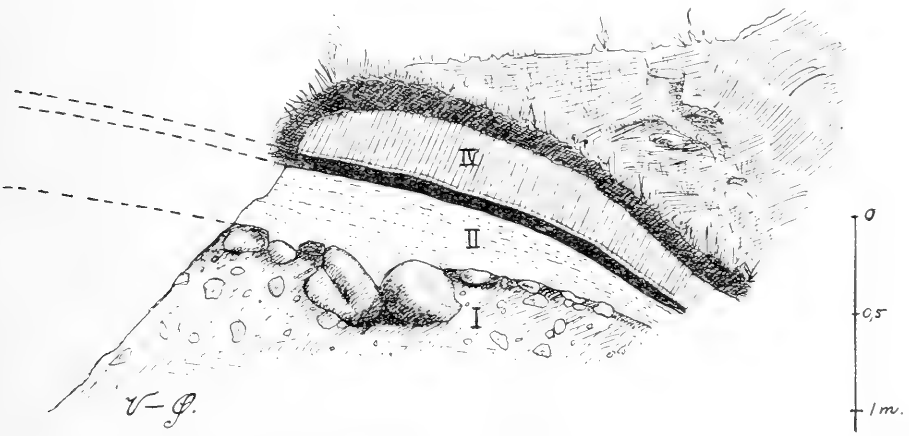

Fig. 18. Profil fra bækkens østside, Gillebu. I = Moraenegrus med blokker. II = bladtufkompleks. III = jordstripe. IV = furutufkompleks. Øverst raahumus og muld.

lagene engang har fortsat sammenhængende over tilvenstre, urglasformig, men senere er blit borterodert av bækken. Dermed er sammenhængen med tufmassene paa bækkens vestside git, og vi kan med sikkerhet paastaa at Gillebutuffen oprindelig har ligget som en skjoldformig masse over det sted hvor nu bækken har sit løp.

Profilet viser ogsaa at furutuffen er ytterst forvitret og daarlig opbevaret. Dette fænomen er endda mere fremtrædende paa bækkens vestside.

Profil II. Vestsiden.

Profilet er optat vis à vis I, men noget mere mot nord, og like i randen av bækkedalen.

I. Grovt oksydert grus.

II. Morkebrun, jernholdig tufjord, 4 cm. Denne sone manglet hvor der laa større stener i bunden.

III. A. Jerntuf, ca. 36 cm. Nedtil var den sterkt brunfarvet og hadde en slaaende likhet med utbrændt koks. Mange blader av *Hippophaës*, *Betula odorata*, *Populus tremula*, *Salix* sp.

B. Haard bladtuf, 15 cm., i midten noksaa uregelmæssig, men optil og nedtil smukt laget. Den var jevnt forbundet med foregaaende.

IV. Løs tufjord, ca. 8 cm., med løse biter av en skjør, laget tuf.

V. Muld og raahumus, 15 cm.

I dette profil er bladtuffen vakkert utviklet og stemmer udmerket med foregaaende profil. Furutuffen derimot er helt forsvundet paa dette sted.

Profil III. Vestsiden.

Profilet ligger ca. 8 m. fjernet fra foregaaende og ret i vest for dette.

I. Grovt grus, med knytnævestore avrundede stener, sammenkittet av kalktuf til en sammenhængende meget haard masse. Det kunde forfølges til 40 cm. dyp.

II. Derpaa fulgte et kuriøst brunt lag, bestaaende av tæt sammenfiltrede levende og døde rotfibre. Det kunde flækkes av som en filt, 0,5 cm. tyk. Aarsaken til lagets forekomst maa søkes i det underliggende ugjennemtrængelige lag, som tvinger den recente vegetations rotter til at forgrene sig horisontalt langs lagets overflate.

III. Bladtufkompleks, tilsammen 20—25 cm.

A. Løs jordagtig tuf, 5 cm.

B. Bladtuf, løs og sprød med bjerkeblader i stor mængde, 10—15 cm.

C. Øverst 3—5 cm. lagdelt sone, som ligner II. C i profil I.

IV. Tufholdig jord, 15—20 cm., med talrike tufbiter fra nøttestore til $(15 \times 10 \times 7)$ $cm.^3$, med sparsomme *furunaaler*, især nedtil, dog i et par stykker i mængde. Desuten rester av en laget, knækkelig og sprød tuf. Laget hadde fleresteds karakteren av løs jord fra øverst til nederst.

V. Muldjord, 10—15 cm., med skiferbiter. Øverst 3—4 cm. raahumus av Hylocomier.

Profilet var helt igjennem temmelig løst og gjennemsat av trærotter. Interessant var det at finde furutufstykker paa dette sted; de var dog meget forvitret og smaa. Ogsaa bladtuffen synes at kile ut vestover.

Profil IV. Vestsiden.

Omtrent 1,5 m. nordvest for foregaaende profil kiler tuffen helt ut. Her saaes følgende serie:

I. Grovt, stenblandet grus med avrundede stener, brunlig av farve (oksydert).

II. Brun tufjord, 5 cm. Fin og jevn.

III. Furutuf, 3—4 cm.; dannet en fast plate med tydelig lagning.

IV. Løs tufjord, 15 cm., med spredte furutufbiter. Rikelig med furunaaler samt et aspeblad.

V. Muldjord med skiferbiter, 25 cm. Øverst som vanlig raahumus.

Dette utkilingsprofil er meget interessant. Bladtuffen er her forsvundet, og underst findes bare brun tufjord. Derimot er furutuffen meget tydelig opbevaret i sammenligning med andre steder i nærheten, og viser at av de to hovedlag i tuffen, har furutuffen transgrediert længst utover til siden. Profilet viser (i likhet med de øvrige) at furutuffen hviler diskordant ovenpaa det underliggende; ti der er ingen overgang mellem bladtuf og furutuf. Den brune jord paa bunden er muligens forvitret bladtuf, men svarer vel snarere til jordstripen i profil I.

Profil V. Vestsiden.

Dette er optat omtrent 3 m. søndenfor profil III og like i kanten av bækkedalen.

I. Grovt grus med større og mindre stener, oksydert.

II. Bladtufkompleks.

A. Jerntufhorisont, 3—4 cm., mørk av farve, tildels sandet. Længer vest i grøften var den 10 cm. og jevnt laget.

B. Eiendommelig laget, haard tuf, 100 cm., avsat skalformig omkring større og mindre stener. Cfr. fig. 19.

III. Muldjord med stener og smaa forvitrede tufbiter, 20 cm.

Fig. 19. Profil V paa bækkens vestside. Den eiendommelige konglomeratagtige tuf, avsat skalformig omkring stenene, sees midt i billedet. August 1918. Nordhagen fot.

En speciel interesse knytter sig til lag II. B. Det synes at bestaa av fysikalsk utfældt, næsten krystallinsk tuf, avsat kuleskalformig omkring runde stener, og viste en meget fin lamellert veksling av rødbrune og gulagtige lag, som uten tvil er uttryk for en viss periodicitet i avsætningen. Det er mulig at vi her befinder os i nærheten av det oprindelige leie for den kalkavsættende bæk, eller rettere sagt: der hvor strømmen i denne har været sterkest.

Profil VI. Vestsiden.

Længer vest i samme grøft, men samtidig noget lavere i terrænget, saaes følgende lagrække:

I. Stenblandet grus som i foregaaende profil, med flere svære blokker.

II. Bladtufkompleks, tilsammen ca. 50 cm.
   A. Jerntuf, 10 cm., typisk, med *Hippophaës* og *bjerkeblader*.
   B. Laget tuf, 20 cm., jevnt forbundet med foregaaende.
   C. Løs bladtuf, 15—20 cm., tildels rent kaotisk med masser av bjerkeblader, desuten sparsomt *Hippophaës* og *Salix caprea*. Mellem B. og C. fandtes ganske lokalt en 2 cm. tyk stripe av tuflere; den forsvandt til begge sider.
   D. Øverst fandtes en ganske tynd (0,5 cm.) lagdelt sone belagt med chokoladefarvet overdrag.

III. Tufjord med løse tufbiter, hvori en og anden furunaal, desuten stykker av en noget lagdelt, sandet tuf.

IV. Muldjord, 20 cm.

Profilet er alt i alt helt normalt, ɔ: det stemmer med de foregaaende. Det gik kontinuerlig over i det sidst beskrevne (V), saa horisonten II. B i dette er bare at opfatte som en speciel horisontal facies av bladtufkomplekset.

C. Oversigt over Gillebutuffens stratigrafi.

Fig. 20 viser et svakt skematisert tverprofil omtrent lodret paa bækkens længdeakse, altsaa V—O. Det er basert paa profilene I, II, III og IV.

Morænegruset.

Tuffens underlag bestaar av et stenblandet grovt grus, som undertiden fører større blokker. Det gir indtryk av at være vandslitt og noget utvasket. Ellers frembyr det ingen specielle træk av interesse. Det maa oprindelig ha dannet en sammenhængende masse der hvor bækkedalen senere er skaaret ned (I paa fig. 20).

I sin øverste del er gruset meget sterkt oksydert, rustbrunt til chokoladefarvet; det maa altsaa ha ligget aapent for forvitring i tidsrummet mellem sin avsætning og dannelsen av de første tuflag. I flere profiler var gruset øverst sammenkittet av utfældt kalk til en konglomeratagtig masse.

Bladtufkomplekset.

Som ovenfor antydet, er de først avsatte tuflag ytterst karakteristiske. De er mørkfarvede, rustbrune til chokoladefarvede, undertiden svakt blaalige, hvilket beror paa kalkens sterke forurensning med jernforbindelser. „Jerntuffen" viser altsaa at da kildene paa stedet begyndte sit løp, indeholdt jordbunden store mængder av oksydations- og forvitringsprodukter, som utfældtes sammen med den kulsure kalk. Jerntuffen ser i sin mest ekstreme form ut som gammelt rustent jernskrap eller koksslagger, og blir op til 30 cm. mægtig. Den er tydelig skiktet og danner hyppig kruster omkring morænegrusets blokker, og viser derfor en meget valket overflate.

Naar man bryter tuffen los og faar væltet stykkene om, saaledes at underflaten blir fri, blir man overrasket ved at finde avtryk av *Hippophaës*-blader hobet paa hinanden i store mængder. Jerntuffen viser os et avtryk av bakkens overflate ved tufavsætningens begyndelse. Desuten sees blader av *Betula odorata* og *Salices*, hvorav en del vakre avtryk vistnok tilhorer *Salix phylicifolia*, men ogsaa andre arter synes at være repræsentert, f. eks. *S. capræa*. Imidlertid er *Salix*-blader overordentlig vanskelige at bestemme i fossil tilstand. Talrike mellemformer av hybrid natur kjendetegner jo specielt denne slegt, som til og med spe-

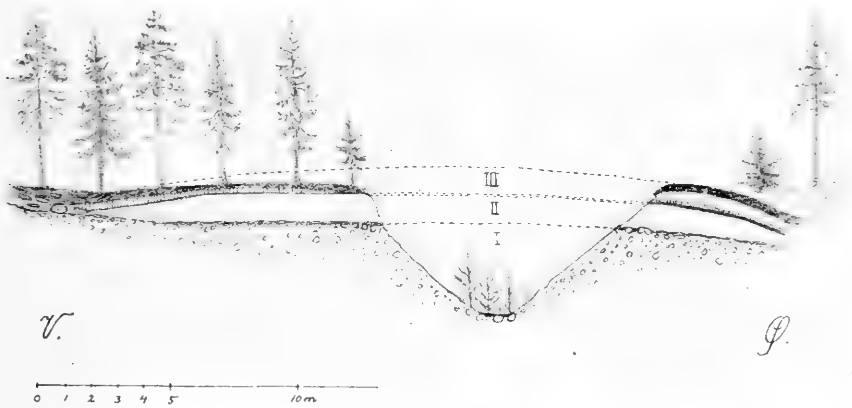

Fig. 20. Tverprofil av Gillebutuffen. I = morænegrus. II = bladtufkompleks med jerntuffen nederst. III = furutuf. Høiden er overdrevet to ganger i forhold til horisontalutbredelsen.

cialistene har vanskelig for at mestre. Det er indlysende at artsbestemmelsen for de fossile Salices' vedkommende maa bli endda mere dubios, da alle de saakaldte „habituelle“ kjendetegn (farve, behaaring, voksemaate, bladenes konsistens etc.) er meget utvisket eller mangler.

Jerntuffens underside har undertiden en hoist eiendommelig traadet struktur, som minder svakt om mosetuf, men som muligens ogsaa kan skyldes blaagronne alger. Nogen tydelig mosetufbænk saaledes som ved Leine foreligger ikke; avsætningen har helt fra begyndelsen av sedimentært præg paa de fleste steder, og turde være fysikalsk utfældt i stor utstrækning.

Over jerntuffen følger oftest vekslende tuflag av vanlig graagul farve, hyppig sterkt kaotiske, med lovblader fossilificert i alle mulige planer. Mange blader viser sig at være forkalket i helt fri stilling, ɔ: det oprindelige blad er helt erstattet av kalk, som fuldstændig har antat bladets form, nervatur og tanding. Visse partier av bladtuffen maa derfor sandsynligvis være dannet meget raskt, idet man vanskelig kan tænke sig en saadan forkalket uordentlig bladmasse, der viser den største likhet med netop nedfaldent, røtet løv om høsten, som en sekulær avsætning[1]. I denne bladmasse finder man hist og her mindre, løse mosetufpartier, overordentlig vakre, med frie, ortotrope skud (op til 5 cm. lange). Ogsaa disse lag synes at være dannet temmelig raskt.

Opad avsluttes komplekset som oftest, og specielt i de mindst forvitrede deler av tuffen, med en utpræget lagdelt sone, som viser tydelig og vakker lamellering, et sikkert vidnesbyrd om periodicitet i avsætningen. Lagene er tildels meget tynde, og denne øvre sone synes i motsætning til den underliggende løse tuf at være avsat gjennem længere tidsrum med noget svakere vandføring i bækken end tidligere. — *Hippophaës rhamnoides* findes spredt gjennem hele bladtufkomplekset og er temmelig almindelig, men bladavtrykkene er ingensteds saa talrike som paa jerntuffens underside. Som helhet betragtet er bladtufkomplekset uhyre trivielt og artsfattig i palæofloristisk henseende, mens kvantiteten derimot er desto mere fremtrædende. I denne henseende er overensstemmelsen med Leinetuffen slaaende. *Betula odorata, Hippophaës rhamnoides, Populus tremula, Salix capræa, S. phylicifolia, Salix* cfr. *nigricans* samt en eller et par *mosarter* — dermed er materialet uttømt. Chancene for ved nye gravninger at finde flere arter er uhyre smaa; ti baade ØYEN og HOLMЕ og undertegnede har undersøkt hundredevis av haandstykker uten at bringe nye former for dagen. Heller ikke de paa sekundært leiested (i Tingvoldgruskeglen) fremfundne typiske bladtufrester gir nye oplysninger om floraen paa den tid. ØYEN anfører herfra (l. c. p. 273) bl. a. *Vaccinium vitis idæa* og *Alnus incana* efter DAHLS og undertegnedes bestemmelser. Jeg har senere gransket disse stykker nærmere og tror at vi gjør rettest i at sætte den sidstnævnte art ut av betragtning, da bestemmelsen nu, efter at jeg har hat anledning til at gjennemgaa mit eget store materiale og svenske samlinger, forekommer mig ganske tvilsom.

Ovenstaaende skildring viser det typiske bladtufkompleks' utformning. Imidlertid møter der os adskillige horisontale facies. Av disse er den konglomeratagtige tuf i profil V tidligere omtalt. De eiendommelige sfæriske kalktufskaller med den fine lamellering og den likefrem krystallinske struktur tyder paa fysikalsk utfældning i strømmende vand[2]. Midt inde i saadanne agat-lignende kuler har jeg paa lagflatene fundet bladavtryk av *Hippophaës* og *bjerk*. Hvordan den gjentatte veksling av rødbrune og gulagtige lag skal fortolkes, tør være tvilsomt. Man kunde tænke paa vaarflom i bækken ledsaget av sterkere avsætning (gulagtige lag) og en trægere utfældning utover sommeren (brunlige lag). Men lagene varierer saa sterkt i tykkelse at jeg ikke vover at paastaa noget med bestemthet. — Ogsaa i andre profiler

1 Cfr. Leinetuffen, hvor bladtuffens karakter overalt var en helt anden.

2 Da de runde stener i laget ligger helt omgit av tuf, kunde man være tilbøielig til at tro at bækken har revet stener med sig ovenfra i flomtiden og avsat dem længer nede. Ogsaa dette moment peker hen paa at vi her befinder os nær bækkens centrale del.

møter man antydning til lignende forhold, f. eks. paa det aller øverste sted i bakken hvor der anstaar tuf. Her er lagene sterkt forvitret, men den samme kuleskalstruktur (omkring runde stener) er her smukt utviklet (fig. 21).

I skraaningen paa bækkens vestside, like nedenfor profil II, hadde jerntuffen en besynderlig breccieagtig struktur, idet den bestod av et utal av smaa tufbiter, som atter var sammenkittet av utfældt tuf. Hvordan dette fænomen genetisk set skal forklares, er meget usikkert. Man kunde tænke sig glidninger, opknusninger og forskyvninger i den først avsatte tufmasse, kanske ogsaa sprængninger foraarsaket av isdannelse. Enkelte partier av bladtuffen minder ogsaa sterkt om cyanofycé-tuf. Men desværre vet vi endda saa overordentlig litet om sammenhængen mellem kalktuffenes dannelsesmaate og deres struktur, at en genetisk klassifikation foreløbig er utelukket. SERNANDERS interessante „genetiska bidrag" (1916 l. c.) er i virkeligheten det eneste sikre som hittil er fremkommet i skandinavisk litteratur vedrørende dette overordentlig vigtige emne. Vi maa derfor foreløbig finde os i at anvende mere eller mindre ufuldkomne, morfologisk-petrografiske analogibetegnelser som „cinter-agtig", „drypsten-agtig", „breccie-agtig" tuf o. s. v.[1], som i virkeligheten ikke sier noget absolut sikkert om dannelsesmaaten.

Fig. 21. Fint skiktet kalktuf, avsat skalformig omkring en sten. (Det undre lamellerte stykke har sittet utenpaa en anden sten, hører altsaa ikke sammen med det øvre). 1/1. B. Larssen fot.

Paa den skematiske figur 16 er ogsaa avmerket det aller nederste sted i bækkedalen hvor kalktuf er paatruffet. Her fandtes bladtufblokker i jorden, som var optil 25 cm. tykke og sterkt forvitret i overflaten. Tuffen var optil smukt skiktet med talrike store blader av *Salix capræa,* desuten *bjerk* og *Hippophaës,* men var delvis mere kompakt og haard end ellers. En blok viste tydelig mosetufstruktur paa undersiden. Som tidligere antydet foreligger der den mulighet, at disse blokker her befinder sig paa sekundært leiested og egentlig hører hjemme høiere oppe i lien.

Jordstripen.

Denne er bare tydelig opbevaret paa bækkens østside, hvilket hænger sammen med at furutuffen her ogsaa er bedst vedlikeholdt. I de øvrige

[1] Cfr. ØYENS „konkretionsagglomerat" etc. (Naturen 1918).

profiler er furutuffen saa forvitret at man oppaa bladtuffen kun finder et tykkere eller tyndere jordlag med stumper og stykker av furutuffen; og det er da ganske klart at den oprindelige lagrække: bladtuf—jordstripe—furutuf er utvisket.

Profil I er derfor særlig værdifuldt, idet det viser os en tydelig diskordans mellem de to hovedlag. Der er ingen overgang at spore. Likheten med Leinetuffen er for saavidt slaaende.

Imidlertid finder vi ved Gillebu ingen spor efter nogen Dryasførende horisont. Og der blir heller ikke, som profil I viser, nogen plads for en saadan, idet baade bladtuffens avslutning og furutuffens begyndelseslag er meget karakteristiske og let kjendelige. Øyen antyder i sit arbeide (l. c. p. 284) at der muligens kan ha været avsat Dryastuf ved Gillebu, da han i det for omtalte furutufstykke paa bækkens østside fandt et blad der mindet om *Salix reticulata*. Det er senere ødelagt under transporten, da det var meget skjørt. — Imidlertid har jeg selv baade i bladtuffen og furutuffen fundet lignende smaa rundagtige *Salix*-blader, som ikke er *Salix reticulata*, da nervevinklene og strukturen er helt anderledes end hos denne art. Desuten var de altfor tynde og sprøde; *Salix reticulata* er altid meget solid og grov selv i fragmentariske avtryk, paa grund av sine tykke læragtige blader. Jeg har som sagt ikke set spor av denne art eller *Dryas* i nogen av de profiler som jeg meget omhyggelig har studert. Og profil I viser at der ikke er plads for nogen Dryastuf, da jordstripen kommer ind i dens sted. Som vi senere skal se, er Dryastuffen som saadan et lokalfænomen eiendommelig for Leine. Det generelle moment derimot ligger i diskordansen mellem bladtuffen og furutuffen.

Furutuffen.

Denne tuf er paafaldende løs og sprød, hvilket utvilsomt er aarsaken til at den er saa sterkt forvitret. Imidlertid har selvsagt forvitringen bidradd sterkt til at gjøre tuffen endda mere skjør og porøs end den var oprindelig.

Komplekset begynder med en ganske specifik dannelse, nemlig den fossilfrie, knækkelige tuf, som utgjør en egen plate underst. Rester av denne er ogsaa fundet paa bækkens vestside. — I profil I er som nævnt furutuffen tildels konglomeratagtig med tilblandede smaa runde stener, hvilket kan tyde paa sterk vandføring i bækken. Enkelte partier var sterkt knudret og valket, tildels avsat som cylindriske rør omkring kvister og pinder, der dannet tynde kanaler gjennem tufmassen.

Artslisten er meget beskeden: *Pinus silvestris* (naaler, en kongle, grener, bark etc.), *bjerk* (mange fragmentariske blader, hvoriblandt sikker *B. odorata*), *Populus tremula*, *Salix* sp.[1], *Vaccinium vitis idæa* (sparsomme blader).

[1] Øyen anfører *Salix aurita* fra furutufstykker paa sekundært leiested ved Tingvold, efter Dahls og undertegnedes foreløbige bestemmelse. Denne er muligens rigtig, men ikke sikker.

Fra gruskeglen ved Tingvold har Oyen og Holme plukket frem en mængde lose furutufstykker, som jeg ogsaa har hat anledning til at undersøke. Men de bringer ingen nye arter for dagen. Et interessant faktum er det at Hippophaës ikke er iagttat i et eneste furutufstykke, hverken fra Gillebutuffen eller Tingvoldgrustaket. Den synes at være utdod paa stedet i tidsrummet mellem bladtuffens avsætning og furutuffens begyndelse. Jeg kommer senere tilbake til dette vigtige punkt.

Profilene paa vestsiden synes at antyde at furutuffen har transgrediert utover til sidene noget længer end bladtuffen. Antageligvis har hele komplekset oprindelig været ganske betydelig ogsaa i vertikal retning.

Hvad der folger efter furutufkomplekset, om der oprindelig har været avsat nok en tufbænk i Gillebuskogen, saaledes som vi saa ved Leine, derom kan vi forelobig ikke opgjore os nogen mening. Det er imidlertid klart at bækken maa ha skaaret sig ned gjennem kalktuffen forst efter at furutuffen var dannet. Nye holdepunkter for bedommelsen faar vi forst efter at ha undersokt gruskeglen ved Tingvold.

D. Gruskeglen ved Tingvold.

Da grustaket ved Tingvold er indgaaende undersokt og beskrevet av Oyen (1920 l. c.), skal jeg her bare gi en kortfattet oversigt over de stratigrafiske forhold paa dette sted.

Av den skematiske tegning fig. 16 og fig. 15 faar man et nogenlunde korrekt indtryk av gruskeglens beliggenhet i terrænget. Den har sit utgangspunkt i skogbrynet tilvenstre for det lille huset paa fig. 15 og brer sig herfra vifteformig ut over det lavereliggende terræng. Avstanden ned til skigarden er ca. 80 m. Bækken har nu gravet sig et litet leie nordenfor grustakets centrale del, og selve keglens overflate er i stor utstrækning opdyrket.

Fig. 22 viser et snit gjennem lagrækken like i overkanten av chausséen ved Tingvold landhandleri. Mægtigheten er her tilsammen 8 à 9 m. over veiens nivaa.

I. Paa bunden ligger et tykt lag av morænegrus med storre og mindre blokker.

II. Derover kommer en mægtig fluvioglacial grusavleiring med skraatstillede lag, som helder 10—15^0 mot ost (Oyen l. c. p. 275 fig. 4).

III. Diskordant avsat herpaa folger en gruskegle med svævende lagstilling, ca. 3 m. mægtig. Oyen adskiller her en hel suite med underavdelinger, som dels har karakteren av utvaskede blokkelag, dels mere normal gruskarakter. Avsætningen gir forovrig et noksaa rotet indtryk. I dens ovre halvdel var det at Holme oprindelig fandt de lose tufstykker. Man finder her en ganske distinkt horisont, som i keglens centrale del har karakteren av et dobbeltlag, med talrike større og mindre tufstykker og løs tufjord med tilblandet muldjord (K—K paa figuren). De enkelte tuflag som vi stiftet bekjendtskap med i Gillebutuffen, er rikt repræsentert. Det lykkedes ØYEN og HOLMBOE at fremfinde ikke mindre end 67 mindre blokker av furutuffen, hvilket gir et tydelig vink om at ogsaa denne oprindelig maa ha været ganske mægtig in situ. — Høsten 1920 viste sig at være ganske heldig for studiet av denne horisonts karakter i den nordvestlige del av gruskeglen, idet der var foretat større gravninger og kjørt væk betydelige grusmasser. Profilet saa her saaledes ut ovenfra og nedad (cfr. fig. 23):

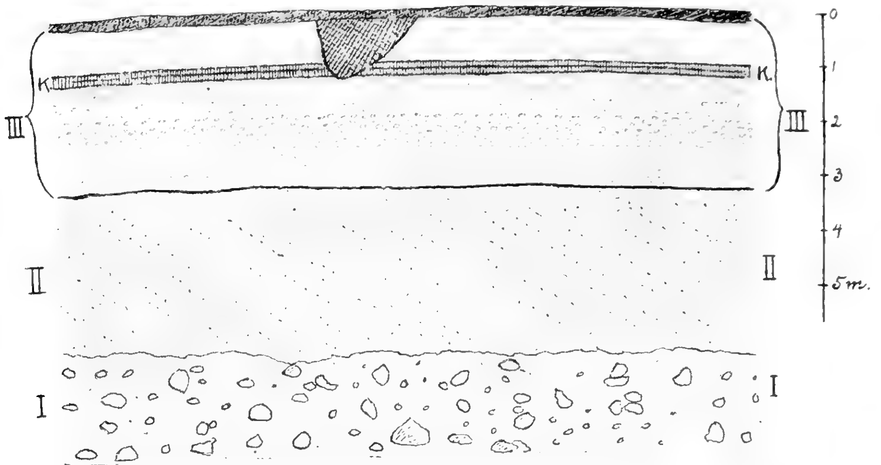

Fig. 22. Snit gjennem grustaket ved Tingvold. I = moræne. II = fluvioglacialt grus. III = gruskegle med svævende lagstilling. K—K = gruslag med kalktufstykker og muld. Skematisert. (Efter Øyens og egne undersøkelser).

A. Muldjord og raahumus, 20 cm.
B. Gruslag, 80 cm., noget varierende.
C. Kalktufførende lag, tilsammen 20—25 cm. (fig. 23).
   1. Smal mørkebrun muldlignende stripe.
   2. Et par cm. blekgraa tufjord.
   3. 5—8 cm. brungraa tufjord.
   4. 5—8 cm. tufgrus, med masser av smaa tufstykker og kalksmuler.
   5. 8 cm. brunlig tufjord.
D. Grovt stenblandet grus, øverst noget sammenkittet av utfældt kalk, fortsatte vistnok ca. 1,5 m. nedover. De dypere lag var overdækket.

Paa dette sted var altsaa den kalktufførende horisont ganske komplicert bygget, men ikke særlig mægtig. Forholdene stemmer forøvrig med Øyens beskrivelse; han omtaler nemlig at horisontens dobbeltkarakter utviskes til sidene (l. c. p. 281).

Over kalktuflaget følger, som profilet viser, atter gruslag. Fleresteds var der antydning til en podsolagtig rustjordstripe akkurat i overkanten av tuflaget; det saa ut som om jernforbindelsene var utfældt netop i grænsesonen (cfr. fig. 23 tilvenstre). Længer øst i grustaket var dette mindre fremtrædende; dog var der her ogsaa tydelige podsoleringsfænomener i de øvre gruslag.

Denne gruskegle er et overmaade værdifuldt supplement til Gillebutuffen, og tilsammen gir disse to geologiske dannelser et meget interessant billlede av forholdene.

Vi ser hvorledes bækken ved tilbakeskridende erosion litt efter litt har arbeidet sig ned i dalsidens dække og avlastet materialet længer nede i det flatere terræng i form av svævende lag ovenpaa det fluvioglaciale grus. Sluttelig har den ogsaa begyndt at angripe kalktuffen, og har i tiden efter furutuffens dannelsesperiode ikke alene evnet at sage sig ned gjennem de forskjellige tuflag og fjerne disse over store strækninger, men har ogsaa gravet sig dypt ned i det underliggende morænegrus, som vi gjenfinder aller øverst i gruskeglens svævende lag. — Nu for tiden er bækken helt ubetydelig og synes ikke engang i flomtiden at foranstalte nogensomhelst katastrofer. I tørre somre torker den næsten helt ind. Gruskeglens dannelse forutsætter en ganske anderledes stor vandføring i bækken.

Naar alle momenter tages i betragtning, kommer man for bækkens vedkommende til det konsekvente resultat, at den likesom kilden ved Leine har været intermitterende, med tre tydelige opsvulmingsperioder av sekulær natur: 1) under bladtuffens dannelsestid, 2) under furutuffens tid, 3) under kalktuffens nedbrytning og bækkedalens utformning paa findestedet. Det er ialfald et ganske respektabelt arbeide som bækken har præstert i tiden efter furutuffens avslutning (cfr. fig. 20).

Mellem bladtuffen og furutuffen ligger der, som vi før har set, et tydelig avbrud i bækkens virksomhet (jordstripen). At der mellem furutuffens tid og den sidste „erosionsperiode" ligger et lignende avbrud, er meget sandsynlig. OYEN fremhæver forekomsten av betydelige mængder muldjord i gruskeglens kalktufførende horisont som et tegn paa at furutuffen efter sin dannelse maa ha været mulddækket og faat tid til at hærdne (l. c. p. 272). Ialfald har vi her et moment som maa tages i betragtning under diskussionen.

Gillebutuffen mangler oiensynlig en tredje tufhorisont (tilvarende til *Alnus*-tuffen ved Leine). Ialfald er der hittil ikke fundet spor efter en saadan. Men til gjengjæld har man her en erosions- og akkumulationsperiode. Dette forhold kan muligens bero derpaa, at bækken ved Gillebu har været stridere og vandrikere end kilden ved Leine. Imidlertid kan aarsaken vel ogsaa ligge i en viss forskjellighet i selve det kalkydende substrat. Bækken ved Leine faar sin kalkgehalt fra moræneleret, og dette er endda ikke uttømt. Ved Gillebu derimot kan neppe det utvaskede dalsidegrus under tuffen og høiere oppe ha levert saa store kalkmængder som Gillebutuffens opstaaen forutsætter. Bækken har vel snarere erhvervet sin kalkholdighet under passage gjennem kalkrike bergarter høiere oppe i dalsiden, og det er tænkbart at den til slut har saget sig ned gjennem disse og saaledes for fremtiden er blit berøvet den oprindelige tilgang paa kulsur kalk. En nøiagtig undersøkelse av bækkeleiet mellem Gillebuskogen og de høiereliggende Rindalssætre vil selvfølgelig kunne gi sikre holde-

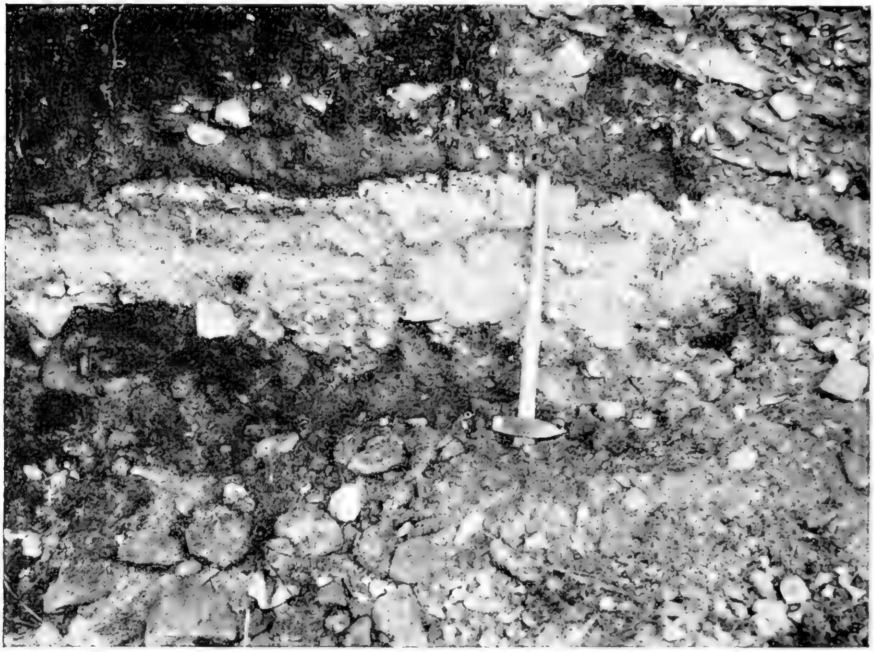

Fig. 23. Den kalktufførende horisont i gruskeglen ved Tingvold (nordvestlige del av grustaket). Nordhagen fot. 6te oktober 1920.

punkter i denne sak. — For tiden er der ingensomhelst antydning til tufdannelse langs bækkedalen.

Da Gudbrandsdalen saaledes som tidligere omtalt har været herjet sterkt av flomkatastrofer helt op imot nutiden, kunde man kanske til en begyndelse være tilbøielig til at sætte gruskeglens dannelse i forbindelse med denslags begivenheter. Men den kalktufførende horisonts jevne forløp og de overliggende jevne gruslag tyder ikke paa nogen pludselig opstaaen. Desuten er der flere ting, som med sikkerhet viser at keglens dannelse ligger langt tilbake i tiden. Som av Øyen paavist, løper nemlig den ældgamle kjørevei i Gudbrandsdalen, „kongeveien", henover gruskeglens overflate. Hvor gammel denne kan være, vet vi ikke med bestemthet; den litteratur om norske veier[1] som jeg har hat anledning til at undersøke, gir

[1] Yngvar Nielsen: Om Norges veier for 1814, Historisk tidsskrift, bd. IV. Joh. Schougaard: Det norske veivæsens historie. 1899.

ingen absolut sikre oplysninger herom. Imidlertid har hovedfærdselsaaren gjennem dalen altid gaat paa nordsiden av Laagen, og da „kongeveien" ved Tingvold synes at ha et hensigtsmæssig og naturlig forløp, tør det nok hænde at den gaar helt tilbake til middelalderen. Under veilegemet gjorde ØYEN og HOLME desuten en anden interessant opdagelse; de fandt nemlig restene efter en kulmile (cfr. fig. 22). Denne maa nødvendigvis være endda ældre, men da der ingen redskaper er fundet paa stedet, kan kulmilen ikke dateres med sikkerhet. ØYEN har fremsat den formodning, at den kanske skriver sig fra jernalderen.

Vi ser saaledes at i lys av disse kjendsgjerninger rykker gruskeglens dannelsestid allerede langt bakover i tiden. Og én ting kan ialfald betragtes som fastslaat: kalktuffens nedbrytning og avsætningen av de svævende gruslag ved Tingvold skyldes ikke nogen recent katastrofe. Sandsynligheten taler for at vi her har med forhistoriske fænomener at gjøre.

Mens vi ved Leine, takket være det øvre tuflag (*Alnus*-tuffen), kunde opspore nutidsvegetationens oprindelse og binde denne sammen med den fossile, er vi for Gillebutuffens vedkommende ikke i den samme heldige situation. Den sidst dannede tufbænk paa dette sted vidner om tæt furuskog som fremherskende plantesamfund. I nutiden indgaar imidlertid granen som en væsentlig bestanddel i det skogsamfund som omgir bækken. Men om granens indvandring og vegetationens forandringer op imot historisk tid, derom fortæller disse interessante avleiringer i Øier desværre intet.

III. Kalktuffen ved Nedre Dal i Faaberg.

Denne kalktuf er indgaaende beskrevet av BLYTT (1892 l. c.). Den ligger i 225 m.'s høide over havet paa Gudbrandsdalens sydside, men med østlig eksposition, og adskiller sig fra baade Leine- og Gillebutuffen ved at mangle distinkte tufbænker.

Tuffen findes i en brat li nedenfor det store opdyrkede jordet paa Nedre Dal. Her kommer en liten bæk frem av bakken og rinder nedover mellem et virvar av større og mindre stener og klippestykker. I jorden mellem stenene ligger der kalktufblokker, hvorav en del er ca. 0,5 m. i diameter, andre mindre. De er forresten nu fjernet og spaltet op i stor utstrækning. Terrænget er i det hele tat meget uryddig og brat, og jeg tror for mit personlige vedkommende at her engang i tiden maa ha gaat et ras. Det store bratte jorde like ovenfor findestedet bestod, saavidt jeg kunde se, av lerholdig moræne, og der er intet iveien for at der her, kanske i forhistorisk tid, har gaat ut et skred.

BLYTT fandt to stratigrafisk og palæofloristisk helt forskjellige nivaaer repræsentert ved Nedre Dal, en bladtuf med bjerk, asp, *Salices* uten makroskopiske fururester, og en furutuf, fuldstændig typisk og overensstemmende med Leinetuffen (og Gillebutuffen, som BLYTT ikke kjendte).

Men blokker av disse to tufslag laa ved siden av hinanden paa stedet, aldrig tydelig ovenpaa hinanden som bænker[1]. Nogen overgangstuf kunde han ikke finde, heller ikke nogen Dryastuf. Blokkene tilhørte alle sammen enten den ene eller den anden sort. BLYTT antok derfor med rette at de skrev sig fra to forskjellige tider, saaledes som ved Leine. Han skriver ogsaa (l. c. p. 9) at han anser blokkene for at ligge der „hvor de blev dannede"; men han har ikke levert noget bevis for at de befinder sig in situ i strengeste forstand.

BLYTT tænkte sig en hel del smaa lokale tufdannelser langs bækken, hvilket altsaa resulterte i blokkenes opstaaen. Og aarsaken til at furutuffen ikke laa ovenpaa bladtuffen, tænkte han sig maatte ligge i det forhold, at det gamle vandløp til en viss grad hadde skiftet retning da det igjen begyndte sit løp under furutuffens tid (l. c. p. 9).

Jeg avla høsten 1920 et besøk ved Nedre Dal og grov op en del tufblokker paa stedet. Saavidt jeg kunde se, laa pragtfulde bladtufblokkker like op til typiske furutufstykker („side om side" BLYTT l. c.), og jeg har vanskelig for at tro at BLYTTS tolkning er rigtig.

At tufblokkene skriver sig fra to forskjellige tider, er hævet over enhver tvil; derom vidner deres helt forskjellige fossilindhold og karakter og den paafaldende overensstemmelse baade med Leine- og Gillebutuffens to horisonter. Men i motsætning til BLYTT og ØYEN, som slutter sig til BLYTTS opfatning eller ialfald refererer denne uten kommentar (1920 l. c. p. 256—258), antar jeg at blokkene befinder sig paa sekundært leiested, og at der oprindelig har eksistert en kalktuf ved Nedre Dal med to tufbænker ovenpaa hinanden, men som senere er ødelagt ved utglidninger. Ialfald har jeg ikke paa nogen anden tufforekomst i vort land set og heller ikke i litteraturen fundet omtalt tufdannelser av en saadan natur og med en saadan genesis som av BLYTT antat.

Bladtuffen ved Nedre Dal er vakkert planskifrig og næsten smukkere utviklet end bladtuffen ved Leine; og jeg har meget vanskelig for at forestille mig, hvorledes en saadan struktur skulde kunne komme istand hvis tufdannelsen var koncentrert paa en række adskilte punkter og uten horisontal kontinuitet, ialfald over en viss strækning. En saadan abrupt blokkedannelse som Blytt tænkte sig, vilde neppe kunne skape en saa planskifrig og regelmæssig struktur. Det moment som imidlertid veier mest i denne forbindelse, er furutufblokkenes optræden side om side med bladtufstykkene, i samme dybde i jorden — et forhold som umulig kan være oprindelig, men som maa bero paa sekundære forstyrrelser. Den antatte utglidning behøver paa den anden side ikke at ha været av særlig store dimensioner.

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[1] ØYEN skriver i sit sidste arbeide (1920 l. c. p. 256) at man ved Dal har to „tufbænker". Dette er altsaa ikke ganske korrekt. BLYTT bruker selv meget konsekvent uttrykket „blokke" om tuffen ved Dal.

I bladtuffen ved Nedre Dal fandt BLYTT foruten de vanlige lovbladrester ogsaa *Prunus Padus, Salix nigricans* og av snegler *Vitrina pellucida, Pupa muscorum* og *Helix arbustorum*, som supplerer artslistene fra de øvrige forekomster i Gudbrandsdalen. Forøvrig stemmer de alle sammen paafaldende godt overens. Det samme gjælder furutuffen, hvor BLYTT ogsaa fandt et blad av *Linnæa borealis*.

I nutiden dominerer *Urtica dioica* i faretruende tætte bestander paa findestedet; dette har som nævnt tildels karakteren av en skraanende, svær stenrøis. Løn (*Acer platanoides*), rogn og hassel er temmelig almindelige paa stedet; men der er ingen sammenhængende skog, bare smaakrat og træklynger.

Kalktuffen ved Nedre Dal er, til trods for de noget dubiøse stratigrafiske forhold, som jeg her har forsøkt at tolke paa en naturligere maate, meget interessant og værdifuld; den viser os nemlig at de to perioder som høiere oppe i Gudbrandsdalen var karakterisert ved bladtuf- resp. furutufdannelse, har været av nøiagtig samme karakter i floristisk og fysiografisk henseende ogsaa helt nede i Faaberg ved dalens begyndelse. Ellers er den historie som tuffen ved Dal fortæller os, adskillig mere fragmentarisk end hvad tilfældet er med Leine- og Gillebutuffene.

IV. Kalktuffer ved Onset i Biri.

A. Blytts undersøkelser.

I 1892 undersøkte BLYTT en kalktufforekomst ovenfor gaarden Onset i Biri ved Mjøsen (cfr. kartet p. 2). Han har selv aldrig publicert noget om sine fund; dog omtaler han i det efterlatte manuskript som blev trykt i Bergens Museums aarbok 1909 (l. c. p. 15), Onsettuffen med følgende ord: „furutuf og birketuf i særskilte blokke fra to forskjellige tidsrum fandtes ogsaa i Biri ved Mjøsen".

BLYTTS efterlatte samlinger opbevares paa Geologisk Museum i Kristiania, og samlingene fra Biri er vedlagt følgende veiledning, skrevet av BLYTT selv: „Al tuf i denne kasse er fra Biri, samlet af A. BLYTT i 1892. Øverst ligger stykker af furutuf, taget i uren ved veien mellem Eriksrud og Kræmmerodden[1]. Al furutuf er fra dette sted undtagen et stykke som har etiket, og er fra Undset[2]. Fra Undset er al den øvrige tuf med *Betula, Salix* cfr. *capræa* etc. Ved Undset ligger furutuffen i klumper i løs jord over birketuffen, som danner større blokke." Derefter anfører han følgende profil:

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[1] Denne lokalitet ligger nordenfor Onset. R. N.

[2] Uthævet her.

Kalkjord.
Smaa tufklumper med Pinus.
Kalkjord.
Større blokker med Betula, Salix.
Kalkjord.
Glacialler.

Desuten har Blytt føiet til: „Mellem Eriksrud og Kræmmerodden kun furutuf i smaa klumper løse i uren.“ (Cfr. Øyen 1920 l. c. p. 259).

I samlingen findes altsaa kun et eneste stykke furutuf fra Onset; resten er fra uren mellem Eriksrud og Kræmmerodden, altsaa en helt anden lokalitet. Den etiket som Blytt omtaler, bærer følgende indskrift: „Furutuf fra Undset. Smaa klumper i løs kalkjord over den i større blokke forekommende birketuf. Maaske er denne klumpformede tuf ækvivalent med Dryastuffen ved Leine.“

Desværre er det nu ikke mulig med sikkerhet at avgjøre hvilket stykke i samlingen denne etiket tilhører. Dog er der ikke mere end to stuffer som det her kan være tale om. Den ene av disse er nu spaltet i fire smaadeler med en meisel og viser en meget fin mosetufstruktur samt en del hulheter koncentrert paa et bestemt sted, intet andet. Disse hule avtryk ser ut som furunaaler ved første øiekast; men flere av dem er helt cylindriske, óg ingen av dem viser det typiske og letkjendelige halvmaaneformete tversnit som udmerker furunaalsavtryk. Jeg tror snarere at de skriver sig fra et græs.

Det andet stykke er meget litet (ca. 4 cm. paa hver kant) og delt i to. Det viser tydelige furunaaltversnit (6—8 naaler) og har ellers en grynet struktur, som vistnok skyldes moser. Ingen av de angjældende stykker viser andre tydelige plante-avtryk (f. eks. av løvblader). Det sidste lille stykke har tydeligvis ligget i jorden, da det er chokoladefarvet og forvitret i overflaten. Det stemmer ellers paafaldende godt med de smaa tufbiter som jeg selv opdaget paa en ny forekomst ved Onset (cfr. det følgende).

Furutufstykkene fra Eriksrud—Kræmmerodden er helt forskjellige fra begge de nævnte stuffer, og bestaar av lakunøs, koralagtig eller cinteragtig tuf med utvisket mosetufstruktur. De bærer alle sammen tydelige spor efter at ha ligget oppe i dagen i den av Blytt omtalte ur; der vokser nemlig moser i smaa gruber paa dem alle sammen, likesom de er mørke og forvitret i overflaten. Et av stykkene er etikettert av Blytt selv.

Jeg omtaler dette saapas utførlig fordi konservator Øyen i sin sidste avhandling beskriver Onsettuffen meget indgaaende, men vistnok uten at være opmerksom paa disse forhold. Øyen omtaler nemlig furutuffen ved Onset paa følgende maate: „Furutuffen er derimot utviklet som en i løs kalkjord liggende klumptuf over birketuffen, der danner større blokker eller en mere sammenhængende tufbænk [1]. Den graagule furutuf, der som

[1] Dette er, som nedenfor omtalt, ikke tilfældet.

regel er fast, viser dog ogsaa i den nedre del mosetuf av drypstensagtig karakter med blader av *Salix capræa*, *Populus tremula* og *Betula odorata*, men her allerede med iblandet *Pinus silvestris*; senere blir den omend tildels vekslende med noget jordagtig tuf, tildels noget graa, breccieagtig med skiferbiter, og her fandtes ved siden av de nu allerede nævnte ogsaa bladavtryk av *Vaccinium Myrtillus* L. Paa mange steder ser man dog i den cinteragtige, graabrungule tuf kun spredte furunaaler uten spor av indblanding av løvtræblade, ja det samme træk gjenfindes paa sine steder

Fig. 24. Breccieagtig kalktuf med bergartsfragmenter.
Biri; Blytts samling (1/2). B. Larssen fot.

selv der, hvor tuffen har noget mere præget av en mosetuf. Furutuffen er saaledes i det hele tat vel skilt fra de underliggende tufforekomster" (l. c. p. 260—261). Da der, som Blytt uttrykkelig gjør opmerksom paa, bare findes et eneste stykke furutuf fra Onset i hans efterlatte samling fra Biri, og dette stykke maa være et av de to som jeg ovenfor har beskrevet, maa denne Øyens karakteristik vistnok bero paa en misforstaaelse.

De nævnte stykker indeholder ingen løvbladrester, hverken av *Salix capræa*, *Populus tremula* eller *Betula odorata*. Og Øyens uttalelser om at furutuffen senere blir „tildels noget graa, breccieagtig med skiferbiter, og her fandtes ved siden av de nu allerede nævnte ogsaa bladavtryk av *Vaccinium Myrtillus*", er for mig ganske uforstaaelig. I samlingen findes nemlig et solid stykke bestaaende av en mængde skiferbiter tæt sammenkittet av haard kalktuf, som er totalt forskjellig fra alle de øvrige stykker i Blytts samling fra Onset. Det har ingen originaletiket; blaabærbladet er ogsaa meget utydelig og høist tvilsomt. I museets samling ligger et andet stykke fra „Biri“ samlet av REUSCH, og dette viser en slaaende likhet med ovennævnte, idet det er propfuldt av skiferfragmenter. Antageligvis stammer begge to fra samme sted og er sikkert opstaat paa den maate, at kalkholdig vand har passert en spræk med forvitringsmateriale, som kalken har kittet sammen, eftersom den blev utfældt (cfr. næste avsnit). Naar ØYEN uten videre indfletter det nævnte tufstykke, som har en helt avvikende struktur, i sin omtale av furutuffen ved Onset og forsøker at gjøre det til en egen „breccieagtig“ facies av denne, saa er dette blot og bart et postulat. Det er for det første høist tvilsomt om stykket er fra Onset; det er ialfald hverken litet eller klumpformet, og har intet med furutuffen at gjøre. Det maatte da i tilfælde være fra Eriksrud—Kræmmerodden; men det ligner heller ikke de typiske furu-mosetufstykker fra dette sted. — Og ØYENS sidste bemerkninger om furutuffen: „Paa mange steder ser man dog i den cinteragtige graabrungule tuf kun spredte furunaaler uten spor av indblanding av løvtræblader, ja det samme træk gjenfindes paa sine steder selv der, hvor tuffen har noget mere præget av en mosetuf“, er mig likeledes ganske uforstaaelig. Denne beskrivelse passer nemlig aldeles udmerket paa stykkene fra Eriksrud—Kræmmerodden (cfr. ovenfor). Man faar uvilkaarlig det indtryk, at ØYEN bygger sin karakteristik av furutuffen ved Onset paa et rikholdig materiale. Det er ialfald en levende umulighet at utlede hele denne utførlige beskrivelse av det ene lille furutufstykke som BLYTT har medbragt fra Onset og etikettert. At der her foreligger en misforstaaelse, er givet. Da det ikke er andre end BLYTT som har set forekomsten, maa man nødvendigvis holde sig strengt til BLYTTS egne veiledende oplysninger, og de er ikke til at ta feil av.

Naar ØYEN desuten mener at kunne rekonstruere følgende sammenhængende profil fra Onset:

1. I bunden en tildels breccieagtig eller ogsaa ofte en konglomeratagtig tuf.
2. Derover en mosetuf, der som en egen avdeling dog nærmest grupperer sig under birketuffen og øverst fører *Betula odorata* sammen med den for avdelingen karakteristiske *Hypnum* sp.
3. *Birketuf.*
4. Noksaa tæt mosetuf, ogsaa tildels med furu under hvis sone den ogsaa nærmest hører som underavdeling.
5. *Furutuf,*

saa maa jeg desværre erklære mig helt uenig ogsaa i denne tolkning. Det faktiske utgangspunkt for ræsonnementet, nemlig BLYTTS materiale, er her absolut avgjørende.

ØYEN forsøker altsaa at gjøre gjældende at Onset-tuffen er en autochten in situ-dannelse, og foretar desuten en opdeling i stratigrafiske underavdelinger, noget som vi ikke finder antydet engang i BLYTTS notiser.

Furutuffen har jeg allerede omtalt utforlig ovenfor. Jeg har ogsaa gransket BLYTTS bladtufmateriale meget kritisk og omhyggelig, og det viser sig at dette lar sig inddele i forskjellige grupper av haandstykker, som utvilsomt horer sammen.

1. En hel del vakre stuffer (15—20 stykker) bestaar av en mosetufgrundmasse, ofte meget grov, desuten med talrike lovbladavtryk av-

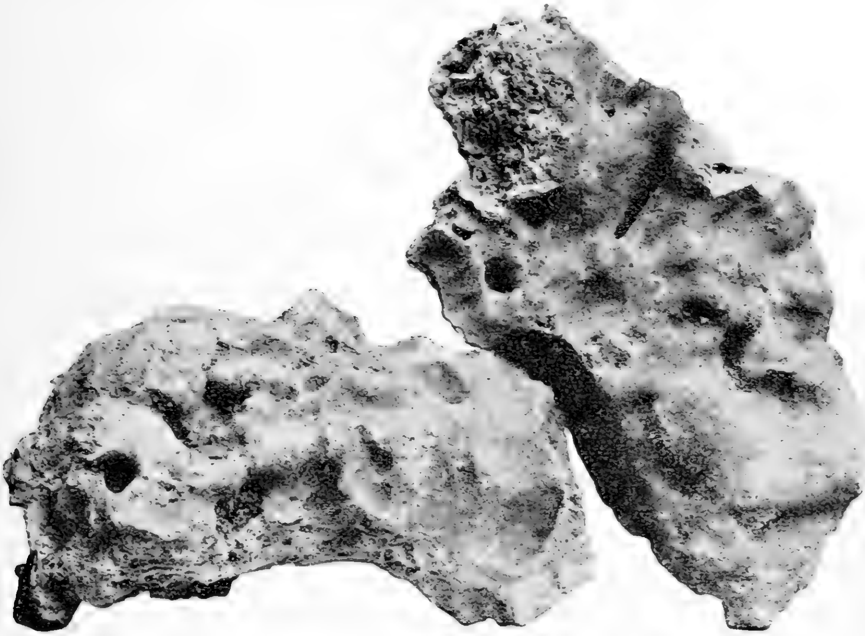

Fig. 25. Bladtufstykker fra Onset med valket overflate (Cyanofycé-tuf ($^1/_2$)). Blytts samling. B. Larssen fot.

vekslende hermed. Deres overflatestruktur er ytterst eiendommelig og viser en ytre, paafaldende glat og valket, fint lamellert sone, som skyldes kalkutskillelse ved blaagronne alger (cyanofycé-matter) (fig. 25). Disse stykker er fremkommet ved opspaltning av en eneste storre blok, idet de lar sig sætte sammen som en mosaik. Denne blok har ligget los i jorden; overflaten er nemlig mork og forvitret.

2. 15 storre og mindre stykker med tildels den samme mosetuf-bladtufkarakter, dog delvis mere kompakte, bærer visne paasittende recente moser i den forvitrede overflate; de maa altsaa faktisk ha stukket op av jorden. Det er altsaa klart at enkelte av BLYTTS bladtufblokker har ligget overst i jordlaget, tildels helt frit.

3. En mængde stykker er morkt chokoladefarvet i overflaten og har ligget lose i muldjorden (cfr. mine egne fund, som omtales i det folgende.

4. Endelig findes der en serie med vakre stuffer bestaaende av avvekslende mosetufpartier og løvbladrike partier, som uten tvil er spaltet løs fra det indre av en eller et par blokker. De bærer nemlig tildels friske brudflater. Et par av dem indeholder skiferbiter.
5. Et par vakre mosetufstykker er tydeligvis halvrecent tuf, idet de bærer halvforkalkede, recente møser i overflaten.

Denne gjennemgaaelse gir det bestemte resultat, at „birketuffen" ved Onset er en mosetufagtig, bladrik tuf (*Alnus incana* m. alm., desuten *Populus tremula, Salix caprœa* og *Salix* cfr. *nigricans, Betula odorata* alm.[1]). Den har, som Blytt anfører, ligget løs i jorden som større og mindre blokker. Vertikale facies (Øyens „breccieagtige (?) eller ogsaa ofte konglomeratagtige tuf" (?) i bunden, derover „mosetuf" som en egen avdeling under den egentlige „birketuf") kan ikke paavises med nogensomhelst sikkerhet. Tuffen er tvertimot paafaldende mosetufrik helt igjennem og temmelig ensartet.

Jeg har lagt meget arbeide paa denne gjennemgaaelse, fordi jeg mener at vi naar det gjælder disse omdisputerte stratigrafiske problemer, maa være saa kritiske som mulig og eliminere alle dubiøse eller hypotetiske momenter. Fremfor alt maa vi ikke la os forlede til forhastede slutninger og korrelationer paa grundlag av et usikkert materiale.

At der her er antydning til en overensstemmelse med Gudbrandsdalens tuffer, er ganske klart. Men ingen kan vite om ikke de smaa furutufstykker ved Onset, hvorav Blytt bare har medført en liten prøve som fortæller svært lite, er av forholdsvis recent natur. I et av Blytts stykker har jeg fundet nogen naaleformige avtryk, som utvilsomt skriver sig fra gran (*Picea excelsa*), og som altsaa maa være av geologisk talt yngre datum. Dette stykke har vel ligget øverst i jorden sammen med de smaa furutufklumper. Vi mangler ethvert sikkert middel til at tidfæste disse løse tufbiter. Det samme gjælder furutuffen fra Eriksrud—Kræmmerodden[2], som forresten heller ikke ligner den virkelige typiske „furutuf" i Gudbrandsdalen.

Desuten kommer her et meget vigtig moment til, som Øyen ikke er opmerksom paa, men som jeg allerede har berørt under omtalen av forekomsten ved Nedre Dal i Faaberg: Ligger tufblokkene der hvor de blev dannet, eller befinder de sig paa sekundært leiested? Er Onsettuffen autochton eller ikke? Under mit besøk i Biri høsten 1920 lykkedes det mig at fremfinde en antageligvis for Blytt ukjendt tufforekomst ved Onset. Denne er i flere henseender interessant og kaster ogsaa lys over det ovenfor opstillede spørsmaal.

1 Pollenanalyser bragte sparsomt pollen av *Alnus, Betula* og *Pinus silvestris* for dagen.

2 I likhet med forholdene paa den av mig opdagede nye tufforekomst ved Onset antar jeg at disse Blytts „løse stykker i uren" er faldt ned ovenfra hammeren (cfr. det følgende).

Forinden jeg gaar over til at omtale mine egne fund, maa jeg imidlertid gaa ind paa nok et forhold av betydning, som ØYEN har trukket ind i diskussionen, og som ogsaa hænger sammen med BLYTTS efterlatte samlinger. ØYEN mener nemlig at ha fundet avtryk av *Dryas octopetala* i et litet tufstykke, som BLYTT medbragte fordi det indeholdt en snegl (*Hyalinia petronella*). ØYEN skriver, at dette lille stykke minder om det furutufstykke fra Onset som BLYTT har etikettert, og antar, om end under nogen tvil, at der ved Onset ogsaa har været en „Dryastuf" (l. c. p. 259—260). Stykket

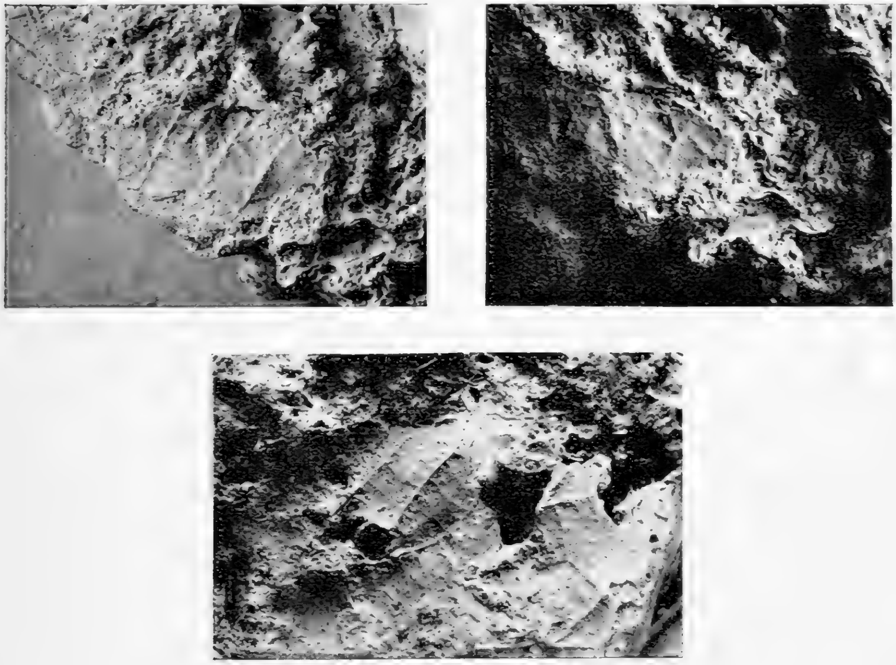

Fig. 26. Øverst „Dryastufstykket" fra Onset fotografert i to forskjellige belysninger. Billedet tilhøire viser tvergaaende forbindelsesnerver mellem de tre hovednerver. Nederst fragment av et tydelig *Alnus*-blad fra Onset til sammenligning. 1/1. B. Larssen fot.

skal ifølge ØYEN ogsaa indeholde et par furunaaler. Nu er det imidlertid at merke at det angjældende lille stykke ligger i en pakke som BLYTT selv har etikettert paa følgende maate: „Snegler fra birketuffen[1] ved Onset, bestemt af frk. B. ESMARK", og sammen med det ligger en del smaa lignende tufbiter med snegler.

Jeg har selv gransket stykket meget indgaaende og er ogsaa kommet til et bestemt resultat. Ved første øiekast kunde man muligens ta avtrykket for at være tre grove Dryasblader paa rad, med midtnervene helt paralelle og med diffuse randpartier (cfr. fig. 26). Men ved nøiere undersøkelse ser man ganske tydelig at disse tre „midtnerver" er forbundet ved

[1] Uthævet her.

et tversgaaende anastomosenet; de hører altsaa sammen. Og ved sammenligning med et rikholdig løvbladmateriale er jeg blit overbevist om at de tre utydelige „Dryasblader“ kun er et bladfragment av *Alnus incana*, som er meget almindelig i bladtufblokkene fra Onset. Vi har her tre av de karakteristiske paralelle sidenerver og forbindelsesnerver lodret paa disse, hvilket netop særkjender orebladene (fig. 26). *Dryas* hører med til de lettest kjendelige av alle fossiler, og jeg anser det for helt utelukket at vi her har med blader av denne art at gjøre. Nogen sikre furunaaler findes heller ikke i stykket, kun et tvilsomt hulrum, som like godt kan være noget andet. Ifølge Blytt skal jo stykket ogsaa være fra „birketuffen“ ved Onset og ikke fra furutuffen. Etiketten „snegler fra birketuffen“ er utvilsomt rigtig.

Øyen har selv karakterisert „Dryastuffen“ ved Onset som noget tvilsom; jeg er selv overbevist om at den ikke har eksistert. Blytt, som kjendte *Dryas* saa godt, har heller ikke opdaget noget bladavtryk av denne art. Og han har sikkert gransket materialet meget omhyggelig.

B. Egne undersøkelser.

Gaarden Onset i Biri ligger ved Mjøsen i 40—50 meters høide over denne. Like bak gaarden stryker et langsgaaende høidedrag i retningen SØ—NV; det bestaar av den eiendommelige „Birikalk“, som her danner steile bergvægger, tildels med urdannelse under styrtningene.

Den av Blytt studerte tufforekomst har efter de oplysninger som jeg indhentet paa stedet, antageligvis ligget et steds ved foten av dette høidedrag i nærheten av en forfalden husmandsplads, som ligger et par hundrede meter sydvest for gaarden. Ret op for pladsen i den skogbevokste skraaning under hammeren lykkedes det mig bare at finde et eneste løst tufstykke, som jeg antok maatte være kommet ovenfra. Jeg klatret da helt op til bergvæggene, og her fandt jeg ganske rigtig en ny tufforekomst. Stedet laa ca. 60 m. høiere end pladsen og denne omtrent 20 m. høiere end Onset, altsaa i alt ca. 75 m. over Onset. Mjøsen angives at ligge 124 m. o. h., og lokaliteten skulde efter dette ligge ca. 250 m. o. h. Dette tal er muligens noget for høit.

Under de lodrette, tildels overlutende kalkklipper fandtes der her en meget brat skraaning med gran og løvtrær. Jordbunden bestod av stenblandet muld med opragende fast fjeld og blokkemasser. Skraaningen var ca. 45^0, tildels brattere. Ved gravning fandtes en mængde smaa tufstykker i jorden, de fleste sterkt forvitret og brune eller chokoladefarvet i overflaten.

Profilet hadde følgende utseende:

I. Muldjord, 20 cm.

II. Løse tufbiter i sort muldjord, især optil en mængde smaa biter, nedtil noget grovere stykker. Tilsammen ca. 50 cm. De fleste stuffer var helt fossiltomme, tildels flintagtig haarde og kompakte, ofte med smaa bergartsfragmenter indesluttet i kalken (breccieagtig). Videre fandtes flere slags mosetuf, tildels med utydelige thallose levermosavtryk. I et større stykke saaes en nøtt av hassel (*Corylus Avellana*[1]), blad av *Salix* sp. (?) samt smaa *furunaaler*. I et andet fandtes utydelige løvblader vistnok av *bjerk*. Endelig indeholdt et par smaa tuffragmenter nogen avtryk, som antageligvis skriver sig fra *grannaaler* (*Picea excelsa*); disse fandtes høit oppe i laget.

Fælles for alle tufstykkene var mangelen paa skifrighet og deres haarde konsistens. Flere biter hadde cyanofycéstruktur.

III. Derefter fulgte stenblandet muldjord uten skarp avgrænsning fra foregaaende lag, med en del mindre tufstykker; disse avtok stadig i antal nedad. Her saaes ingen bestembare fossiler. Tuffen var gjennemgaaende flintagtig haard og kompakt. Dette „lag" kunde forfølges til 50 cm.'s dyp under det foregaaende, men fortsætter sikkert dypere ned.

Fig. 27. Klipper av Birikalk ovenfor Onset med to mørke søileformige kalktufmasser nederst. Disse er dækket av moser og cyanofycéer. Nordhagen fot. 20de oktober 1920.

Nogen tydelig stratigrafi kunde altsaa ikke paavises, heller ikke nogen skarp grænse mellem lag II og III. Men der er altsaa en anrikning av tufbiter optil, mot overflatens muldlag.

Merkelig nok bar lokaliteten svake spor efter gravning, og jeg antok derfor først at jeg hadde fundet BLYTTS lokalitet. Men folkene paa Onset gaard fortalte at efter BLYTTS besøk i 1892 hadde der været flere oppe og rumstert under fjeldet, vistnok for at se efter kalk til at forbedre akerjorden med. BLYTT angir desuten „glacial-ler" i bunden av sit profil, hvilket tyder paa at det er optat et steds længer nede ved foten av skraaningen. Overlærer HOLME, som ogsaa har avlagt besøk ved Onset, antar

[1] Denne busk fandtes paa tuffindestedet ogsaa i nutiden.

at BLYTTS forekomst maa være ødelagt ved ras, hvilket er meget vel tænkelig.

Men hvorfra skriver nu alle de løse tufstykker sig? En nærmere granskning av selve hammeren ret op for findestedet gav opløsning paa gaaden. Her fandtes nemlig et par meget interessante, halvrecente tufmasser avsat skalformig utenpaa de lodrette eller overlutende kalkklipper. Kalkholdig vand syntes at komme frem langs nogen revner i fjeldet, og langs disse hadde der bygget sig op søileformige eller ribbeformige tufansamlinger (cfr. fig. 27 og 28), som nu var klædt av en tæt pels med moser og cyanofycéer. Disse kalksamlende organismer syntes at forkalkes langsomt og kontinuerlig. Da jeg besøkte stedet (20de oktober 1920), var mosene fugtige, men der var ikke rindende vand tilstede. Foruten disse pilarformige masser laa der under hammeren en svær tufblok, som tydelig nok var løsnet fra bergvæggen og faldt ned paa underlaget. Ogsaa paa denne var der svak mosetufdannelse (fig. 28).

Den vigtigste tufdannende mos var *Mollia æruginosa*, som dannet svære kaker, men av et yderst sykelig utseende; den var meget sterkt forkalket, kun med faa opstikkende blader øverst. De øvrige arter dannet i grunden en serie med hensyn til sin kalksamlende evne: *Swartzia montana, Mollia tortuosa, Leersia contorta, Myurella apiculata, M. julacea* og *M. tenerrima* følger nærmest efter ovennævnte art. *Ditrichum flexicaule* og *Amblystegium protensum* var meget svakere forkalket, *Leucodon sciuroides* uhyre svakt. Foruten disse 10 arter saaes *Hypnum sericeum, H. Bambergi* og *Solorina saccata* paa den nedfaldne store blok; men disse arter vokste helt tørt og var uten spor av kalkansamling.

Mellem mosene og paa disse fandtes store kvantiteter av kalksamlende blaagrønne alger. *Mollia æruginosa* var ofte saa overtrukket av filtete traadmasser av *Scytonema mirabile* (BORNET) at den var helt sortbrun og lignet mørke, korte tafser[1]. Foruten denne cyanofycé-art, som ogsaa dannet rene, smaa, filtagtige puter, var *Chroococcus turgidus* (NAEG.) rikelig tilstede samt flere andre *Chroococcus*-arter. Merkelig nok optraadte ogsaa en svakt likenisert *Collema*-art som brunlige gelé-klumper mellem mosene og cyanofycéene. Blandt *Scytonema mirabile* forekom ogsaa enkelte traader av *Petalonema alatum* (BERKELEY).

Denne liste over kalktufdannende moser og cyanofycéer supplerer den av SERNANDER publicerte fortegnelse fra svenske forekomster (l. c. p. 165—179). Av Sernanders arter har jeg i Norge kun gjenfundet *Amblystegium filicinum*[2] og *Swartzia montana* som recente tufdannere. De øvrige 9 mosarter fra Onset er hittil ikke iagttat som kalksamlere i Sverige, hvor til gjengjæld en 5—6 andre arter er fundet.

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[1] Bestemt av assistent H. OLIVCORONA.

[2] Cfr. Leine p. 14.

Av recente kalktufdannende cyanofycéer anfører SERNANDER 3 arter: *Rivularia hæmatites* (C. A. AG.), *Petalonema crustaceum* (C. A. AG.) og *Diplocoleon Heppii* (NAEG.). Desuten nævner han *Chroococcus varius* (A. BR.) og *Chr. turgidus* (NAEG.) som usikre kalksamlere.

Til denne forholdsvis sparsomme skandinaviske liste kan vi altsaa nu føie *Scytonema mirabile* (BORNET) og *Petalonema alatum* (BERKELEY). Desuten bestyrker mine fund den av Sernander antatte kalktufdannelse hos *Chroococcus turgidus*.

Fig. 28. En stor kalktufblok, som har løsnet sig av fra klippevæggen. Paa avløsningsstedet sees mørke polstere av *Mollia æruginosa* og *Scytonema mirabile* (øverst tilvenstre). Hammeren ved Onset. 20de oktober 1920. Nordhagen fot.

SERNANDER antar ogsaa at cyanofycéene leverer betydelige bidrag til kalkansamlingen i mostuene, at disse organismer altsaa supplerer hinanden. For Onsetforekomstens vedkommende maatte man, hvis man anskuet forholdene plantesociologisk, tale om en tufdannende *Mollia æruginosa*—*Scytonema mirabile*-association. De øvrige arter forekom indsprængt i denne eller dannet mindre bestand. Interessant var det at gjenfinde *Mollia æruginosa* som recent tufdanner ved Børju-bækken nær Leine i Kvam (cfr. ovenfor p. 3). Denne synes vistnok at være almindelig paa norske tufforekomster. — Som en kuriositet vil jeg nævne, at den *Collema*-art som optraadte mellem mosene ved Onset, ogsaa syntes at bevirke kalkutskillelse, idet den flekvis var belagt med en kornet kalkmasse. Imidlertid var denne lavart som ovenfor omtalt svakt likenisert, eller rettere sagt: den *Nostoc*-art som utgjør alge-komponenten i laven, var kun svakt omspundet av sophyfer, saa kalkansamlingen blir allikevel let forstaaelig.

Hvad *Leucodon sciuroides* og *Ditrichum flexicaule* angaar, som begge var ytterst svakt kalksamlende ved Onset, og hvorav ialfald den første i almindelighet er knyttet til træstammer, maa man vistnok anta at kalkutskillelsen omkring deres basaldel skyldes de tilstedeværende blaagrønne alger (cfr. SERNANDER l. c. p. 179).

Tufmassene ved Onset syntes at udmerke sig ved en temmelig træg vekst; ialfald var mosene svært lite frodige og tildels ganske kvalt av algene. Jeg har derfor valgt at kalde disse tufpilarer og kaker for halvrecente, idet jeg tror at der har medgaat ganske lang tid til deres dannelse.

Ret ned for disse kalkklipper, kun 2—3 meter lavere, laa den ovenfor beskrevne masseforekomst av mindre tufstykker i jorden. Og det er ingen tvil om at disse skriver sig fra kalkklippene; de har faldt ned ovenfra i tidenes løp. Deres karakteristiske konsistens, mangel paa skifrighet, kompakte struktur etc.[1] faar ogsaa herigjennem sin naturlige forklaring: det skyldes altsammen den eiendommelige dannelsesmaate. Disse tufstykker i jorden tyder paa at der har paagaat tufdannelse langs hammeren i betydelige tidsrum. Men da stykkene desværre er saa uhyre fossilfattige, fortæller de os saare lite om utviklingen paa stedet. Den merkelige ophobning av smaa tufbiter øverst i jorden under muldlaget betyr utvilsomt et eller andet. Men om fænomenet beror paa forvitring og sterk avløsning av tuffragmenter langs den ovenfor værende klippevæg (under et tørt klima) eller skyldes rask tufdannelse paa dette sted, derom tør jeg ikke uttale mig.

I lyset av disse fænomener, som knytter sig til denne nye forekomst ved Onset, blir den av Øyen omtalte tuf ganske dubiøs. Hvem vet om de av Blytt fremfundne løse blokker befinder sig in situ? Det er meget mulig at ogsaa deres dannelsescentrum oprindelig har ligget et eller andet sted oppe i skraaningen eller under hammeren, og at de senere er faldt ned. Et par av Blytts bladtufblokker har som tidligere nævnt cyanofycéstruktur i overflaten, flere stykker indeholder ogsaa bergartsfragmenter, hvilket betegner likhetspunkter med den av undertegnede opdagede forekomst. Ialfald er der hittil ikke levert noget bevis for at Blytts profil skriver sig fra en autochton tuf in situ. Indtil dette er gjenfundet og undersøkt paany ute i naturen, kan tuffen ved Onset ikke tillægges nogen avgjørende betydning. Ræsonnementet blir nemlig staaende paa altfor svake føtter.

[1] Likeledes forekomsten av bergartsfragmenter i tuffen.

GENEREL DEL.

I den specielle del har jeg fremlagt hele det rent deskriptive materiale som vi nu raader over fra Gudbrandsdalens kalktuffer. Jeg har ogsaa forsokt at paavise likheten og forskjellen mellem de enkelte forekomster, og likeledes gjennemgaat de forskjellige tuflag og diskutert de stratigrafiske, genetiske og biologisk-plantegeografiske problemer som knytter sig til dem.

I avhandlingens generelle del skal jeg gaa nærmere ind paa undersokelsens almindelige resultater og forsoke at besvare folgende sporsmaal: hvorledes stemmer disse tuffer med andre i litteraturen beskrevne forekomster? Er de stratigrafiske fænomener som tuffene aabenbarer, av rent lokal eller mere generel natur? Hvorledes stemmer de plantegeografiske eiendommeligheter som Gudbrandsdalens tuffer opviser, med de resultater som torvmyrforskningen og andre palæobotaniske undersokelser har git os? Alt dette er centrale sporsmaal, som maa besvares forinden man kan gaa til en tidfæstelse av de enkelte lag.

For at faa en tidsbestemmelse bakover i tiden blir det nodvendig at omtale isavsmeltningen i Gudbrandsdalen forst. Jeg har ogsaa fundet det hensigtsmæssig at gi en oversigt over hvad man for tiden vet om den forste flora og vegetation under avsmeltningstiden, da dette er av betydning for de efterfolgende avsnit.

I. Isavsmeltningen i Gudbrandsdalen.

Desværre foreligger der i norsk geologisk litteratur ingen samlet og fuldstændig fremstilling av isens avsmeltning i denne del av landet, kun spredte iagttagelser publicert av forskjellige forfattere.

For Kristiania-fjordens omgivelser og traktene op til Mjøsen er forholdene nu klarlagt paa en tilfredsstillende maate. Man adskiller her en række stadier i avsmeltningen, som vi med Øyen betegner som:

Rastadiet	Smaalenene—Jarlsberg-trinnet Moss—Horten-trinnet
Aasstadiet	Aas-trinnet Ski-trinnet

Akerstadiet	Nydals-trinnet Maridals-trinnet
Romerikstadiet	Skedsmo-trinnet Berger-trinnet

(Øyen 1911 l. c., Bjørlykke 1913 l. c.).

At disse dobbeltrækker er oscillationsmoræner (Øyen 1904), dannet under fremstøt av isranden, fremgaar av de intramorænale forekomster av marint ler tildels med marine fossiler, som man nu har kunnet paavise i saagodtsom alle de nævnte morænerækker. Disse mange svingninger i brærandens stilling under tilbakerykningen er av stor teoretisk betydning for den absolute kronologi; det er nemlig vanskelig at avgjøre hvor store tidsrum disse oscillationer repræsenterer. Man har her en ganske væsentlig feilkilde som maa tages med i beregningene.

Nordenfor Romerik-stadiet møter vi en vældig morænerække foran Mjøsen—Hurdalsvand—Randsfjorden—Spirillen, som man oprindelig betegnet som „indsjøtrinnet“ eller det „epiglaciale“ trin (fig. 29). De fænomener som knytter sig til denne række, er omstridte.

Øyen har i denne moræne fundet svære blokker av fint skiktet havler op til 4—5 m. i diameter (1915 l. c. p. 310), hvilket viser at bræene her har rykket frem over en tidligere havbund og pløiet op lerlagene foran sig.

I lermassene paa den romerikske slette som er avsat foran denne bræfront, gjorde Øyen sine opsigtvækkende fund av den yngste *Portlandia arctica*-fauna (1903 l. c.). Mens man kun har den ældre *Portlandia* (*Yoldia*)-fauna (ældre og yngre *Yoldia*-ler efter Brøggers terminologi 1900—1901) utenfor raene eller i nær tilslutning til disse[1], har man faktisk paa et langt senere stadium en fornyet opblomstring av *Portlandia arctica* (i en eiendommelig mindre varietet) paa Romerikssletten. Man har villet forklare dette fænomen ved at anta at ishavsmuslingen trak sig tilbake fra Vänernbassinet og nordover og optraadte som relikt paa Romerike (De Geer, Geol. Fören. Förh. 1913 p. 308—309). Men dette er ingen tilfredsstillende forklaring paa det faktum, at *Portlandia arctica* her har en ny blomstringstid. Øyen har nu fundet den paa en mængde lokaliteter helt op til Elverum og Solør (Norsk Geol. Tidsskr. 1913 p. 2). En relikt, som tydelig avhænger av temperaturforholdene i vandet, opviser ikke uten videre en saadan paafaldende levedygtighet og spredningsevne.

En hel række andre kvartær-geologiske fænomener har ført Øyen til at opstille det saakaldte „*Portlandia-nivaa*“ som en egen avdeling i vort lands kvartærhistorie.

En ældre og en yngre *Portlandia arctica*-førende avdeling var allerede tidligere kjendt fra Trondhjemsfeltet ved Øyens undersøkelser, og viste sig at være ikke alene petrografisk forskjelligartet, men var ogsaa adskilt ved

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1 Cfr. dog Øyen 1915 l. c.

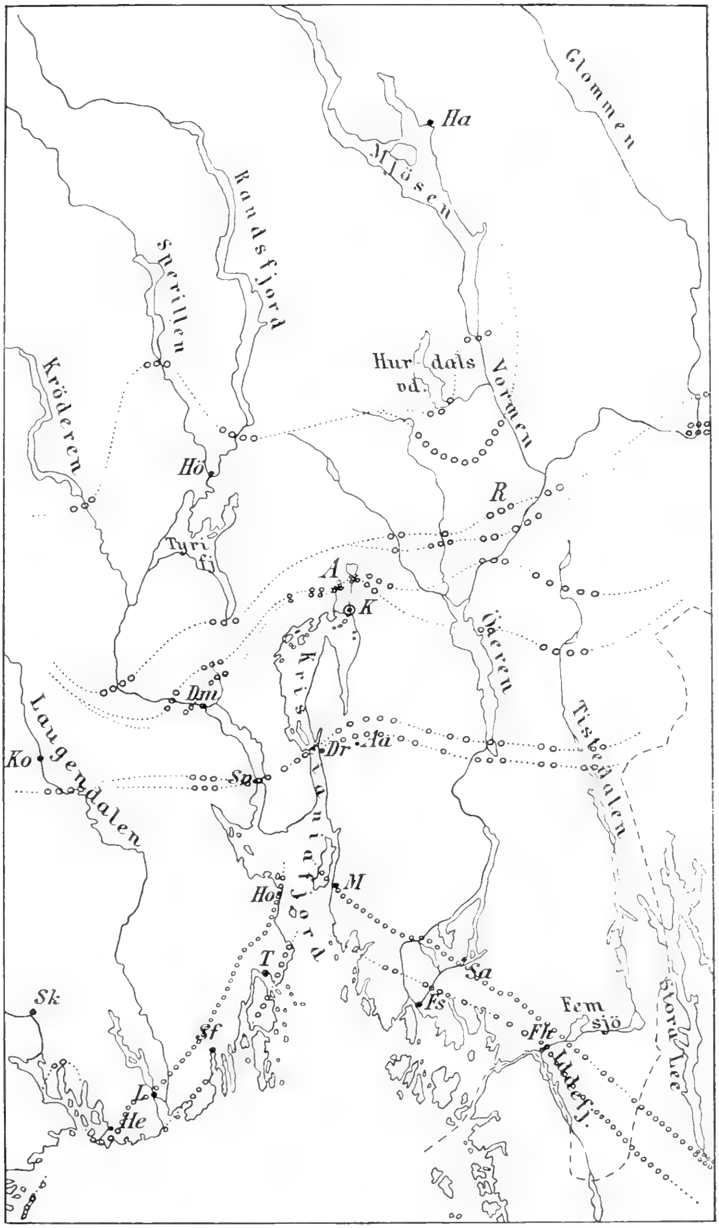

Fig. 29. Kart over de vigtigste morænerække i det sydostlige Norge. Sydligst Rastadiets dobbeltrække, derefter Aas-stadiets to trin, nordenfor dem Aker-stadiets dobbeltrække og Romerik-stadiet. For Mjøsen — Hurdalsvand — Randsfjorden o. s. v. „Indsjøtrinnet“. (Efter ØYEN 1911 l. c.)

avsætninger hvis fauna hadde et noget mildere præg. Og da ØYEN gjenfandt noget tilsvarende i Kristianiafeltet og desuten opdaget den merkelige tempererte og rike *Mytilus*-fauna ved Kristiania (1902) ved selve den marine grænse, maatte man uvilkaarlig studse. Ti alle disse fænomener stemte ytterst daarlig med det billede som man indtil da hadde opgjort sig av avsmeltningstidens natur.

Paa den ene side hadde man altsaa den tempererte *Mytilus*-fauna (*M. edulis, Mya truncata, Macoma baltica, Saxicava pholadis, Balanus crenatus*[1]) i 221 meters høide ved Kristiania, paa den anden side den yngste *Portlandia*-fauna i rik blomstring paa Romerike i et noget lavere nivaa, som dog korresponderer med en havstand som gaar op mot den marine grænse (som her forøvrig er vanskelig at fiksere).

Naar saa hertil kom at allerede BLYTT (l. c. 1892) mente at finde spor i vore fjelddaler efter en yngre bræfremrykning (efter den egentlige avsmeltningstid), og ØYEN ved sine tidligere studier i det centrale Norge, specielt Atnedalen, kom til det resultat, at store dalbræer her hadde bevæget sig nedover dalførene efter selve storbræens ophør (1899 l. c.), vil man forstaa at det laa noksaa nær at forsøke paa at kombinere alle disse fænomener.

Dette har da ØYEN gjort. Han antar at der efter Romerikstadiet fulgte en mildere periode, „*Mytilus-nivaaet*", hvorunder bl. a. de rike banker ved Kristiania i 221 m. høide blev dannet. Under denne tid trak bræene sig langt tilbake, men i hvor stor utstrækning indlandsisen avsmeltet, kan ikke avgjøres med bestemthet. ØYEN antar videre at havet nu gik ind i Mjøsen helt op forbi Lillehammer. Denne periode paralelliseres med BLYTTS „arktiske" tid.

Efter denne mildere periode fulgte atter en depression av klimatet under „*Portlandia-nivaaets*" tid. Bræene skjøt fra det centrale Norge nedover hoveddalførene og helt ned til enden av de store indsjøer. Da hadde havet allerede sunket noget. Bræene pløiet op lerlagene fra *Mytilus*-nivaaets tid, og disse blev indpresset i de store endemoræner foran Mjøsen, Hurdalsvandet o. s. v. Denne periode paralelliseres med BLYTTS „subglaciale" tid.

Forholdene ved Lillehammer synes at stemme godt med denne opfatning. Allerede i 1895 omtaler nemlig REKSTAD nogen merkelige avleiringer ved Aaretta 1 km. syd for Lillehammer, ved Nyflot nær Losna o. fl. steder. Paa den første lokalitet saaes en veritabel moræne oppaa horisontale sandlag av betydelig mægtighet (1895 l. c. p. 14). „Disse sand- og lerlag maa rimeligvis være avsat under svingninger av bræstanden i slutningen av den sidste istid." Det hele tyder paa „at mildere klima er bleven fulgt av glaciale tilstande" (l. c. p. 14). Senere har overlærer HOLME iagttat lignende fine sand- og lerlag overleiret av glaciale avsætninger, til-

[1] Flere av disse arter optræer i sydlige varieteter.

dels ogsaa hvilende paa ældre moræner paa en række steder ved Lillehammer og nordover til Myre st. ØYEN, som ogsaa har undersøkt forholdene her, tolker alt dette som *Mytilus*-nivaaets dannelser overleiret av *Portlandia*-nivaaet (ØYEN 1915 l. c. p. 307—310). BJØRLYKKE har ogsaa iagttat lignende merkelige stratigrafiske forhold ved Svanefoskanalen og ved Lena-elven paa Toten (de mellem morænene liggende lerlag var her 3,5 m. tykke) (BJØRLYKKE l. c. p. 144).

Den yngste *Portlandia arctica*-fauna paa Romerike faar herigjennem sin naturlige forklaring. Ishavsmuslingen har hat gunstige livsvilkaar under denne nye kuldeperiode. Man mener ogsaa at ha fundet *Mytilus*-førende ler under *Portlandia*-førende ved Jesseim; men dette er endda ikke bevist. BJØRLYKKE mener at det motsatte er tilfældet (ØYEN: Nogle bemerkninger om klimatforandringer. Vid.-Selsk. Forh. 1904. BJØRLYKKE 1913 l. c. p. 151).

ØYEN har ogsaa senere fundet brudstykker av *Portlandia arctica* ved Skaadalen st., ca. 16 m. lavere end de ovenfor nævnte *Mytilus*-banker (1909 l. c. og 1915 l. c. p. 290). Han antar at drivis under *Portlandia*-nivaaets tid har støtt mot stranden paa dette sted og trykket og knuget ældre sandlag med *Mytilus*-faunaen ind i lerlag med *Portlandia*-faunaen. De forstyrrede lag som blev fundet her, er ialfald vanskelige at forklare paa nogen anden maate. Saavidt vites har ingen anden norsk geolog forsøkt at utrede denne forekomsts natur.

Endelig fortjener det at nævnes at den store bræ i Atnedalen, som fra Rondemassivet har skutt ned mot Østerdalen (ogsaa beskrevet av WERENSKIOLD 1911), ifølge ØYEN maa ha dæmmet op for Glommen og tvunget denne til at rende østover mot Rendalen. Under denne periode skal „Jutulhugget" være blit utformet[1]. Pashøiden over hugget korresponderer med de laveste seter i Østerdalen (cfr. HOLMSEN 1915 p. 143), som likeledes tolkes som minder fra denne opdæmning.

Nu, alle disse fænomener som jeg her har referert, er tildels meget omstridt, og flere norske geologer stiller sig skeptisk, tildels avvisende overfor *Mytilus*- og *Portlandia*-nivaaet saaledes som disse teoretisk er utformet av ØYEN. Paa Vestlandet har KALDHOL (1909 og 1912 l. c.), delvis ogsaa KOLDERUP (1911) fundet forhold som stemmer med ØYENS opfatning.

Imidlertid kræves der endnu omfattende undersøkelser for at klargjøre forholdene. Vi kjender endda ikke sikkert lagfølgen paa den romerikske slette; vi vet heller ikke, hvor langt bræene trak sig tilbake indover mot det centrale Norge forinden de atter rykket frem til enden av de store indsjøer. Hvor stor rest av indlandsisen overlevet *Mytilus*-nivaaet, vites ikke; vi kjender heller ikke dette intervals varighet og hele oscillationens amplitude. ØYEN har forsøkt paa grundlag av sine studier over lersedimentene i Trondhjemsfeltet at tidfæste bræsjø- og sete-perioden i det

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[1] Smlgn. ogsaa SCHETELIG (foredrag, referert i Norsk Geol. Tidsskrift B. 1. p. 44), og REUSCH (1917 l. c.), hvor Jutulhugget omtales.

østenfjeldske Norge. Han antar at denne avsluttedes hovedsakelig før *Mytilus*-nivaaets tid (1915 l. c. p. 294—297). Landisen maatte altsaa paa denne tid ha været sterkt decimeret. HOLMSEN mener derimot at en del av isresten i øst overlevet denne mildere periode, og at den atter vokste noget under *Portlandia*-nivaaets tid (samtidig med lokalglaciationen), da snelinjen blev forskjøvet nedad. (G. HOLMSEN: Forskyvninger i snelinjens høide under avsmeltningsperioden. 1918 l. c.).

Dette tvistepunkt er overordentlig vigtig. Svenske kvartærgeologer hævder nemlig i motsætning til ØYEN, at indlandsisen i øst vedvarte et godt stykke utover i postarktisk tid, ja man ser gjennemgaaende paa svenske karter ogsaa indlagt en vedvarende pølseformet isrest langt ind i Gudbrandsdalen. Dette punkt kommer vi tilbake til i de følgende avsnit. Kalktuffene er i denne forbindelse meget betydningsfulde.

Ogsaa fra andre kanter i Skandinavien er der beskrevet eiendommelige avleiringer og fænomener som i flere henseender synes at stemme overens med ØYENS tolkning. Dette gjælder først og fremst den saakaldte Allerød-oscillation i Danmark[1], som nu maa betragtes som videnskabelig fastslaat, idet alle de indvendinger som har været reist herimot, har vist sig at være ugrundet (Naturforskermøtets forhandlinger, Kristiania 1918, p. 418—421). „Allerød-tiden" har NORDMANN og ØYEN paralellisert med *Mytilus*-nivaaets tempererte periode („senglaciale klimatoptimum" JESSEN 1920 l. c.), „den yngre Dryas-tid" med *Portlandia*-nivaaet. At der i Danmark har skedd store forandringer i vegetationsdækket under denne oscillation, er en videnskabelig kjendsgjerning.

I Sverige har ENQUIST i flere arbeider behandlet hvad han kalder „lokalglaciationen". Han opdaget først (1910 l. c.) at visse bræer i Herjedalen—Jemtland tidligere har været betydelig større end nu; saaledes har Helagsfjeldets bræ engang skutt 1500 m. længer frem end i nutiden. Lignende fremstøt markert ved endemorænen har han iagttat flere steder (i Norge har HOLMSEN omtalt en endemoræne fra Hummelfjeldet i Tolgen[2]). Senere mener ENQUIST at ha fundet spor efter intens lokalglaciation paa en række steder i det nordvestlige Skandinavien (1918 l. c.). Eiendommelig nok synes ENQUIST ikke at kjende til den diskussion som man i norsk litteratur har ført om lokalglaciation (f. eks. BLYTT 1892, ØYEN: „Kontinentalglaciation og lokalnedisning" 1899 o. s. v.). Hans opfatning av hele fænomenet er ogsaa en anden end ØYENS. ENQUIST antar nemlig at de av ham studerte fænomener skriver sig fra den sidste istids avsmeltningsfase, specielt

[1] Litteratur om Allerød-perioden: HARTZ og MILTHERS 1901 l. c., HARTZ 1903 l. c., JOHANSEN 1904 l. c., NORDMANN 1912 l. c., ØYEN 1915 l. c., DE GEER 1916 l. c., NORDMANN 1918 l. c., JESSEN 1920 l. c.

[2] 1915 og 1918 l. c. ENQUIST anfører ogsaa i et senere arbeide (1918 l. c.) (ifølge H. SMITH), at der paa Knutsho, Dovre, skal findes en endemoræne som tyder paa lokalglaciation. Antageligvis er dette den sidemoræne i 1500 m. høide som HOLMSEN har omtalt (1915 l. c. p. 189), og som ifølge ham skriver sig fra indlandsisen.

fra dennes første del, da det sammenhængende isdække forsvandt fra visse omraader og gav plads for lokale bræer. Hans kart over isdækkets utbredelse under denne tid er imidlertid meget lite overbevisende og staar for Norges vedkommende i strid med hvad vi vet om isavsmeltningen i det trondhjemske, hvor en lang række med morænetrin er beskrevet og delvis sammenstillet med de østlandske stadier. At lokalglaciationen netop skal svare til det tidspunkt, da bræene i det sydlige Norge stod ved raene[1], er ogsaa i grunden bare et postulat. — De av ENQUIST omtalte fænomener, specielt fra Herjedalen—Jemtland, kan, saavidt jeg forstaar, ogsaa meget godt tages til indtægt for ØYENS lille atpaa-istid (*Portlandia-nivaaet*), som han sammenstiller med Bühl-Vorstoss i Alperne og med amerikanernes Post-Wisconsinperiode.

Jeg har med vilje omtalt *Mytilus*- og *Portlandia*-nivaaene ganske indgaaende, fordi de spørsmaal som knytter sig til dem, er ganske centrale i norsk kvartærgeologi. Saalænge der ikke opnaaes enighet paa dette punkt, kommer man ikke av flekken. Man maa haabe paa at disse problemer i fremtiden blir underkastet en kritisk og indgaaende behandling og belyst fra forskjellige sider; ellers kan der jo ingen diskussion bli. Mange svenske geologer negligerer desværre helt disse vigtige spørsmaal. Jeg for min del tror at dette i første række skyldes det forhold, at der i norsk litteratur ikke foreligger nogen tilfredsstillende klar og koncis fremstilling av disse aktuelle problemer. Polemiske og krigerske utfald mot anderledes tænkende fører her aldrig til maalet, men kun en kritisk og saklig utredning.

Saalænge situationen ligger saaledes an, er det vanskelig at faa istand en overensstemmelse mellem de nyere svenske oversigter over isdækkets avsmeltning og de norske forhold[2].

Skal man gi en fremstilling av isavsmeltningen i selve Gudbrandsdalen, vil denne i høi grad avhænge av den opfatning man har av *Mytilus*- og *Portlandia*-nivaaene. Man finder den ene morænerække efter den anden fra Lillehammer og helt op til Otta, hvilket utvetydig viser at bræene her i den sidste avsmeltningstid har bevæget sig nedover dalen (NV—SØ), og at deres utgangspunkt har været i nærheten av landets høideakse (REKSTAD 1895, 1896 og 1898). Isskillet har ligget ved grænsen mellem Dovre og Sel herred. De kartografiske fremstillinger som man finder i litteraturen, hvor en pølseformet isrest placeres over S. Fron, Ringebu eller Øier, er altsaa ikke rigtige. (Cfr. ØYENS undersøkelser ved Rosten 1899 l. c. p. 54—56 og HOLMSENS stripekart 1915 l. c. p. 22). Man

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[1] Disse er helt feilagtig indtegnet paa ENQUISTS kart.

[2] Cfr. ØYEN: Naturen 1916 p. 223 og HOEL i Geol. Fören. Förh. Stockholm 1916 p. 484.

har i denne del av Gudbrandsdalen overhodet intet tegn til at bræbevægelsen paa noget sted har været rettet opover dalføret, saaledes som f. eks. i Østerdalstraktene[1].

Hvis man nu akcepterer *Portlandia*-nivaaet som en egen avdeling karakterisert ved lokalglaciation i det centrale Norge, maa man anta at alle disse moræærækker i dalen er sammenskjøvet av de sidste bræer i disse strøk under *Portlandia-nivaaets* avslutningsfase, og at de markerer temporære stilstande eller mindre fremrykninger under den sukcessive avsmeltning. Ældre avleiringer er ogsaa tildels bevaret, men det er de sidste bræer som har sat de tydeligste merker efter sig.

Anerkjender man derimot ikke *Portlandia*-nivaaet som nogen egen periode, blir moræærækkene at henføre til selve indlands-isrestens avsmeltningstid. Av moræænenes placering og skuringsmerkene fremgaar det da at der her har været nedgaaende dalbræer fra isskillet nær landets høideakse og ingen pølseformet isrest over strøket Fron—Øier.

Da jeg selv ikke har arbeidet med disse ting, skal jeg her bare nøie mig med denne orientering i problemstillingen[2].

I indledningen omtalte jeg de merkelige moræneavleiringer som opbygger Leinebakkene i Kvam. Disse har som nævnt engang sikkert fyldt op hele den nedre del av Veiklas nuværende dalføre, idet der anstaar rester av fyldningen ogsaa paa elvens østside. Den har sandsynligvis gravet sig ned gjennem disse og flyttet sig vestover. Moræneleren indeholder talrike blokker, fleresteds i tætpakkede lag (skyldes ogsaa ras). For om mulig at komme paa spor efter isbræens bevægelsesretning, medtok jeg en del bergartsprøver, som professor J. Schetelig har været saa elskværdig at undersøke. Det viste sig at være forskjellige sparagmittyper, kalksandstener, fylliter, desuten saaes blokker av en grov, rød øiegneis. Alle disse bergarter angives av Bjørlykke for traktene nord og delvis nordøst for Leine; den kalkrike morænelere forutsætter kalkholdige bergarter, og saadanne optrær ogsaa i nærheten. Øiegneis anstaar i foten av den lille top Gnedden nord for Leine og i Formokampen nord for Otta (Bjørlykke 1905 l. c.).

Ved Kolloen nær Sjoa og Sandbovangen (fig. 30) litt høiere oppe i dalen findes der store endemoræner, beskrevet av Rekstad, og disse angir en bræbevægelse NV—SØ (ut Hedalen og Ottadalen). Morænemassene ved Leine er ældre og vistnok avsat av en bræ fra nord—nordvest; men om dette har været hovedbræen fra Ottadalen, som har presset sig sydøstover

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[1] En undersøkelse av blokkene i de *nedre* moræneavleiringer paa de steder hvor man har intramorænale sand- eller lerlag (cfr. ovenfor), maa kunne gi oplysninger om man her nogen gang har hat blokkeflytning opover dalføret. (Cfr. Frödins utredning av Frösöfyndet. Geol. Fören. Förh. B. 38. 1916).

[2] Jeg har her ikke omtalt Dovretraktens bræsjø og de omdisputerte sete-dannelser aller øverst i dalen. Tidsbestemmelsen vil her ogsaa avhænge av det standpunkt man indtar til *Portlandia*-nivaaet.

Fig. 30. Den store endemoræne ved Sandbovangen syd for Otta. REKSTAD fot. (Efter BRØGGER: Norges Geologi i „Norge 1814–1914".)

Torgerkamp-plataaet[1], eller om en mere nordostlig bræ fra Rondemassivet Furusjoen har arbeidet sig sydover mot Kvam, vet vi forelobig ikke. Blokkene i leret gir ingen sikker besked herom. Moræneleren gaar op til 6 à 700 m. o. h., altsaa temmelig hoit. Werenskiold omtaler imidlertid sidemoræner i S. Fron op til 600 m. hoide (1911 l. c.).

Avsætningene ved Leine maa utvilsomt kunne tidfæstes i forhold til moræner baade sondenfor og nordenfor Kvam; men geologene har hittil merkelig nok ikke ofret dem nogen opmerksomhet eller diskutert deres alder.

II. Nogen bemerkninger om den første flora og vegetation under avsmeltningstiden.

I ældre palæobotaniske oversigter finder man opfort en saakaldt „Dryastid" for saagodtsom hele Skandinavien som den forste epoke efter isens avsmeltning. Imidlertid har opfatningen paa dette punkt ændret sig ganske betydelig i de senere aar, eftersom forskningen er skredet fremover.

I Danmark maa det nu ansees for fastslaat at man har hat en oprindelig „ældre Dryastid" med fuldstændig arktisk præg. Derefter folger den eiendommelige „Allerod-oscillation", som synes at udmerke sig ved aapne kratskoger av bjerk, asp og vidjer (Jessen 1920 l. c. p. 218). Under den „yngre Dryastid" synes atter de arktiske planter at ha hat overtaket.

Oprindelig antok man at en lignende arktisk vegetation var fulgt efter isen nordover gjennem Sverige til Norge. Og i det sydlige Sverige, hvor Nathorst gjorde sine klassiske undersokelser, har nok dette været tilfældet. Men jo længer nordover man kommer, desto m i n d r e m a r k e r t synes den arktiske floras blomstringstid at ha været, desto mere opblandet er den med subarktiske arter (G. Andersson 1906 l. c. p. 60). Rigtignok er arktiske planterester iagttat paa en række steder helt nord til Laxå i Mellem-Sverige, og ved Kristiania har Øyen bl. a. fundet *Salix polaris* i lerlag paa flere steder. Men forholdene stemmer i almindelighet, saavidt man kan se, ikke ganske med de i Danmark paaviste. Og en række botanikere og geologer synes at være av den opfatning, at da isen hadde trukket sig saa langt tilbake som op i Mellem-Sverige, hadde de klimatiske forhold ændret karakter; de var ikke længer arktiske, men tempererte. Man antar at en blanding av arktiske og subarktiske arter her tok landet i besiddelse (Andersson l. c., Wille l. c. p. 325).

For at kunne forklare den skandinaviske fjeldfloras tilstedeværelse har man grepet til forskjellige teorier, som desuten forsoker at lose en række gaader som knytter sig til det samme flora-element. Blytt (1893 l. c. p. 21) og Sernander (1896 p. 117) har allerede for lang tid siden hævdet, at vi i Norge maa ha hat plantekolonier som paa i s f r i e n u n a t a k k e r

[1] Skuringsstripene paa Gudbrandsdalens ostside i stroket Sel kirke — Otta st. — Bredevangen tyder paa dette (cfr. Rekstads kart 1896 l. c.).

overlevet den sidste istid. Av nyere datum er teorien om den isfrie kystrand under den sidste istid, med overlevende haardføre arter (HANSEN 1904, WILLE 1905, FRIES 1913, TENGWALL 1913). Denne teori kombineres nu ofte med nunatak-teorien, som jo ikke er væsensforskjellig fra den første (FRIES 1913, TENGWALL 1913).

Fund av arktiske planterester i det trondhjemske og langs Norges vestlandskyst taler til gunst for denne opfatning, selv om de strengt tat ikke beviser andet end at isranden her i vest og nordvest blev efterfulgt av arktiske planter, saaledes som i Danmark og Syd-Sverige.

Av stor teoretisk interesse er ØYENS fund i det trondhjemske, specielt naar disse stilles i relation til isens avsmeltning i disse strok. I sit arbeide om Trondhjemsfeltet (1915) paralelliserer ØYEN den store „Ørlandsbanke" ved mundingen av Trondhjemsfjorden med „Stagnations-trinnet" i Danmark — med andre ord: vi skulde i Ørlandsbanken ha grænsen for den sidste istids (Mecklenburgian) brædække i denne del av landet (cfr. USSINGS kart). Denne opfatning, som er basert paa de eiendommelige faunistiske forhold som udmerker disse gamle avleiringer, der stemmer med tilsvarende avsætninger i Danmark[1], medfører meget vigtige konsekvenser; der aapner sig da muligheter for en isfri, om end smal kystrand søndenfor Trondhjemsfjorden, ialfald muligheter for opragende fjeldpartier.

Ved Ytterland fandt ØYEN blader av *Salix polaris* (1901), hvilket viser at der paa Ørlandet eller i dets nærhet har været en arktisk vegetation. Senere har ØYEN kunnet forfølge denne arktiske flora eftersom den trak sig længer indover det trondhjemske. Sommeren 1900 fandt han nemlig *Salix polaris* ved Nidaros og Reitgjerdet teglverk nær Trondhjem og i 1901 *Salix reticulata* og *Dryas octopetala* i 164,4 m. høide ved Sandsætervolden nær Hommelvik (Mytilus-nivaaet. 1915 l. c. p. 291). I 1909 fandt BJØRLYKKE *Salix reticulata* ved Reitgjerdet.

Alle disse fund er fra en langt senere periode end Ørlandsforekomsten og maa ikke sammenstilles med denne, saaledes som ENQUIST har gjort paa sit kart (1918 l. c. p. 82)[2]. De interessante fund av arktiske planterester som H. SMITH i den nyeste tid har gjort i Jemtland-Herjedalens fjeldomraader (1917 l. c., 1920 l. c.), og som utvilsomt er meget gamle, danner paa en maate en fortsættelse østover av de ovenfor nævnte forekomster i Trondhjemsfeltets marine avleiringer. Dog maa man medgi at en sikker tid-

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[1] Cfr. *Portlandia arctica, Macoma Torelli, Macoma Loveni, Buccinum terrae novae, Sipho virgatus* og *S. Verkrützeni, Cylichna scalpta, Utriculus pertenuis,* høiarktiske bryozoer etc. (ØYEN 1915 l. c. p. 177).

[2] Her fremstilles alle norske fund av arktiske planterester tilsyneladende sans façon som synkrone. Ja, raene trækkes helt op til Kristiania, vistnok fordi *Salix polaris* er fundet i byens nærhet, og fordi disse findesteder helst „burde" ligge utenfor raene! Man maa virkelig ha lov til at spørre hvad meningen er med alle disse manipulationer? Naar man finder det umaken værd at indtegne findestedene paa et kart, bør man ogsaa studere originaloplysningene og citere forfatteren.

fæstelse av arktiske plantefund i et høifjeldsomraade er forbundet med adskillige vanskeligheter. SMITHS tolkning virker dog meget tiltalende, og det maa vel nu betragtes som fastslaat at der har gaat en overordentlig vigtig indvandringsstrøm av fjeldplanter fra Norge i vest og østover ind i det centralsvenske høifjeldsomraade. I de bundlag som SMITH har analysert, fandtes der ikke spor av pollen hverken av bjerk eller furu. Dette stemmer med den av ANDERSSON og BIRGER fremsatte anskuelse (1912 l. c. p. 142): „Vi anse det således sannolikast att tallskog icke funnits eller åtminstone icke spelat någon roll väster om isdelaren sa länge någon afsevärd inlandsisrest ännu kvarlåg.“ ANDERSSON antar ogsaa at bjerkeregionens arter senere vandret den samme vei østover ind i Sverige fra Norge i de angjældende trakter (1912 l. c. p. 141). Dette forutsætter med bestemthet en „bjerk-asp-periode“ ialfald i visse deler av Norge (nordvestlige og centrale del) — et punkt av stor vigtighet, som vi senere kommer tilbake til.

De mange interessante fund som HOLMBOE, REKSTAD og KOLDERUP har gjort paa Vestlandet, viser at ogsaa her har en rent arktisk vegetation holdt til langs isranden under avsmeltningstiden; men tidfæstelsen i forhold til bestemte avsmeltningsstadier er her meget vanskelig.

TH. C. E. FRIES har i sit interessante arbeide fra det nordlige Sverige (1913) trukket frem en række nye plantegeografiske fakta som taler til gunst for en „overvintrende Mecklenburgo-glacial flora“ paa visse strækninger i Norge (cfr. hans inddeling av fjeldplantene i bicentriske arter, vestarktiske arter o. s. v. 1913 l. c. p. 330). „Ob das eisfreie Land eben an der Küste gelegen war, lasse ich dahingestellt sein. Es sprechen indessen gewisse pflanzengeographische Verhältnisse dafür daß die eisfreien Nunatakken nicht an der Küste sondern weiter in das Land hinein gelegen waren“ (l. c. p. 315).

Jeg hadde sidste sommer anledning til at gjøre nogen iagttagelser fra et av de omraader i det nordlige Norge, hvor baade FRIES og TENGWALL tænker sig at der har været overvintrende Mecklenburgo-glaciale plantekolonier, nemlig i stroket Saltdalen—Sulitjelma. Jeg vil her benytte anledningen til at nævne litt om forholdene i disse strøk; de er nemlig adskillig mere problematiske end vistnok mange har tænkt sig.

Jeg skal her kun opholde mig ved forekomsten av *Carex scirpoidea* og *Saxifraga Aizoon*, to arter som baade av FRIES og TENGWALL regnes med til de interglaciale overvintrere.

Carex scirpoidea har sine eneste europæiske voksesteder ved Solvaagtind i Junkersdalen (DYRING 1900 l. c. p. 277). Den vokser her over en kortere strækning paa fjeldets sydøstlige side i 760 m. høide omtrent 150 m. over skoggrænsen. I 1916 blev arten ogsaa fundet paa vestsiden av Solvaagtind paa skraaningen av fjeldet Trækta av Dr. E. HÄYRÉN (Finlandias Årsbok 1919 p. 57). Dette lave fjeld (912 m.) danner den vestligste begrænsning av Solvaagtinds skraaning mot Saltdalen. Det nye findested ligger 4 à 5 km. fjernet fra det ældste kjendte.

Under et besok paa stedet sommeren 1920 kunde jeg konstatere at fjeldskraaningene paa Solvaagtinds ostside til og med i et hoiere nivaa end findestedet for *Carex scirpoidea* var belagt med erratiske blokker (tyndt morænedække). Og av hele topografien og isskuringen kan man se at bræmassene her har presset sig fra Junkersdalen nordvestover netop i skaret

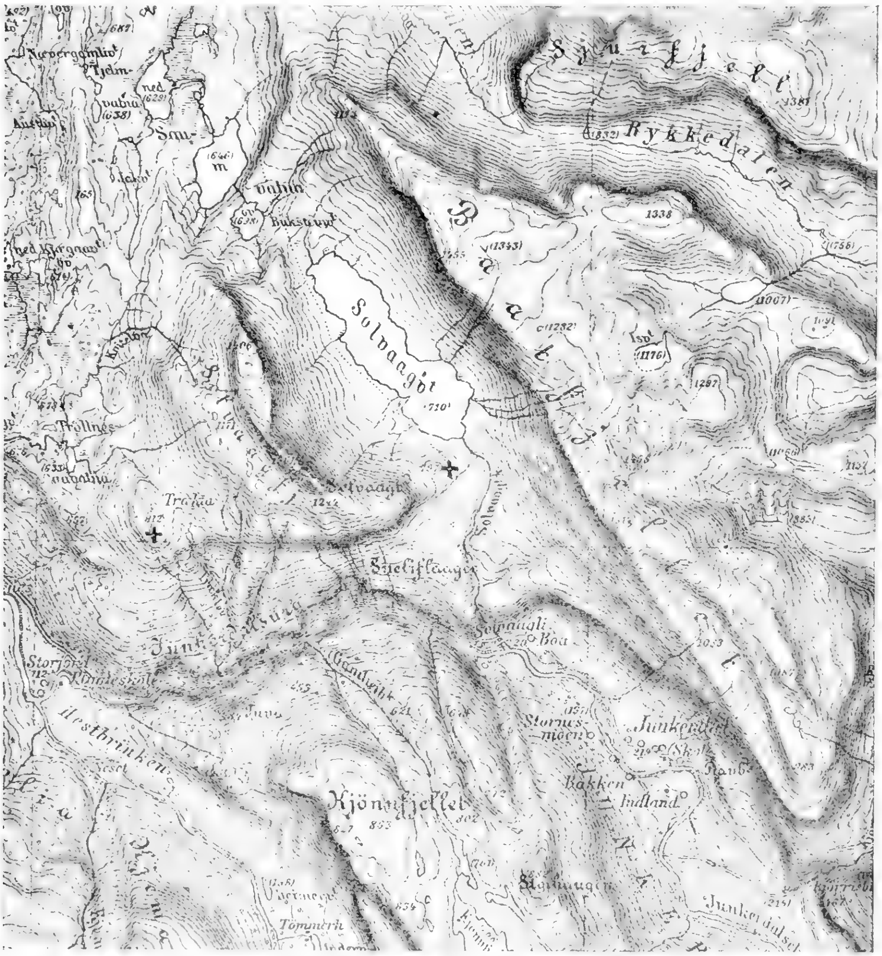

Fig. 31. Kart over stroket Solvaagtind—Baatfjeld i Junkersdalen. Voksestedene for *Carex scirpoidea* er avmerket med .

mellem Solvaagtind og det ostenfor beliggende Baatfjeld. Naar man har hat anledning til at se Solvaagtinds besynderlig formede top fra forskjellige kanter, faar man indtryk av at den er tilslepet som en vridd kam av isen, der har glidd forbi paa ostsiden og vestsiden. En ting er ialfald sikker: *Carex scirpoidea* kan umulig ha vokset paa de nuværende voksesteder under den sidste istid. Planten synes ogsaa at være noget fordringsfuld i valget av voksested. Den optrær paa smaa skraanende græsmyrer med *Carex parallela, C. capillaris, C. alpina, C. rigida, Salix reticulata, Silene acaulis, Saussurea alpina, Polygonum viviparum, Bartschia alpina* o. fl. samt en del eutrafente moser i bunden. Høiere oppe paa skraaningen av tinden findes den ikke, og dennes nakne top med de steile styrtninger er aldeles uskikket for planten i nutiden, og endda mindre under et strengere klimat. Hvis *Carex scirpoidea* har overlevet den sidste istid i disse strok, maa det ha været paa et andet sted. Det lar sig ogsaa tænke at denne eneste og merkelige forekomst av arten i Europa er de sidste rester av et tidligere større utbredelsesfelt. Specielt maa man

Fig. 32. Utsigt fra Rosnevarre og sydover mot Salefjeldet og Skaitidalen. Lave, avrundede klipper. 12te juli 1920. Nordhagen fot.

tænke sig at den postglaciale varmetid med sin vældige forskyvning av skoggrænsene opad paa fjeldene har utryddet mange arter og indskrænket deres utbredelsesfelt (HANSEN 1904). Det er ogsaa forskjellige ting ved denne Solvaagtindlokalitet som synes at staa i forbindelse hermed. I nutiden er der netop paa østsiden av fjeldet og i skaret ved Solvaagvandet en voldsomt sterk vindvirkning, som presser skoggrænsen nedad. Denne „avtrækkanal" til og fra Junkersdal, som specielt i gamle dager, da rideveien til Evenesdalen og Salten førte forbi her, var berygtet blandt befolkningen, har utvilsomt altid paavirket vegetationen paa stedet[1], og sikkert ogsaa under den høiereliggende skoggrænses tid forhindret skogen i at

[1] I Juli 1920 maatte man krype paa alle fire for overhovedet at komme gjennem passet mot Solvaagvandet.

sætte sig fast paa disse avblaaste skraaninger. *Carex scirpoidea* maa her ha hat specielt gunstige betingelser for at kunne overleve varmetiden og dens utryddelseskrig mot fjeldplantene.

Problemet *Carex scirpoidea* og dens „overvintring" er vanskeligere at løse end vistnok mange har tænkt sig. Dette gjælder i endda høiere grad *Saxifraga Aizoon*. Denne art har efter LÆSTADIUS', SCHLEGEL og ARNELLS og i nyere tid overingenior KARLSONS undersokelser et litet utbredelsesfelt i det nordlige Norge nordost for *Carex scirpoidea*, nemlig paa begge sider av Balvandet syd for Sulitjelma. Sidste sommer kunde konservator OVE DAHL og undertegnede konstatere at planten fremdeles findes paa Balvandets østside (LÆSTADIUS' lokalitet „Balvandsryggen"), hvilket man har betvilet, idet den flere ganger har været eftersokt, men med negativt resultat.

Fig. 33. Balvandsryggen nær Kvebilokskaret. Isskuret fjeld med erratiske blokker. *Saxifraga Aizoon*-polstere i forgrunden. Det kamel-lignende fjeld i bakgrunden er Nord-Saulo. Utsigt mot nordost. Den lille top tilhoire er i virkeligheten en lang hoideryg, som her sees i profil. 11te juli 1920. Nordhagen fot.

Baade paa Rosnevarre i nordvest for Balvand og paa Balvandsryggen (ved grænsen) optrær *Saxifraga Aizoon* i forholdsvis lave nivaaer. Fjeldene er ikke høiere end 8 à 850 m., og planten overstiger neppe 800 m. Disse to fjeldpartier er paafaldende like. De er jevne og glatskuret av isen, som her er kommet fra SØ (cfr. REKSTAD og HOLMSENS kart 1917 l. c.). Overalt paa disse avrundede berg og jevne skraaninger finder man et tyndt bundmorænedække, saa tyndt at det væsentlig bestaar av utstrødde blokker, som ofte ligger placert paa de besynderligste steder (cfr. billedene fra Rosnevarre og Balvandsryggen). Berggrunden bestaar begge steder av kalkholdig glimmerskifer og bærer gjennemgaaende en sparsom og aapen vegetation paa grund av manglende løsmateriale. Her vokser *Saxifraga Aizoon* ganske talrik paa flate berg eller svake fjeldskraaninger i smaa sprækker og fordypninger, ikke paa hylder eller steile avsatser, som man gjerne tænker sig paa forhaand. Voksestedet er i det hele tat meget karakteristisk og eiendommelig.

Det er nu ganske klart, at da planten kun optrær her i relativt lave nivaaer paa steder som har været isdækket lang tid utover i avsmeltningstiden, kan den umulig ha overlevet den sidste istid paa dette sted. Den synes at ha lette konkurrencevilkaar paa disse glatskurte klipper, idet den xerofile vegetation her er meget aapen. Dette er kanske en av aarsakene til at den holder sig netop her. Desuten kommer det samme moment til som jeg omtalte for *Carex scirpoidea*, nemlig skoggrænsen under varmetiden.

Hverken paa de angjældende deler av Rosnevarre eller Balvandsryggen kan der ha vokset virkelig skog under varmetiden, som kan ha utkonkurreret fjeldplantene paa stedet (f. eks. ved beskygning). Vi har her kanske en av aarsakene til at Balvandsryggen ogsaa ellers rummer saa mange sjeldenheter.

Men hvorfra er da *Saxifraga Aizoon* kommet? Typiske nunatakformer (Turmskulptur, Enquist 1918 l. c.) findes ikke i nærheten, og partiet syd for Balvand (Argaladei—Salefjeldet o. s. v.) synes at ha været et bræcentrum. Planten forekommer heller ikke i store høider. Man maa vistnok anta, at den har fulgt efter isen da denne trak sig tilbake fra Skjærstadfjorden og indover landet, og at den oprindelig hadde et videre utbredelsesfelt end nu. Dens nuværende isolerte forekomst er øiensynlig betinget av voksestedenes eiendommelige natur.

Baade for *Carex scirpoidea* og *Saxifraga Aizoon* er spørsmaalet om „overvintring under den sidste istid" ikke saa kurant som man kanske til en begyndelse skulde tro. Ovenstaaende utredning viser hvor uhyre vanskelig det er av en plantearts mere eller mindre isolerte forekomst i nutiden at trække slutninger bakover i tiden. Det nuværende alpine utbredelsesfelt er nemlig bestemt eller saa at si resultanten av en række faktorer, først og fremst: 1) plantens utbredelsesfelt før den postglaciale varmetid, 2) indskrænkninger og utdøen under den høiereliggende skoggrænses tid, 3) eventuelle nyere spredninger efter det klimatomslag som rykket skoggrænsene ned til sit nuværende leie, og som følgelig utvidet regio alpina.

Jeg har her villet omtale disse fænomener fordi slagord som „nunatakkolonier" og „isfri kystrand" i de senere aar stadig dukker op i litteraturen, men uten at vi er rykket problemene nærmere ind paa livet. Specialundersøkelser mangler nemlig totalt. Og det nytter efter min mening ikke længer bare at ræsonnere mere eller mindre abstrakt over disse problemer; ialfald kommer vi ikke videre ad den vei.

I likhet med Hansen (1904) og Wille (1905) antar Fries at en del av den skandinaviske fjeldflora er indvandret fra øst i senglacial tid[1]; desuten regner han med en indvandring fra syd.

Tengwall har fæstet opmerksomheten bl. a. ved *Kobresia bipartita, Pedicularis Oederi, Campanula barbata, Gentiana purpurea* og *Ranunculus platanifolius*, som han kalder sydlige fjeldplanter[2]. For disse antar han en sydlig indvandringsvei; men da de ikke har formaadd at sprede

[1] Fries fordeler imidlertid de østlige indvandrere paa flere grupper (fjeldarter, bjerk- og naaleskogarter). Hans inddeling er saaledes en anden end de nævnte forfatteres og problemstillingen mere specialisert.

[2] Til disse slutter *Nigritella nigra* sig.

sig utover hele den skandinaviske fjeldkjede (de fire første findes bare i det sydlige Skandinavien), antar TENGWALL at den sydlige indvandringsvei har været mindre væsentlig.

Man maa utvilsomt gaa ut ifra at der virkelig har indvandret fjeldplanter til det centrale Skandinavien fra syd (Alperne og Mellem-Europa) via Dan-

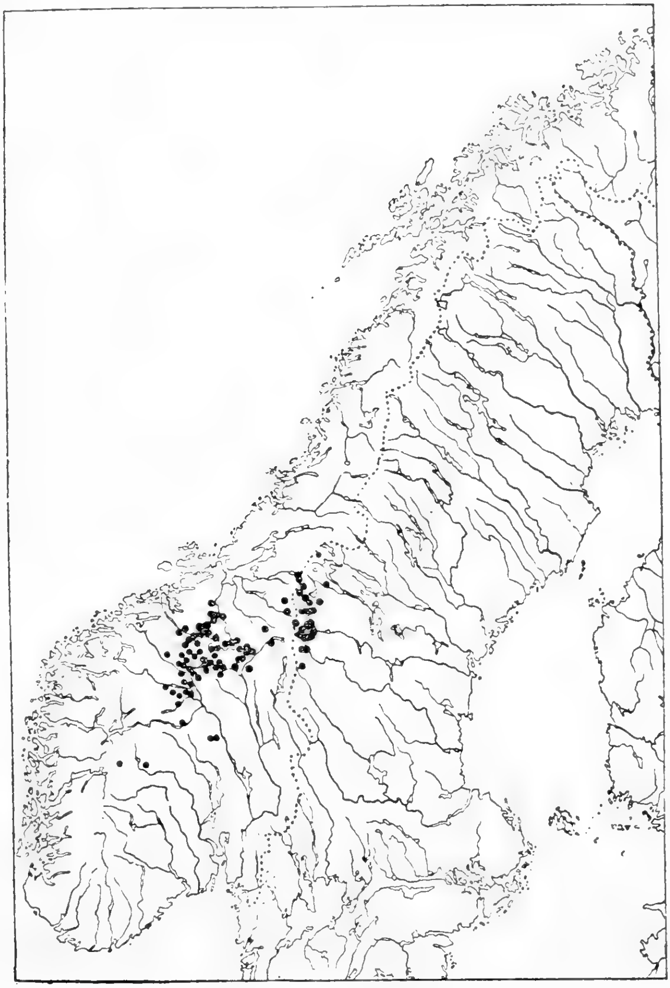

Fig. 34. *Kobresia bipartita's* utbredelse i Skandinavien. Efter Tengwall (Enquist 1918 l. c.).

mark og Sverige. Hvorledes skal man ellers forklare forekomsten av *Kobresia bipartita, Gentiana purpurea* etc. i Norge? Mens man oprindelig ansaa denne indvandringsstrøm for den vigtigste, slaar man nu over i den motsatte yderlighet. Nu skal nærsagt alle fjeldplanter enten være interglaciale eller østlige. Det ene behøver ikke at utelukke det andet. Naar *Dryas* og andre fjeldplanter har kunnet vandre helt op til

Laxa (indenfor den moræne række som svarer til raene), har de nok ogsaa evnet at komme sig op til Kristianiatrakten. Og i anledning av DANIELSSENS interessante fund av arktiske planterester ved Kristiansand (1908, 1910, 1912 l. c.), ligger det snublende nær at anta en spredning over Skagerak fra Jylland, f. eks. med vinterstormene henover det tilfrosne hav (WARMING 1904 p. 13 og 18). Man antar jo nu at der i postarktisk tid har indvandret planter direkte fra England[1] og Danmark til Norge (WILLE, Salmonsens leksikon XIII p. 503 og 1915 p. 101), og at der i nutiden paagaar en indvandring til Danmark i motsat retning (WARMING 1904 p. 15—17). Saadanne spredningsmuligheter har selvfølgelig altid været tilstede og ikke bare været begrænset til noget enkelt tidsrum.

At fjeldplanter fra sydost eller sydvest er vandret helt op til Kristiania, fremgaar av ØYENS fund av *Salix polaris* i Aker og Asker fra Portlandianivaaets tid[2]. Nordmarken ved Kristiania har topper som nu gaar op til over 700 m. o. h., og som var ca. 500 m. dengang havet stod ved den marine grænse. Da isen forsvandt herfra efter Aker-stadiet og Romerikstadiet (cfr. ovenfor), har utvilsomt en arktisk vegetation hat gode betingelser paa disse koller og hoidedrag. ØYENS fund av *Dryas octopetala* og *Betula nana* fra yngre avleiringer (som dog er vanskelige at tidfæste) ved og i Kristiania by, viser at fjeldplantene ogsaa har holdt sig her en stund utover i postarktisk tid (ØYEN 1915 l. c. p. 35).

Vi maa anta at den skandinaviske fjeldflora er blit rekrutert ogsaa fra syd, og det er forelobig meget vanskelig at avgjore om enkelte arter har været interglaciale overvintrere, eller om de er sydlige indvandrere. Vort kjendskap til den vegetations beskaffenhet som fra syd fulgte efter det avsmeltende isdække opover mot det centrale Norge, er imidlertid uhyre mangelfuldt. De fleste er vel nu tilboielige til at anta at den var mere blandet arktisk-subarktisk end egentlig arktisk, og at vi i Norge kun har hat en egte „Dryas-tid" i de deler av landet som allerførst blev isfrie (det trondhjemske, vestlandets fjordegne med tilstotende fjeldtrakter, kystranden nordover), og at de lavere landsdeler i syd og ost som blev blotlagt senere, og som laa aapne for den sydlige indvandringsstrom, ikke har hat nogen veritabel Dryastid av høiarktisk præg. Her har ogsaa store strækninger ligget under hav i det kritiske tidsrum.

Imidlertid er der her en mulighet som ikke bør oversees, og som ØYEN har fæstet opmerksomheten ved. Hvis vi nemlig i Norge har hat en saadan senglacial klimatoscillation som Allerodperioden i Danmark (*Mytilus*-nivaaet) og betydelige deler av landet under denne tid var isfrie, maa dette ha været en gylden tidsalder for fjeldvegetationen (ØYEN 1915 l. c. p. 296), som dog atter i betydelig grad maatte bli decimert, ialfald i visse

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1 NORMAN (1855) er vistnok den første som har fremsat denne mening.

2 ØYEN 1907 B.

strok, under *Portlandia*-nivaaets nye bræfremrykning. Vi ser altsaa at ogsaa paa dette punkt er sporsmaalet om *Mytilus*- og *Portlandia*-nivaaets natur og specielt disse perioders klimatologiske valor av indgripende betydning.

Det bør efter ovenstaaende utredning ikke virke særlig overraskende naar vi i bunden av Gudbrandsdalens kalktuffer ikke finder rester av arktisk-alpine planter. Imidlertid har der i den forste tid efter isens endelige avsmeltning i disse strok ikke været gunstige betingelser for kalktufdannelse. Som tidligere omtalt viser baade Leine- og Gillebutuffen at den første tid efter isens forsvinden har været meget kontinental, kanske arid. Og den første flora og vegetation har derfor ikke efterlatt sig noget spor i tuffene. Det kan for den saks skyld godt ha været fjeldplanter, det kan ogsaa ha været en mere blandet vegetation. Vi vet heller ikke hvor længe dette tidsrum, som er indhyllet i morke, har varet.

III. Gudbrandsdalens kalktuffer og Blytts teori.

Blytt tok kalktuffene til indtægt for sin bekjendte teori om de vekslende torre og fugtige perioder efter den sidste istid (1876), ja han betragtet dem som vigtige stottepunkter for sin teori.

Om denne har stridens bolger altid gaat meget hoit. Man har kritisert Blytts torvmyrundersøkelser, og med en viss berettigelse, idet de ikke tilfredsstiller nutidens krav. Men saa hadde Blytt heller ikke det erfaringsgrundlag at bygge paa som senere forskere. — Blytts teori fremstilles ogsaa undertiden i litteraturen som et slags „skema“, som vel i sin tid hadde heuristisk betydning, men som nu forlængst har passert henover tidens slipesten. Imidlertid vil enhver der ser objektivt paa forholdene, maatte indromme at dette ikke er tilfældet. Den av Blytt hævdede opfatning er modificert paa mange maater; en hel del av hans meninger har tiden ogsaa visket ut. Men studerer man opmerksomt moderne skandinavisk kvartærgeologisk litteratur, skinner Blytts teori igjennem paa en række punkter.

Dette gjælder saaledes læren om stubbelagene i torvmyrene. Ved nyere svenske, danske og norske (Holmsen 1919 og 1920 l. c.) undersøkelser har det vist sig at ialfald det yngste av Blytts stubbelag har generel betydning i Skandinaviens myrer. Under den hydrofile „yngre Sphagnumtorv“ optrær en markert „uttorringshorisont“, som oftest i form av et stubbelag, hvis tilstedeværelse ikke kan forklares paa anden maate end ved den antagelse, at der dengang laget blev dannet, fremhersket et tort klimat, saaledes som Blytt antok. Disse to yngste lag i myrene benævnes nu almindelig den subatlantiske torv og den subboreale uttørkningshorisont[1]. Dette fænomen (den subatlantisk-subboreale kontakt) er nu beskrevet fra saa mange lokaliteter at man ingen grund har til at betvile dets generelle karakter. (Cfr. BLYTTS, SERNANDERS, VON POST'S og deres elevers arbeider, JESSENS nye studier i Danmark, HOLMSENS i Norge).

Under det subboreale stubbelag optræer der i myrene gjennemgaaende sterkt hydrofile torvdannelser, som av de forskere der akcepterer BLYTT-SERNANDERS opfatning, benævnes „atlantisk torv". Og under denne kommer i mange tilfælder atter et avbrud, „det boreale stubbelag", som forøvrig ikke synes at være saa sterkt markert som det subboreale (VON POST 1918 l. c., JESSEN 1920). Disse fire hovedled i torvmyrenes opbygning (ovenfra nedad):

subatlantisk torv,
subborealt uttorkningslag,
atlantisk torv,
borealt uttorkningslag,

gjenfinder man i alle de nyeste oversigter inden skandinavisk torvmyrlitteratur. Svenske forskere har ogsaa trukket frem en mængde andre fakta (bl. a. hydrografiske studier over avløpslose sjoer i boreal og subboreal tid[2]) som bekræfter ovennævnte periodiske vekslinger.

Hvad der ligger under det boreale lag, er derimot meget omdisputert. BLYTT antok oprindelig at der her fandtes et „subarktisk torvlag"; senere paastod han til og med at der under dette torvlag atter fandtes et ældre stubbelag (i de myrer som laa hoiest over havet), og han forandret da terminologien derhen, at torvlaget kaldtes „infraborealt" og stubbelaget „subarktisk" (sensu stricto). Imidlertid er det paafaldende, at ingen av de forskere som i nyere tid har arbeidet med torvmyrene, tydelig har gjenfundet disse to horisonter. De „præboreale" lag er forovrig lite bearbeidet (cfr. SERNANDERS uttalelser 1916 p. 136—138); men hvis forholdene hadde været saa markerte som BLYTT mente, vilde disse lag utvilsomt ogsaa faat sin rette plads i den kvartærgeologiske oversigt. De fleste palæobotanikere synes vistnok at helde til samme anskuelse som SERNANDER, nemlig at betegnelsen „subarktisk" bor anvendes om alt det som er ældre end det boreale lag (altsaa BLYTTS oprindelige betegnelse), og at dette navn kun er et uttryk for mere eller mindre usikre fysiografiske forhold („glidende utviklingsmomenter").

Allerede BLYTT forsøkte at faa istand en korrelation mellem torvmyrforskningens resultater og de marine nivaaforandringer i postarktisk tid; dog hadde han et høist utilstrækkelig materiale at bygge paa (1882 l. c. p. 8).

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1 WEBERS „grænsehorisont" (1910 l. c.), som udmerker Nordtysklands myrer.

2 SERNANDER 1910 (utforlig litteraturfortegnelse) p. 205, 213—214.

For Norges vedkommende har senest ØYEN søkt at sammenstille resultatene fra disse forskningsgrener. Og det eiendommelige er, at mens i torvmyrene de „præboreale" lag er daarligst kjendt, er i grunden det motsatte tilfældet med de norske marine avleiringer. Ved ældre geologers og i nyere tid BRØGGERS og ØYENS vidtløftige studier er de avleiringer som ligger mellem den marine grænse og Tapes-nivaaet, meget godt kjendt (BRØGGER 1900—1901, ØYEN (talrike avhandlinger)).

Da bræene for sidste gang stod ved de store indsjøer i det østenfjeldske Norge, hadde landplaten allerede begyndt at hæve sig en smule. Et klimatomslag begyndte nu at gjøre sig gjældende. Den yngste *Portlandia*-fauna dør ut, og isteden faar vi *Littorina-nivaaets* tempererte fauna[1]. Dette nivaa er meget utpræget baade i Kristiania- og Trondhjemsfeltet og udmerker sig ved fremtrædende skjælbanker (littorale avsætninger), derimot ved svak akkumulation, hvorfor ØYEN tolker denne periode som relativt kontinental.

Landet fortsatte imidlertid at hæve sig, og vi kommer over i en periode hvis avsætninger følgelig ligger lavere end de foregaaende. ØYEN kalder dette karakteristiske nivaa for *Pholas-nivaaet*. Det udmerker sig ved forekomsten av betydelige lerterrasser i Kristianiafeltet, altsaa en akkumulationsperiode. Det maa utvilsomt ha været en tid med rik vandføring og store slammængder i elvene, en relativt fugtig periode, hvis fauna var av sydvestlig præg og betydelig mere varmekjær end den foregaaende periodes.

Endelig opfører ØYEN *Mactra-nivaaet* som det tredje led i rækken; det udmerker sig atter ved manglende akkumulation, ved skjælbanker og ved en varmekrævende fauna. Efter *Mactra*-tiden synes der at ha skedd en tydelig sænkning av landplaten, som dog er liten baade ved Kristiania og Trondhjem, men som maa paralelliseres med „Littorina-sænkningen" i Sverige og Danmark. Denne fører os over i *Tapes-nivaaet* (sensu stricto), den fugtige atlantiske tid, atter med akkumulation og dannelse av lerterrasser.

At *Tapes-nivaaet* og den „atlantiske periode" falder sammen, derom synes nu alle kvartærgeologer at være enige. Under denne periode skal da det atlantiske torvlag i myrene være dannet. Og ØYEN paralelliserer da helt naturlig

Littorina-nivaaet	med BLYTTS	subarktiske tid (sensu stricto)
Pholas-nivaaet	—„—	infraboreale tid
Mactra-nivaaet	—„—	boreale tid.

Vi ser altsaa at de norske marine avleiringer stemmer med BLYTTS opfatning av de præboreale lag, og ØYEN finder derfor anvendelse for BLYTTS engere opdeling av den oprindelige „subarktiske" tid i to forskjellige avsnit.

ØYENS nivaa-inddeling for disse ældre postarktiske tidsrum er fast underbygget og anerkjendes nu av saagodtsom alle norske geologer (cfr.

[1] Dette nivaa maa ikke forveksles med „Littorina-tiden" i Sverige og Danmark.

BJØRLYKKE 1913, BRØGGER 1914). Saa meget er ialfald sikkert, at hvad de marine avleiringer angaar, saa kan vi i Norge meget vel karakterisere avsnittet mellem den marine grænse og Tapes-nivaaet, saavel faunistisk som klimatologisk. Men da kjendskapet til torvmyrenes præboreale lag er mangelfuldt, er det al grund til at være forsigtig og ikke generalisere ovennævnte resultater uten videre. Fremtiden faar avgjøre om vi ogsaa i præboreal tid har hat perioder synkrone for hele Skandinavien.

De avleiringer som er yngre end Tapes-nivaaet, er ogsaa meget interessante baade i Kristiania- og Trondhjemsfeltet. ØYEN har her indført betegnelsen „*Trivia-nivaaet*" efter et „faunistisk kompleks" (*Trivia europæa, Lima loscombi* og *Conulus millegranus*), som udmerker skjælbankene i et nivaa lavere end Tapes-nivaaet. Av faunaens utpræget sydlige og varmekjære karakter, den manglende akkumulation etc. utleder ØYEN at *Trivia-nivaaet* betegner den aller varmeste og aller tørreste del av den postglaciale varmetid. Dette gjælder tildels ogsaa første del av det efterfølgende nivaa, som ØYEN kalder *Ostræa-nivaaet*, som falder i et ældre og et yngre avsnit. Skillet mellem disse avsnit ligger ved en havstand av ca. 11 m., og Ostræa-nivaaets yngste avdeling synes at ha været relativt fugtigere og noget kjøligere end det ældre avsnit mellem 11 m. og 22 m. o. h.[1].

Nu skulde man tro at ØYEN vilde paralellisere sit Trivia-nivaa og første del av Ostræa-nivaaet med BLYTTS „subboreale" periode, som jo karakteriseres som varm og tør, og den anden del av Ostræa-nivaaet med den „subatlantiske periode". Imidlertid har BLYTT i den korrelationsoversigt som han utarbeidet, sat grænsen mellem disse to perioder ved en havstand 9,4 m.—13 m.

subboreal 15,7—13 m. o. h.
subatlantisk 9,4— 0 m. o. h.
(BLYTT 1882 l. c. p. 8, 9, 12—13 og 1892 p. 44—45).

Og til trods for at ØYENS nivaaer hvad strandlinjens beliggenhet angaar, ellers stemmer meget daarlig med BLYTTS (paa et mangelfuldt materiale baserte) beregninger[2], lar han her BLYTTS angivelser gjøre utslaget og paralelliserer kun Ostræa-nivaaets første del med BLYTTS subboreale og det samme nivaas senere del (under 11 m.) med BLYTTS subatlantiske periode. Paa denne maate blir Trivia-nivaaet staaende igjen uten relation til nogen av BLYTTS perioder, til trods for at det er mere markert kontinentalt og varmt end Ostræa-nivaaets første del. Trivia-nivaaets strandlinje gaar nemlig helt op til 47 m. o. h.

Følgen av det hele blir da den, at ØYEN blir nødt til at indføre to nye betegnelser: „neoboreal" for Trivia-nivaaet og „neoatlantisk" (= sub-

[1] Ostræa-nivaaets ældre avsnit skal dog ifølge ØYEN være en smule mere maritimt betonet end Trivia-nivaaet.

[2] Cfr. ØYEN 1915 l. c. p. 99.

boreal + subatlantisk) for Ostræa-nivaaet for at faa orden paa tingene. Men disse nye betegnelser, hvorav den sidste „neoatlantisk" likefrem bryter med hele traditionen i BLYTTS nomenklatur, idet her ordet atlantisk (ɔ: fugtig, maritim) anvendes som fællesbetegnelse baade paa en tør (subboreal) og en fugtig (subatlantisk) periode, bidrar bare til at øke nomenklaturvanskelighetene. Det store spørsmaal blir da om baade Trivia-nivaaet og første del av Ostræa-nivaaet skal paralelliseres med BLYTTS „subboreal". En kombinert studie av skjælbanker og lerlag mellem Tapes-nivaaet og nutidsstrandlinjen paa den ene side, og torvmyrer med utviklet subboreal—subatlantisk kontakt i det samme spatium paa den anden side, kan her alene si det avgjørende ord. Hvis nemlig Trivia-nivaaet, saaledes som ØYEN antar, har været den varmeste og mest kontinentale periode efter isens avsmeltning, maa torvmyrene utvilsomt bære vidnesbyrd herom i form av et stubbelag. Dette bør være meget markert, ialfald vel saa markert som den horisont som Ostræa-nivaaets første avsnit har efterlatt sig („subboreal" i ØYENS mening). Men hvis nu Trivia-nivaaet og Ostræa-nivaaet I begge har været hovedsakelig av kontinental natur, burde man a priori bare vente at finde ett yngre stubbelag (eller uttørkningshorisont) som vidnesbyrd om begge disse to avsnit[1] — hvilket jo ogsaa er tilfældet. — Paa dette punkt er korrelationen mellem de marine avleiringer og torvmyrene temmelig usikker.

Nedenstaaende skema viser korrelationen mellem ØYENS nivaaer og BLYTTS perioder:

Mytilus-nivaaet[2]	—	arktisk
Portlandia-nivaaet[2]	—	subglacial
Littorina-nivaaet	—	subarktisk (sensu stricto)
Pholas-nivaaet	—	infraboreal
Mactra-nivaaet	—	boreal
Tapes-nivaaet	—	atlantisk
Trivia-nivaaet	—	
Ostræa-nivaaet I }	—	subboreal
Ostræa-nivaaet II }	—	subatlantisk.

Jeg skal ikke her gaa nærmere ind paa disse detaljer. Sammenlignes ØYENS opfatning med de svenske torvmyrforskeres (SERNANDER, VON POST etc.), er der for saavidt en vigtig overensstemmelse som ØYEN meget bestemt henlægger det postglaciale klimatoptimum til tiden efter Tapes-nivaaet, mens man tidligere antok at den atlantiske tid betegnet klimaks[3]. Likeledes er det meget paafaldende at mens Tapes-nivaaet (sensu stricto) utpræger sig som en fugtig akkumulationsperiode, synes Trivia-nivaaets (og tildels første del av Ostræa-nivaaets) avleiringer

[1] Altsaa en „neoboreal-subboreal" fælleshorisont efter ØYENS terminologi.

[2] Denne periode er tidligere omtalt under kapitlet „Isavsmeltningen i Gudbrandsdalen".

[3] Cfr. BRØGGERS redegjørelse hos SERNANDER 1910 l. c. p. 226—227.

at vidne om kontinentale klimatforhold, som atter synes at slaa om ved 11 meters strandlinjen, dog uten voldsomme ændringer.

Imidlertid harmonerer dette ikke videre godt med den nyere svenske opfatning (SERNANDER, VON POST o. fl.), hvor den varme og tørre „subboreale“ tid henlægges til den yngre stenalder og bronsealderen, den fugtige „subatlantiske“ til overgangen mellem bronsealderen og jernalderen. ØYEN maa nemlig forlægge sit Trivia-nivaa og Ostræa-nivaa I meget længer bakover i tiden, da Trivia-nivaaets strandlinje ved Kristiania og Trondhjem gaar op til mellem 40 og 50 m. o. h., mens strandlinjen i bronsealderen synes at ha indtat omtrent samme stand som i nutiden (BRØGGER 1905 l. c.). Imidlertid kan vi f. eks. i Kristianiafjorden konstatere et andet omslag ved overgangen til nutidsstrandlinjen; en række sydlige og sydvestlige former utdør, og *Mya arenaria* indvandrer (ØYENS *Mya-nivaa* = recent tid). Denne er ikke fundet fossil over nuværende havstand (ØYEN 1915 l. c. p. 381). Den marine faunas utvikling vidner dog ikke om nogen voldsomme ændringer.

Hvorledes disse divergenser skal utjevnes, blir det den fremtidige forsknings sak at avgjøre. De stratigrafisk-biologiske fænomener som ligger til grund for hele denne lære om vekslende klimatiske perioder, er i begge tilfælder de samme, og alle ting tyder paa at vi har hat synkrone perioder for hele Norden. For saavidt skulde problemet ha utsigt til at bli endelig løst. Men dertil kræves nye undersøkelser og atter nye undersøkelser.

BLYTTS teori og SERNANDERS videre selvstændige utformning av samme har i likhet med ØYENS opfatning i disse spørsmaal været gjenstand for tildels voldsom kritik og imøtegaaelse. Og jeg kan saa godt forstaa at mange forskere finder den anførte inddeling og karakteristik av den postarktiske tid altfor indviklet. Det var meget lettere for videnskapen hvis alle disse mange perioder kunde undgaaes!

Men undersøkelsene ute i marken viser os atter og atter at forholdene har været meget komplicerte. Og læser man med opmerksomhet de nyere avhandlinger f. eks. av G. ANDERSSON, som kanske mere end nogen anden har stillet sig i opposition til klimavekslingsteorier, vil man finde at han ogsaa ganske tydelig maa ta sin tilflugt til variationer, ikke bare i temperatur, men ogsaa i nedbør, for at kunne forklare stratigrafiske og biologiske forhold. Saaledes skriver ANDERSSON (1909 S. G. U. Årsbok p. 77): „in the Baltic bassin after a period that was warmer and drier than the present, during the latter part of the Ancylus age, there followed gradually under the Littorina-age, an equally warm but much wetter period“ (senere anfører han en antat aarlig nedbørhøide av ca. 1 000 mm.). Samme forfatters uttalelser p. 67 og specielt i note 2 paa samme side er ogsaa ganske paafaldende. Man har her tydelig ansatser til en klimavekslingsteori, selv om periodene ikke blir helt synkrone med andre forfatteres.

Gaar vi derefter over til kalktufstudiet i norden, saa har det ogsaa bragt en lang række stratigrafiske og plantegeografiske eiendommeligheter for dagen, som viser at forholdene efter den sidste istid ikke har været helt enkle.

Efter Blytts avhandling i 1892, som maa siges at være klassisk inden denne forskningsgren, er der specielt fra svensk side kommet en lang række monografiske arbeider over svenske tuffer (Hulth, Kurck, Sernander, Halle, Kjellmark o. fl.). Av disse er kanske Skultorptuffen i Västergötland den som fortjener størst opmerksomhet, da den gir det mest sammenhængende og uforstyrrede billede av utviklingshistorien. Benestadtuffen i Skaane er ogsaa uhyre interessant og teoretisk betydningsfuld. Om Jemtlands tuffer maa man nærmest si at de stratigrafiske forhold der er mere problematiske og vanskeligere at tolke.

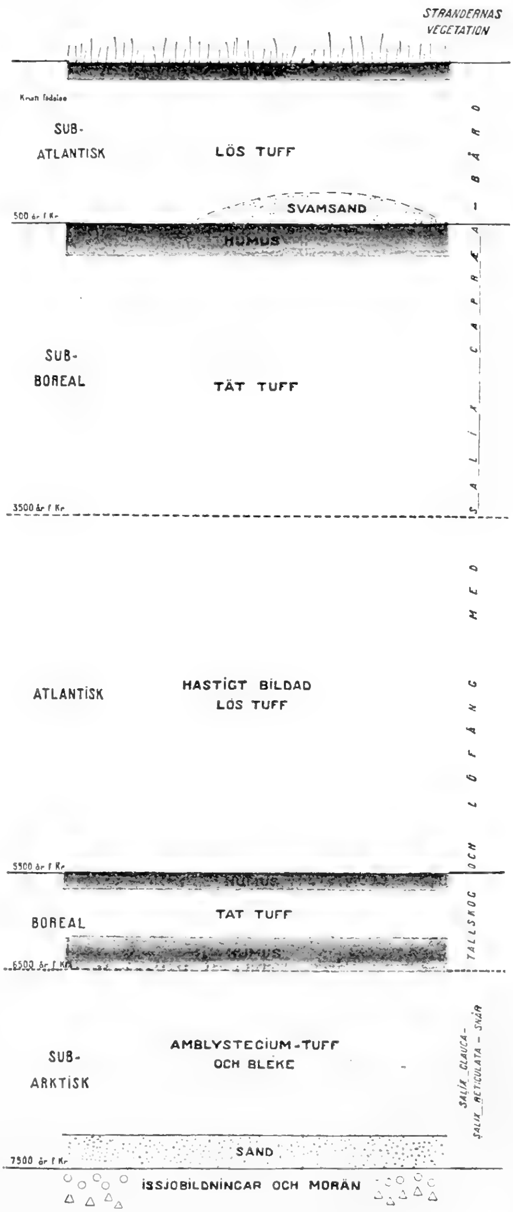

Fig. 35. Skultorptuffen. (Sernander 1916).

Det av Blytt for Gudbrandsdalens tuffer paaviste fænomen, at avsætningen ikke har paagaat kontinuerlig, men intermitterende, har senere vist sig at ha nærsagt generel betydning. Saaledes konstaterte Hulth for Skultorptuffen 2 markerte avbrud, karakterisert ved optræden av humusrænder i tuffen eller tydelige forvitringsfænomener. Hulth fandt 3 tydelige tufdannende perioder og 2 uttørkningshorisonter, og det laa da nær at paralellisere disse med de av Blytt og Sernander antatte klimatiske epoker (Hulth 1899 l. c.). At saagodtsom hele den postarktiske tid var repræsentert i Skultorpprofilet (fig. 35), fremgik av floraens gradvise forandringer; selv ikke de arktiske elementer manglet i bunden. Av Kurcks (1901) og senere Sernanders studier (1916 l. c.) fremgaar det at ogsaa Benestadtuffen har 2 avbrud; men paa grund av en omfattende eksploitering av denne kalkforekomsts øvre del, er de yngre lag, som indeholder det yngste („subboreale“) avbrud, fjernet over næsten hele omraadet og derfor vanskelig tilgjængelige (cfr. dog profilet fra Skvattemöllan, Sernander 1916 l. c. p. 160). — Endelig har vi Halles arbeide over den floristisk høist interessante Botarfve-tuf paa Gotland (1906 l. c.), som foruten en del smaa lokale avbrud viser én markert muldstripe gjennem hele tuffen. Da findestedet har ligget under hav til langt ut i den postglaciale varmetid, burde man her ogsaa a priori vente at finde bare ett distinkt avbrud, idet nemlig ældre lag svarende til ovennævnte tuffers undre deler, ikke har kunnet komme til utvikling paa stedet. Ogsaa fra andre deler av Sverige er der beskrevet mindre kalktuffer med humusrænder.

Av nærværende avhandling vil det ogsaa fremgaa at Gudbrandsdalens tuffer, saaledes som vi nu kjender dem ved Øyens og Holmes samt undertegnedes nye undersøkelser, taler et meget bestemt sprog og stemmer godt overens med de resultater som svenske kalktufforskere er kommet til.

Ja, undertegnedes studier over Leinetuffen har til og med git det forbløffende resultat, at denne stemmer meget bedre med klimavekslingslæren end Blytt selv ante.

Blytt var selv til en begyndelse meget i tvil om hvorledes Leinetuffen burde tolkes. I sin første beskrivelse (Naturen 1891) tolker han furutuffen som synkron med det yngste torvlag i myrene (subatlantisk). Dryastuffen blev da subboreal og birketuffen samtidig med det næstyngste torvlag, altsaa atlantisk:

Furutuf — subatlantisk
Dryastuf og kalkler — subboreal
Birketuf — atlantisk.

Imidlertid bragte kalktuffen ved Nedre Dal ham bort fra denne tolkning; han ansaa det nemlig høist usandsynlig at en birketuf av subalpint præg paa saa lavt nivaa som Nedre Dal kunde skrive sig fra en saa ung periode som den atlantiske, der tvertom, efter andre undersøkelser at dømme, syntes at ha været varmere end nutiden. Blytt forkaster derfor den første forklaring og hævder at tuflagene maa være ældre (1892). Den nye korrelation blev da:

Furutuf — atlantisk
Dryastuf — boreal
Birketuf — infraboreal.

Imidlertid maa dette siges at være en temmelig dristig tolkning; for konsekvensen av det hele blir at der i Gudbrandsdalen ikke har været nogen tufdannelse under den sidste av BLYTTS fugtige perioder, den subatlantiske tid. Med andre ord: Torvmyrenes subatlantiske torvlag og subboreale uttorkningshorisont, som jo netop har vist sig at være de mest generelle, skulde altsaa ikke ha nogen ækvivalent i Gudbrandsdalens tuffer.

At BLYTT selv har undret sig over forholdet, fremgaar tydelig av det citerte arbeide. Han skriver nemlig (l. c. p. 23): „Man maa jo ogsaa let tænke sig at kalkgehalten i grunden kan uttommes saa at de senere fugtige tider kan gaa hen uten tufdannelse. Ja da vi ved Nedre Dal saa at furutuffen laa ved siden av birketuffen og ikke over den, er endog den mulighet forhaanden, at yngre tuflag kan findes baade ved Nedre Dal og Leine[1], ihvorvel jeg anser dette for lite rimelig."

Omtrent 30 aar efter at disse uttalelser fremkom, lykkedes det imidlertid undertegnede ved Leine virkelig at fremfinde et yngre tuflag (*Alnustuffen*), som hviler diskordant paa furutuffen. Og vi kan nu med bestemthet si at den subboreale uttorkningshorisont og det subatlantiske torvlag har sin fuldstændige stratigrafiske motsvarighet inden Leinetuffen.

Denne kalktuf tvinger os nu simpelthen ind i BLYTTS tankegang:

Alnus-tuf — subatlantisk
Forvitring og diskordans — subboreal
Furutuf — atlantisk
Xerofil Dryasmatte og diskordans — boreal
Bladtuf og mosetuf — subarktisk (i videste forstand).

Som jeg før har nævnt, bygger Alnus-tuffen paa en udmerket maate bro over til nutidsforholdene, hvilket ogsaa befæster ovenstaaende korrelation.

Jeg var selv oprindelig temmelig skeptisk overfor BLYTTS tolkning av tuffene, idet jeg nemlig i likhet med mange andre fandt hele dette indviklede system av perioder en smule usandsynlig. Og jeg fandt ogsaa det fænomen, at de to sidste perioder, som andre steder i Skandinavien er de mest markerte, skulde ha gaat sporløst hen over dalens tuffer, noget mystisk. Men naar man saa en vakker dag finder netop det som BLYTT savnet, men hvis tilstedeværelse han i grunden har forutsagt, er dette altfor paafaldende til at bero paa nogen tilfældighet.

Naar man videre ser hen til at nøiagtig de samme perioder og avbrud synes at komme igjen i Gillebu—Tingvoldprofilene (ØYEN 1920) (avleiringene fra den sidste periode dog i en noget modificert, men utpræget form), maa man uvilkaarlig studse. I likhet med Skultorp og Bene-

[1] Uthævet her.

stadtuffen viser baade avsætningene ved Leine og Gillebu—Tingvold 3 tydelige opsvulmninger av de virksomme kilder og 2 avbrud i avsætningen. Overensstemmelsen med torvmyrforskningens resultater og de marine avleiringers vidnesbyrd er likeledes paafaldende.

Alt i alt maa man ogsaa indromme, at klimavekslingsteorien paa en utvungen maate formaar at løse alle disse stratigrafiske problemer. Vi har for tiden ingen anden arbeidshypotese som er bedre[1]. Og akcepterer man ikke denne forklaring, blir Gudbrandsdalens kalktuffer en eneste lang række av spørsmaalstegn, en indviklet serie av merkelige og uforklarlige, men lovmæssige vekslinger.

Jeg stiller mig skeptisk overfor mange av de konsekvenser som Blytt i sin tid trak av sin teori. Saaledes tror jeg at hans floristiske grupper tildels er grove skematiseringer, og at vor flora ogsaa gjemmer problemer som Blytt ikke var opmerksom paa. Hans plantevandringslære indeholder sikkert ogsaa store overdrivelser og mange ensidige synsmaater.

Men hvad der for undertegnede i denne forbindelse staar som hovedsaken, er selve klimavekslingslæren som kvartærgeologisk arbeidshypotese. Til trods for de mange divergerende opfatninger som her ogsaa gjør sig gjældende, maa man dog indrømme at denne fremdeles er et aktuelt centrum — eller stormcentrum — i nordisk kvartærgeologi[2].

Korrelation.

Blytts perioder	Leine	Gillebu—Tingvold	Nedre Dal
Recent tid	Forvitring, svak mosetufdannelse	Forvitring	Forvitring
Subatlantisk	Alnus-tuf	Erosion med avsætning av grus og tufstykker paa sekundært leiested	Utglidning?

[1] Cfr. Sandegrens oversigt over svensk kvartærgeologisk forskning i sidste hefte av Geol. Fören. Förh. Stockholm 1921, hvor den Blytt-Sernanderske teori og dens store betydning belyses paa en udmerket maate.

[2] Henrik Printz har i sit netop publicerte store arbeide over „The vegetation of the Siberian—Mongolian Frontiers" (l. c.) git en række interessante oplysninger om klimatiske forandringer i de angjældende trakter av Asien i nutiden (forskyvninger i steppens utbredelse paa skogens bekostning som en følge av klimaets utvikling i tør retning). Printz synes ogsaa at ville søke forklaringen herpaa i Blyttsk retning, og hans arbeide turde faa betydning for diskussionen om den „subboreale" periodes klima og plantevekst.

Blytts perioder	Leine	Gillebu—Tingvold	Nedre Dal
Subboreal	Forvitrings-horisont	Forvitring	?
Atlantisk	Furutuf	Furutuf	Furutuf
Boreal	Dryastuf og diskordans	Jordstripe	Diskordans
Subarktisk	Bladtuf og mosetuf	Bladtuf	Bladtuf
(I Gudbrandsdalen 2 forskjellige avsnit, det ældste meget kontinentalt)	Rød lere	Forvitret moræne, anrikning av jernforbindelser	?
Sidste isbræ	Morænelere med blokker	Morænegrus	Moræne

IV. Bemerkninger om Gudbrandsdalens plantevekst i postarktisk tid.

I det følgende skal jeg behandle de enkelte avsnit i kalktuffenes utviklingshistorie mere indgaaende og omtale de konsekvenser som ovenstaaende korrelation medfører.

A. Den subarktiske tid.

Jeg anvender her Blytts oprindelige og videste betegnelse, idet jeg ikke føler mig helt overbevist om at Blytts „infraboreale“ og „subarktiske“ (sensu stricto) perioder er av generel natur. Paa dette punkt maa man avvente torvmyrforskningens resultater med hensyn til de „præboreale“ lag.

Jeg har allerede under gjennemgaaelsen av tuffene omtalt den kontinentale periode umiddelbart efter isens endelige avsmeltning i dalen, som udmerket sig ved forvitrings- og oksydationsfænomener i overflatelagene. Vi har her et forhold som er av stor betydning for diskussionen om tuffenes alder og opstaaen.

Andersson og Birger, som omtaler baade Jemtlands og Gudbrandsdalens tuffer i sit store arbeide om Norrlands flora (1912), uttaler følgende herom:

„Det torde kunna starkt ifrågasättas om ej kalktuffernas i tiden uppenbarligen skarpt lokaliserade förekomst, kan ställas i samband med den stora mängd grundvatten som tillfördes dessa kalktrakter just i samband med isens afsmältning. — — — — Tuffbildningen skulle, om ofvan framkastade möjlighet visar sig riktig, icke statt i samband med någon „vat" period, som flera forskare förmodat, utan med afrinningen af den sista delen af den i inlandsisen under årtusenden magasinerade nederbörden" (l. c. p. 144—145). Om Jemtlands tuffer uttaler forfatterne senere: „Enligt här häfdade uppfatning skulle de egentliga kalktufferna till alldeles öfvervägande del bildats under några århundraden alldeles vid tiden för de sista isresternas definitiva afsmältning." Leine og Nedre Dal „ligga i ungefär samma läge till dessa trakters isdelare, som de jämtländska tufferna (fig. 20) och ha en i alla detaljer fullständigt motsvarande flora" (l. c. p. 145), og forfatterne synes at ville utstrække den samme forklaring til ogsaa at gjælde disse norske tufforekomster.

Av redegjorelsen i nærværende arbeide vil det imidlertid fremgaa at tufdannelsen i Gudbrandsdalen slet ikke har begyndt i tilslutning til isavsmeltningen, men først senere. Der er et markert og eiendommelig interval imellem, som antageligvis ikke har været helt kortvarig. Den av Andersson og Birger hævdede opfatning maa altsaa forkastes. Desuten er baade Leine- og Gillebu—Tingvold-avleiringene saa avvekslende og indviklede, at det bare av den grund er en umulighet at anta at altsammen er dannet i løpet av nogen aarhundreder, ved den tid da de sidste isrester avsmeltet. Paa forfatternes kartskisse (fig. 20 l. c. p. 138), hvor isskillet og kalktuflokalitetene er indlagt, er isskillet over det østenfjeldske Norge ogsaa indtegnet feilagtig; det er placert like nord for Nedre Dal, passerer altsaa ret over Gillebu i Øier herred. Og Leine er anbragt et godt stykke nordvest for isskillet, hvilket altsammen ikke stemmer med de faktiske forhold, saaledes som disse for længe siden er klarlagt av Rekstad og Øyen. Isskillet laa nemlig flere mil høiere oppe i dalen end Leine, saaledes som jeg før har omtalt.

Da Gudbrandsdalen i nutiden har et utpræget kontinentalt klimat, sammenlignet med andre deler av vort land, er det forbundet med adskillig risiko at ville generalisere den kontinentale periode hvorom tuffenes underlag bærer vidnesbyrd. Fordi om forholdene var ekstreme oppe i dalen, behøver dette ikke at ha været tilfældet andre steder i landet.

Da Øyens *Littorina-nivaa* repræsenterer den første tid efter isens endelige avsmeltning, og udmerker sig ved svak akkumulation og typisk skjælbankedannelse baade i Kristiania- og Trondhjemsfeltet, betragter Øyen forvitringshorisonten i bunden av kalktuffene som et hermed overensstemmende og synkront fænomen, med andre ord: perioden skal ifølge Øyen allikevel ha været av generel natur (1920 l. c. p. 335).

Hvorledes Gudbrandsdalens plantevekst var beskaffen i den allerførste tid efter isens forsvinden, er uvisst. Da kildene begyndte at springe frem som en følge av øket nedbør, fandtes der en subarktisk løvtrævegetation baade ved Leine, Gillebu og Nedre Dal. Ved Leine har vistnok enkelte fjeldplanter været tilstede. Man faar et levende indtryk av at Gudbrandsdalen maa ha frembudt et billede som et av vore subalpine dalfører med frodige bjerkelier tilblandet asp, heg og Salices (baade grønne og graalodne).

Forekomsten av furupollen kan bero paa en sporadisk optræden av furu paa specielt gunstige lokaliteter; men som før nævnt er langflugt ikke utelukket[1]. Flere ting vidner ialfald om at furuen maa ha været løvtrærne helt underlegen.

Ved Gillebu dækkes tuffen og bækkedalens omgivelser i nutiden av en blandet furu- og granskog, som er meget vakker. Terrænget passer ogsaa udmerket for furu (utvasket morænegrus); at granen her som alle andre steder har presset sig frem paa furuens bekostning, er en sak for sig. Vi har ogsaa set at under furutuffens tid har findestedet hat typisk furuskog. Hvis nu furuen under subarktisk tid hadde været almindelig i Øier rundt omkring findestedet, hvorfor skulde den da „tilfældigvis" mangle netop paa denne lokalitet, hvor den i den efterfølgende periode (furutuffens tid) synes at trives fortrinlig, til trods for at jordbundsforholdene hele tiden er de samme, og likeledes i nutiden?

Det samme gjælder Leine. Under furutuffens tid har lerbakkene og tufkildens nærmeste omgivelser været rigtig et ønskested for furuen, at dømme efter den kolossale masse med avfald som tuffen indeholder. Skal ogsaa her den typiske bladtufbænk, uten makroskopiske fururester, skrives paa tilfældighetenes regning? Mangler furuen her bare fordi der „tilfældigvis" stod en hel del løvtrær „iveien" netop paa tuffindestedet?

Hvis fænomenet kun hadde været karakteristisk for én av lokalitetene, kunde et saadant standpunkt forsvares. Men ogsaa tuffen ved Nedre Dal, som ligger paa dalens sydside like i nordvest for Lillehammer, med østlig eksposition, viser den samme mægtige bladtuf. Alt dette tyder med bestemthet paa at vi her i det centrale Norge i subarktisk tid har hat en dominerende subalpin løvtrævegetation, en klimatisk betinget bjerk—aspperiode, selv om furuen sandsynligvis allerede paa dette tidspunkt var indkommet til dalen.

Spørsmaalet om pollenets langflugt er endda ikke tilfredsstillende utredet. At man ikke bør negligere denne feilkilde, fremgaar kanske bedst av Hesselmans forsøk paa fyrskibene utenfor Sveriges kyst, hvor pollenregnet paa havet var ganske paafaldende (1919 l. c.). Det omdisputerte furupollen paa Novaja-Zemlja bør ogsaa mane til forsigtighet. Jeg har selv under en geologisk ekskursion til Finse (september 1914) indsamlet løvblader av asp, bjerk og or (eller hassel) paa Hardangerjøkelen flere

[1] Holmsens opsats om pollen i kalktuf har ikke været mig tilgjængelig under manuskriptets utarbeidelse (trykt i sidste hefte av Norsk Geol. Tidsskrift 1921).

mil fra de nærmeste forekomster baade i øst og vest[1]. Fra Alperne er lignende fund (bokeblader) fra en række bræer omtalt i SCHRÖTERS „Das Pflanzenleben der Alpen" (p. 738). Bekjendt er ogsaa „salthaglen" paa Gotthardt i 1870; de saltkrystaller som her faldt til jorden (op til 0,76 gr.), maa mindst ha passert 250 à 300 km.s veilængde (fra Genua eller Venedig), kanske betydelig længer. Ytterst interessant er likeledes KERNERS oplysning (Pflanzenleben I, 1888 p. 36) om, at han i alle de prøver av „rød sne" som han har undersøkt fra Alpernes gletschere, har fundet pollen av forskjellige naaletrær. — Fordi om furupollen er fundet i bladtuffen ved Leine, er det forhastet at trække den slutning, at træet har vokset i nærheten. Blomsterstøvet kan med opstigende luftstrømmer være kommet længer nedenfra dalbunden, kanske langveisfra[2].

Spørsmaalet om der i Skandinavien har været en almindelig „bjerk asp-periode", saaledes som STEENSTRUP oprindelig antok, er i den senere tid hyppig diskutert.

STEENSTRUPS opfatning (1842 l. c.) synes nu mere og mere at maatte opgives. Allerede i 1894 undlot SERNANDER i sine „Studier öfver den gotländska vegetationens utvecklingshistoria" at medta nogen bjerk—asp-tid for denne ø, da han ikke fandt beviser herfor i Gotlands myrer. HOOPS fremhæver i 1905 med bestemthet at hverken i Nord- eller Mellem-Europa har bjerk og asp alene været dominerende efter isens avsmeltning, men furuen har fulgt like efter de nævnte træsorter, ialfald ubetydelig senere. L. VON POST mener paa grundlag av pollenanalyser helt at maatte stryke bjerk—asp-perioden i det sydlige Sverige (1918 l. c.). Og helt nylig har K. JESSEN for Sjællands vedkommende hævdet at „Rene Birke—Bævreaspskove i den Forstand, at Skovfyr manglede i dem, synes ikke at have været eneherskende i Nordostsjælland. Baade makroskopiske Rester og anseelige Mængder af Pollen af Fyr er fundne saa dybt i den alluviale Gyttje som til nogle faa cm. fra Dryaslerets Overkant" (l. c. p. 221). HOLMSENS nye undersøkelser i Norge synes ogsaa, saavidt jeg har kunnet erfare av de foredrag han har holdt, tildels at gaa i samme retning. Baade HOLMBOE (1903) og WILLE (1915) opfører imidlertid en „Bjerkeperiode" for Norge.

Da det STEENSTRUPIANSKE skema ogsaa i andre henseender ikke synes at svare til de faktiske forhold (VON POST 1918 l. c.), er der ingen grund til at holde paa det. Men jeg tror dog, at Gudbrandsdalens tuffer paa dette punkt taler et sprog som ikke helt kan negligeres. Der synes i det centrale Norge virkelig at ha været en bjerk—asp-periode,

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[1] Konservator J. LID, Kristiania, har meddelt mig, at han flere ganger har konstatert at løvblader blaaser over fra Hardanger til Voss.

[2] En pollenundersøkelse av den slaggagtige mosetuf (allerunderste horisont ved Leine), bragte uhyre sparsomt bjerkepollen for dagen, og i de 10 præparater (dækglas 18 × 18 mm.) som blev gjennemset, fandtes kun et eneste pollenkorn av furu. Dette kan skyldes forurensning og kan ialfald ikke tillægges nogen avgjørende betydning.

om end ikke saa decidert som palæobotanikerne i sin tid antok[1]. Det er ingen grund til at anta at forholdene i Gudbrandsdalen har stemt fuldstændig overens med forholdene paa Sjælland eller i Mellem-Sverige; i nutiden er jo forskjellen betydelig mellem disse omraader.

Blytt har i sin avhandling trukket en hel del konsekvenser av den subarktiske bladtufs forekomst i bunden av tuffene. Han har utvilsomt ret i at klimatet dengang var koldere end nu (1892 p. 27); ti alle de iagttatte planter og snegler er subalpine, tildels alpine; ingen sydlig art er fundet. Dette er saa meget mere paafaldende som baade Leinebakkene, Gillebuskraaningen og lien ved Nedre Dal i nutiden opviser en mængde sydlige, varmekjære arter. Men naar Blytt desuten paa grundlag av de manglende makroskopiske fururester hævder at hele Gudbrandsdalen fra Mjøsen av har ligget over furuens grænse i denne første tid, kan neppe dette ræsonnement betragtes som overbevisende, selv om det er fuldt logisk konsekvent. Furupollenets forekomst staar her iveien og maner til forsigtighet. Jeg skulde anta at Leine har ligget over furugrænsen, og at denne har ligget betydelig lavere end i nutiden; men opfatningen paa dette punkt maa nødvendigvis bli noget subjektiv.

Den subarktiske bladtufbænk er meget vigtig, idet den viser os at allerede i denne periode hadde bræene i det centrale Norge trukket sig tilbake til høifjeldet. En vedvarende ispolse over midtre del av Gudbrandsdalen helt til boreal tid er saaledes en levende umulighet; vi har her frodig løvskog hele veien fra Kvam til Faaberg. Under omtalen av Jemtlands tuffer kommer jeg tilbake til dette vigtige punkt.

En speciel interesse knytter sig til forekomsten av *Hippophaës rhamnoides* ved Gillebu og den undre *Dryas*-horisont ved Leine. *Hippophaës* og dens indvandring vil bli nærmere behandlet i det specielle avsnit „Hippophaës-problemet". Hvad vi her særlig skal merke os, er at denne busk er en av de planter som har lettest for at tape i konkurrencen med andre trær og busker. Av hele dens forekomstmaate i nutiden har en række botanikere trukket den bestemte slutning, at *Hippophaës* i høi grad er lyselskende, og at dens værste fiende er tætte bestander av skogdannende trær. Derfor formaar den i nutiden kun at hævde sig dels paa strandkanter langs Nordeuropas kyster, hvor andre planter ikke kan gjøre den rangen stridig (flyvesand, storstenet strand, overalt lokaliteter hvor konkurrenceforholdene er lette), desuten langs flodbredder og gruset-stenete bækkedaler i Mellemeuropa og Centralasien, hvor likeledes konkurrenceforholdene er lette paa grund av den urolige jordbund. I klimatologisk henseende er den indifferent i høi grad, idet den kan trives saavel langs Norges og Englands nedbørrike kyst som i Asiens

[1] Allerede ovenfor (Generel del, avsnit II) har jeg berørt dette problem under omtalen av plantevandringer fra Norge og østover ind i det centrale Sverige.

orkentrakter (KÖPPEN l. c. p. 644). Den gaar i Himalaya 5000 m. o. h., i Alperne 1900 m. o. h. (ifølge meddelelse fra Dr. H. GAMS, München).

Forekomsten av *Hippophaës* i det centrale Norge i subarktisk tid viser at forholdene her har været ganske eiendommelige, og taler til gunst for den opfatning, at lysaapne bjerkeskoger har været fremherskende.

Det er likeledes høist interessant at *Hippophaës* blir mere sporadisk opover i bladtuffen, og at den forsvinder med denne, altsaa før furutuffens dannelse begynder. Da jordstripen ved Gillebu maa tolkes som boreal, kan man med god grund paastaa, at Hippophaës i Gudbrandsdalen utdør under boreal tid eftersom furuskogen tykner til, og at vi netop i furuens sukcessive dominans har aarsaken til artens utdøen (beskygning)[1]. I det hele tat kaster *Hippophaës* et eiendommelig lys over denne subarktiske periode. Livskaarene maa for plantene tildels ha været ganske ekstraordinære, og dette tidsrum gjemmer utvilsomt paa mange botaniske hemmeligheter som nok kunde gi os nøklen til forstaaelsen av visse arters eiendommelige utbredelse i nutiden.

Den undre Dryashorisont ved Leine supplerer *Hippophaës* paa en udmerket maate. Rigtignok er *Dryas octopetala* økologisk set en noget anden type end *Hippophaës*, men begge er lyselskende, og det er ganske paafaldende, at det ved Leine er furuen som i slutten av boreal (senboreal) tid gjør ende paa fjeldplantene i likhet med *Hippophaës* ved Gillebu (cfr. den lokale „klidagtige“ förna-tuf ved Leine med de sidste *Dryas*-blader). I furutuffen finder man hverken *Dryas*, *Salix reticulata* eller *Hippophaës*. Der er her en lovmæssig paralellitet tilstede mellem furuens tiltagende kvantitet (fra subarktisk til senboreal tid) og ovennævnte fotofile planters avtagende frekvens og utdøen, som ikke beror paa tilfældigheter. Og disse rent biologiske forhold bekræfter efter min mening den opfatning som jeg ovenfor har gjort gjældende med hensyn til Gudbrandsdalens plantevekst i subarktisk tid. Disse fænomener er ogsaa av den største betydning naar vi senere skal prøve at sammenbinde Jemtlands og Gudbrandsdalens kalktuffer.

B. Den boreale tid.

Under boreal tid har tufavsætningen stadig avtat og snart ophørt saagodtsom fuldstændig, og isteden indtrær forvitring baade ved Leine og og Gillebu. Samtidig med denne avtagen i fugtighetsforholdene ændres vegetationens karakter. En xerofil Dryasmatte utbrer sig ved Leine paa den fugtige bjerkeskogs bekostning eftersom lerbakkene tørres mer og mer ut, og til slut finder vi her en meget aapen og spredt bjerk-furuskog, som har tillatt en bundvegetation av fotofile arter. Furuen gjør nu sin indtræ-

[1] Cfr. SIEGRIST, R.: Die Auenwälder der Aare l. c. Her findes ypperlige eksempler paa hvorledes furuen langs flodbredder i Schweiz dræper *Hippohaës*-bestandene (p. 156—157).

delse paa findestedet, utvilsomt som en følge av gunstigere klimatiske forhold (høiere sommertemperatur), og fordi den subalpine løvskogs magt nu er brutt. Ved Leine er vi videre i den heldige situation, at vi kan konstatere hvorledes furuen utvider sig jevnt og sikkert og til slut bringer *Dryas* og de andre fjeldplanter til undergang paa grund av den tiltagende beskygning (i senboreal tid).

Det samme har utvilsomt været tilfældet ved Gillebu, hvor *Hippophaës* møter samme skjæbne. Imidlertid fortæller den jordstripe som her ækvivalerer Dryastuffen, intet om periodens plantevekst.

Blytt betragtet Dryasmatten ved Leine som et lokalfænomen, beroende paa lokalitetens store høide over havet (l. c. p. 11). Og mine undersøkelser har vist at vi ikke noget andet sted i Gudbrandsdalen har antydning til nogen Dryastuf. Derimot finder vi stratigrafisk og genetisk likeværdige horisonter i form av jordstriper eller diskordanser. Dryastuffen ved Leine er imidlertid betydningsfuld i flere henseender. Jeg har tidligere nævnt at lerbakkene i boreal tid maa ha frembudt et enestaaende syn. Specielt er denne masseoptræden av *Dryas* interessant, naar man tar i betragtning at planten i nutiden hverken findes i lerbakkene eller paa skiferklippene høiere oppe, eller i skraaningen under Tunsbergfjeldet.

Paa den anden side er det utænkelig at *Dryas*, dengang den vokste paa tuffindestedet, ikke ogsaa fandtes paa skiferklippene. Disse har i boreal tid sikkert været dækket av en Dryasmatte. Følgende plantearter, som allesammen vokser paa klippene i nutiden (cfr. fortegnelsen i den specielle del p. 11), indgaar i *Dryadeta octopetalae* som jeg har studert baade ved Finse og paa Sylene:

Antennaria alpina	*Gentiana tenella*
Astragalus alpinus	*Juncus trifidus*
Carex capillaris	*Poa alpina*
Carex sparsiflora	*Poa cæsia*
Cerastium alpinum	*Parnassia palustris*
Cetraria nivalis	*Polygonum viviparum*
Draba hirta	*Potentilla verna*
Draba incana	*Selaginella spinulosa*
Gentiana nivalis	*Veronica saxatilis*

Flere av disse er til og med typiske indikatorer paa denslags løs, smuldrende skiferbund som *Dryas* netop ynder. Antageligvis er flere av disse arter at betragte som associations-relikter fra den tid da Dryadeta i boreal tid dækket skraaningene. I motsætning til *Dryas* selv har de klart sig under varmetiden med dens hævning og ekspansion av furuskogen i disse trakter. Dog er det mulig, at enkelte arters forekomst i dette nivaa ogsaa skyldes senere nedvandring, i tiden efter det klimatomslag som gjorde ende paa varmetiden og rykket skogen nedover igjen. En ting er ialfald sikker: *Dryas* selv døde her ut under furuskogens første tid og har endda ikke formaadd at spre sig paany til disse skiferbakker eller længer nedover lien.

Naar situationen for Leines vedkommende faktisk var den, at *Dryas*, *Salix reticulata* etc. i boreal tid hadde en meget større utbredelse end i nutiden, maa man ha lov til at generalisere dette fænomen ogsaa for andre høiereliggende strækninger i dalen. Den boreale tid synes at ha været gunstigere for fjeldplantene end nutiden; antageligvis har regio alpina dengang været større end den nuværende. Alting tyder paa at isen under denne tid var avsmeltet omtrent til sin nuværende lokale utbredelse i norsk høifjeld, og fjeldfloraen synes i denne tid før skoggrænsen begyndte at bevæge sig opad, at ha hat glimrende betingelser. Dryastuffen ved Leine kan ikke tolkes paa nogen anden maate. At furuen her kommer til sammen med *Dryas*, viser at vi her saa at si befinder os i den undre grænse for fjeldplantenes domæne. Ned til Gillebu og Nedre Dal har de ikke evnet at komme.

Spørsmaalet om „regio subalpinas" og „regio alpinas" tidligere utstrækning under de postarktiske perioder sammenlignet med nutidsforholdene, er blit mere og mere aktuelt i de senere aar. Da furuen som bekjendt under varmetiden (specielt under optimum) gik 150—300 m. høiere tilfjelds end nu, antok man oprindelig at ogsaa bjerkens øvre grænser var forskjøvet opad i tilsvarende grad, til trods for at de palæontologiske fakta ingenlunde kunde siges at bevise at saa hadde været tilfældet. Fund av fossile bjerkerester ovenfor grænsen for fossil furu er nemlig meget sjeldne (Birger 1908, Smith 1911, Fries 1913, Smith 1920), og hele spørsmaalet er saagodtsom ikke utredet (cfr. Tengwall 1920 l. c. p. 285). Desuten hviler den tankegang som ligger til grund for denne analogi-anskuelse, paa et postulat, nemlig at bjerkens og furuens avhængighet av sommertemperaturen ikke er væsensforskjellig, kun kvantitativt forskjellig (furuen synes at kræve betydelig høiere sommertemperatur end bjerken).

Imidlertid er svenske botanikere ved sine nyere undersøkelser kommet til det resultat, at skoggrænseproblemet er vanskeligere at løse end man oprindelig tænkte sig (Fries 1913, 1918, Tengwall 1920, Smith 1920 l. c.). Det ser nemlig ut som om ikke alene sommertemperaturen for bjerkens vedkommende bør være over et visst minimum; bjerken synes desuten at kræve en vegetationsperiode av en viss længde, som ikke maa avknappes (ɔ: bjerken kræver for at kunne leve en minimumstid i hvilken den kan utføre alle sine normale livsfunktioner, hvilket selvfølgelig forutsætter at ogsaa temperaturen den hele tid befinder sig over et visst lavmaal). Man har nu videre tænkt sig, at kanske varmetidens klima (ialfald under optimum) var av den natur at vistnok den gjennemsnitlige sommertemperatur har været høiere end nu, men selve vegetationsperioden (tiden mellem løvspræt og løvfald) behøver ikke at ha faat en tilsvarende forlængelse, med andre ord: furugrænsen kan ha bevæget sig opad 150—300 m. høiere end i nutiden (hvilket er konstatert), men vi har ingen ret til at slutte det samme om bjerken. Bjerkegrænsen kan for den saks skyld gjerne ha ligget relativt stille eller kun undergaat svingninger i mindre skala. Ja, man maa regne med den mulighet, at i postglacial tid har kanske furuen, altsaa et naaletræ, dannet baade skoggrænsen og trægrænsen i de skandinaviske fjeldtrakter i likhet med forholdene i Alperne, Sibirien o. s. v. i nutiden. Det nuværende bjerkebelte eller „regio subalpina" skulde da i overensstemmelse hermed være et forholdsvis recent fænomen, opstaat efter varmetidens slut (furuen har rykket ned, mens bjerken er blit staaende, eller har ialfald ikke rykket saa langt ned som den første; de har opført sig forskjellig og uavhængig av hinanden).

Dette ræsonnement, som i første række skyldes Dr. Th. C. E. Fries' epokegjørende studier i Torne lappmark, er ialfald teoretisk set meget vigtig og skjærper problemstillingen i høi grad, likesom det angir retningslinjene for den fremtidige forskning.

Selv om Gudbrandsdalens tuffer, paa grund av furuens noget tvilsomme stilling i den første tid, ikke taler et helt avgjørende sprog paa dette punkt, synes det mig dog tvingende nødvendig at anta at vi i subarktisk (vistnok ogsaa i boreal) tid, altsaa før den egentlige varmetid, har hat en subalpin bjerkeskogsregion i det centrale Norge likesom i nutiden, fremkaldt av et subalpint klima, men med andre grænser end i nutiden.

Om regio alpina, hvis utstrækning hænger paa det nøieste sammen med regio subalpinas, uttaler Sernander som sin mening (Herjedalen 1910 l. c. p. 208) at „regio alpina icke en gång omedelbart efter isens afsmältande kunnat vara mera utsträckt än i nutiden, utom tvärtom mycket snart måste genom skogens uppryckning ha reducerats i sådan skala at troligen många af de först inkomna fjällväxterna utdött". Dryastuffen ved Leine og det ræsonnement som jeg har fremført i anledning av de merkelige skiferklippers vegetation, fører dog til det resultat, at fjeldplantene i det mindste i begyndelsen av boreal tid har hat en større utbredelse end i nutiden. Jemtlands kalktuffer synes at vise det samme. Ialfald har vi her et interessant fænomen som vi bør stoppe op for og ikke negligere. Vi bør være taknemmelige for ethvert lite indblik vi faar i disse gamle perioders plantevekst og klimatiske forhold. For endda er de i stor utstrækning indhyllet i mørke.

For det sydlige Skandinavien antar man med rette at den boreale tid indvarsler de varmekjære løvtrærs æra i norden og i det hele tat indvandringen av sydlige og sydøstlige typer, som saa i løpet av varmetiden spredte sig vidt utover landet baade nordover og vestover (Blytt, Hansen, Sernander l. c.).

En sammenligning mellem Gudbrandsdalens og Jemtlands kalktuffer.

En korrelation mellem Gudbrandsdalens og Jemtlands tuffer er tildels vanskelig at gjennemføre. Øyen behandler dette problem i sit sidste arbeide, og angriper her baade Sernanders og Halles tolkning av de jemtlandske forekomster. Men nogen tilfredsstillende forklaring faar man dog ikke; i grunden lar OYEN sporsmaalet staa fuldstændig aapent.

Imidlertid aapner HALLES interessante undersokelser nye muligheter for en korrelation mellem disse norske og svenske tuffer. HALLE har trukket frem en række nye stratigrafiske og biologiske momenter (1915 l. c.), som er av den allerstorste værdi, og som i al korthet kan resumeres i folgende punkter:

1. I bunden av Jemtlands tuffer er der i de ældste tuffer antydning til en smal undre sone uten fururester; ialfald er furuen her sparsommere end ellers.
2. *Dryas octopetala* og *Hippophäes* optræer i denne undre sone i stor mængde og karakteriserer den. De forsvinder opad eftersom furuen øker.
3. Hoiere oppe i lagrækken dominerer furuen. Granen mangler.

Forskjellen mellem disse tuffer og de norske ligger i forekomsten av bladtufbænken i Gudbrandsdalen, hvilket baade ANDERSSON og BIRGER (1912 l. c. p. 145) og HALLE (1915 p. 38) finder paafaldende og vanskelig at forklare. Saaledes stiller altsaa saken sig set med svenske oine; for os, som har arbeidet med de norske tuffer, er netop den manglende bladtuf i Jemtland vanskelig at forstaa.

Men bortset fra denne undre tufbænk, er likheten meget fremtrædende. Likesom i Jemtland folges Dryas og Hippophaës ad ogsaa i de norske tuffer og forsvinder samtidig. Rigtignok er de her endda ikke fundet sammen, men dette betyr ikke saa meget da stratigrafien ved Leine og Gillebu stemmer fuldstændig overens. — I begge tilfælder er det en okning i furuens frekvens som er utslaggivende og skjæbnesvanger.

SERNANDER har senere i overensstemmelse med HALLES fremstilling tolket den *Dryas*-matte som optræer i bunden av visse jemtlandske tuffer, som en „senboreal hede" (1915 l. c. p. 540), og det ligger i det hele tat snublende nær at sammenstille denne med Dryastuffen ved Leine, som vi ikke finder anden plads for end netop i den boreale tid.

Men hvorfor er der da ikke ogsaa utviklet en bladtuf i Jemtland? Dette kan hovedsakelig bero paa to ting: enten har de klimatiske forhold her lagt hindringer iveien for tufdannelsen i den første tid efter isens avsmeltning, eller rester av indlandsisen har persistert længer i denne del av Skandinavien end i det centrale Norge.

Ved studiet av Ragundasjoens uttapning har svenske geologer (DE GEER 1915 l. c. p. 191) forsøkt at fiksere tidspunktet for den østlige isrests tvedeling (bipartition) i en nordøstlig og en sydvestlig del, og man er nu tilboielig til at ville henlægge denne begivenhet til boreal tid (SERNANDER 1916 p. 539). At der i det centrale Norge umulig kan ha ligget igjen nogen isrest i boreal tid, har jeg allerede ovenfor omtalt. Det store spørsmaal blir da hvorledes disse opfatninger skal kombineres sammen. Hvis virkelig isrestens bipartition først skedde saa sent som i boreal tid, hvor stor utbredelse hadde da den tilbakeblivende sydvestlige del av isen? DE GEER synes at være fuldt opmerksom paa at der her er vanskeligheter tilstede, idet han paa sit kart (1915 l. c.) over isens bipartition ikke bringer den søndre isløbe til nogen naturlig avslutning vestover i Norge.

Jeg skal her ikke gaa nærmere ind paa dette problem, som er meget vanskelig. Svenske og norske opfatninger divergerer paa dette punkt ganske sterkt. Mytilus-nivaaet og Portlandia-nivaaet spiller her ind paa norsk side, likeledes tidfæstelsen av de brædæmte sjøer (cfr. avsnit I) o. s. v.

Men at der efter HALLES undersøkelser er banet vei for en korrelation mellem de norske og svenske forekomster, anser jeg for givet. Mange gode grunder taler for at *Dryas-Hippophaës*-sonen i Jemtlands tuffer skriver sig fra boreal tid, og dette bekræfter den mening som jeg ovenfor har hævdet, nemlig at denne periode maa ha været specielt gunstig for fjeldplantene. Aarsakene hertil kan dog ha været forskjellige.

Furutuffen i Jemtlands-forekomstene tolkes av SERNANDER som atlantisk, nærmere betegnet som gammelatlantisk (l. c. p. 540). Forfatteren tænker sig at tufavsætningen her er blit avsluttet forholdsvis tidlig „genom det öfversilande vattnets själfdränering i distinkta erosionsfåror". Imidlertid er det al grund til i fremtiden at undersøke det muld- eller humuslag nøiagtig som pleier at overdække furutuffen; for efter den erfaring som undertegnede har gjort baade ved Leine og Gillebu, er det meget let ved en hastig gravning at overse eventuelle forvitrede yngre tufrester i jordlaget. Disse er ofte forsvindende smaa, men kan allikevel gi værdifulde oplysninger (cfr. Alnus-tuffen ved Leine og de ubetydelige furutufrester i visse profiler ved Gillebu).

Hippophaës-problemet.

I den foregaaende fremstilling er *Hippophaës rhamnoides* nævnt flere ganger. Denne arts merkelige utbredelse i nutiden og dens fossile forekomst paa Gotland, i Jemtland og Åsele lappmark har siden lang tid tilbake sat plantegeografenes fantasi i bevægelse. Meningene om dens indvandringsveier til Skandinavien har været noget delte, og flere teorier har været opstillet i sakens anledning.

Paa kartet fig. 36 er alle kjendte norske og svenske lokaliteter for nulevende og fossil *Hippophaës* indtegnet. For Finlands og Danmarks vedkommende er fremstillingen noget ufuldstændig, men hovedlinjene i plantens utbredelse træer dog tydelig frem. Langs Tysklands Østersjøkyst er bare nogen faa lokaliteter indlagt. *Hippophaës'* forekomst i Kurland er tvilsom (ældre angivelser hos KÖPPEN l. c., men ikke gjenfundet i nyere tid).

Av de fossile findesteder er F = Fröjel paa Gotland (G. ANDERSSON 1895 l. c. p. 45), G = Gillebu i Øier (ØYEN 1917). De jemtlandske lokaliteter er ifølge HALLE (1915) følgende: Raftkälen (NATHORST 1885 l. c.), Digernäs (SERNANDER 1899 l. c.), Sikaskälen (CARLSON ifølge HALLE 1915 p. 39), Gaxsjö (CARLSON), Filsta (G. ANDERSSON), Tracksta i Hallen (KJELLMARK), Gulastjärn (HALLE l. c.). Den nordligste lokalitet i Sverige er Långsele i Dorotea sogn, Asele lappmark (NATHORST 1885, planche 18). *Hippophaës*-pollen er paavist i sandlag med arktiske planterester paa Snasahögarna og V. Enadalshöjden av H. SMITH (1920 l. c. p. 138); disse lokaliteter er ikke indtegnet paa kartet, da der vel kan disputeres om hvor stor vegt man skal tillægge forekomsten av pollen av en vindbestøver. Forøvrig slutter disse forekomster sig meget smukt til de øvrige.

Utbredelse i Sverige i nutiden.

Norrbotten: Neder-Kalix skärgard; Lulea skärgard: Junkön, Småskären o. s. v. (BACKMAN og HOLM p. 247). Seskaröen (/7 1899 E. HAMMARÉN Hb. Ups.). Haparanda skärgård (J. A. Z. BRUNDIN 3/7 1900 Hb. Ups.). Pitea skärgård: Hunden 7/6 1892 E. LUNDBERG Hb. Ups.), Buskin (1870 A. N. LUNDSTRÖM Hb. Ups.), Mellerstön, Kluntarne, Rebben, Svartnäs, Trundön; Neder-Lulea: Alhamn (1917 E. MARKLUND l. c. p. 796). Kalix skärgard: Granön (27/6 1906 F. E. A. BLOCK Hb. Ups.).

Västerbotten: Umea: Tafla (1887 N. L. ANDERSSON Hb. Ups.).

Medelpad: Brämön; Njurunda: Galtström mellem Furuskär og Sathamn, Björköbyn, Björköviken; Alnön: ej långt från Spikarna, Rödön, Lillkalven, Granön; Tynderö: Skilsåkersmalen, Aston söder om Kalvhällberget (COLLINDER p. 118).

Hälsingland: Gnarp: Ragvaldsnäs fram till Medelpadsgränsen; Jättendalkredsands allmänning. — Fleresteds dyrket „såsom vid Ljusdal, Hudiksvall etc." (WISTRÖM).

Gästrikland: Gevle: Brynäs (/7 1823 herb. Wahlenberg in Hb. Ups.), Brobänken (4/6 1852 R. F. FRISTEDT & F. J. BJÖRNSTRÖM Hb. Ups.), Iggön (/7 1895 TORSTEN ARNELL Hb. Ups.), Granön (16/7 1894 T. ARNELL Hb. Ups.), Miramar (/6 1885 C. O. SCHLYTER Hb. Ups.).

Uppland: om *Hippophaës*' utbredelse i Uppland cfr. E. ALMQUIST 1921 l. c.[1]. Den er her almindelig ned til Grisslehamn; sondenfor er den betydelig mere sjelden. De sydligste lokaliteter er Nickö i Ljusterö og Svartlöga i Blidö, beliggende ved ca. 59° 35' (E. ALMQUIST in litt.). Lokalitetene paa kartet er indtegnet efter et kartkoncept utfærdiget av ALMQUIST. I Uppland træffes den mange steder paa enger, langs veikanter o. s. v. i kystens nærhet, undertiden flere km. fra nuværende strand (kulturpaavirkede steder).

Bohuslän: Oxevik i Dragsmark sn. (/7 1884 G. WALLIN Hb. Ups.); Dragsmark (/7 1889 A. U. JONSSON Hb. Ups.); Tanum: 0,5 km. sydvest for Tanums jernbanestation (MAGNUSSON Sv. Bot. Tidskr. 1918 l. c. p. 472); Svenneby: Spånslätt (12/8 1869 G. M. L. GERKE Hb. Göteb., ifølge MAGNUS-

[1] Denne avhandling vil bli publicert i Svensk Bot. Tidskrift 1921.

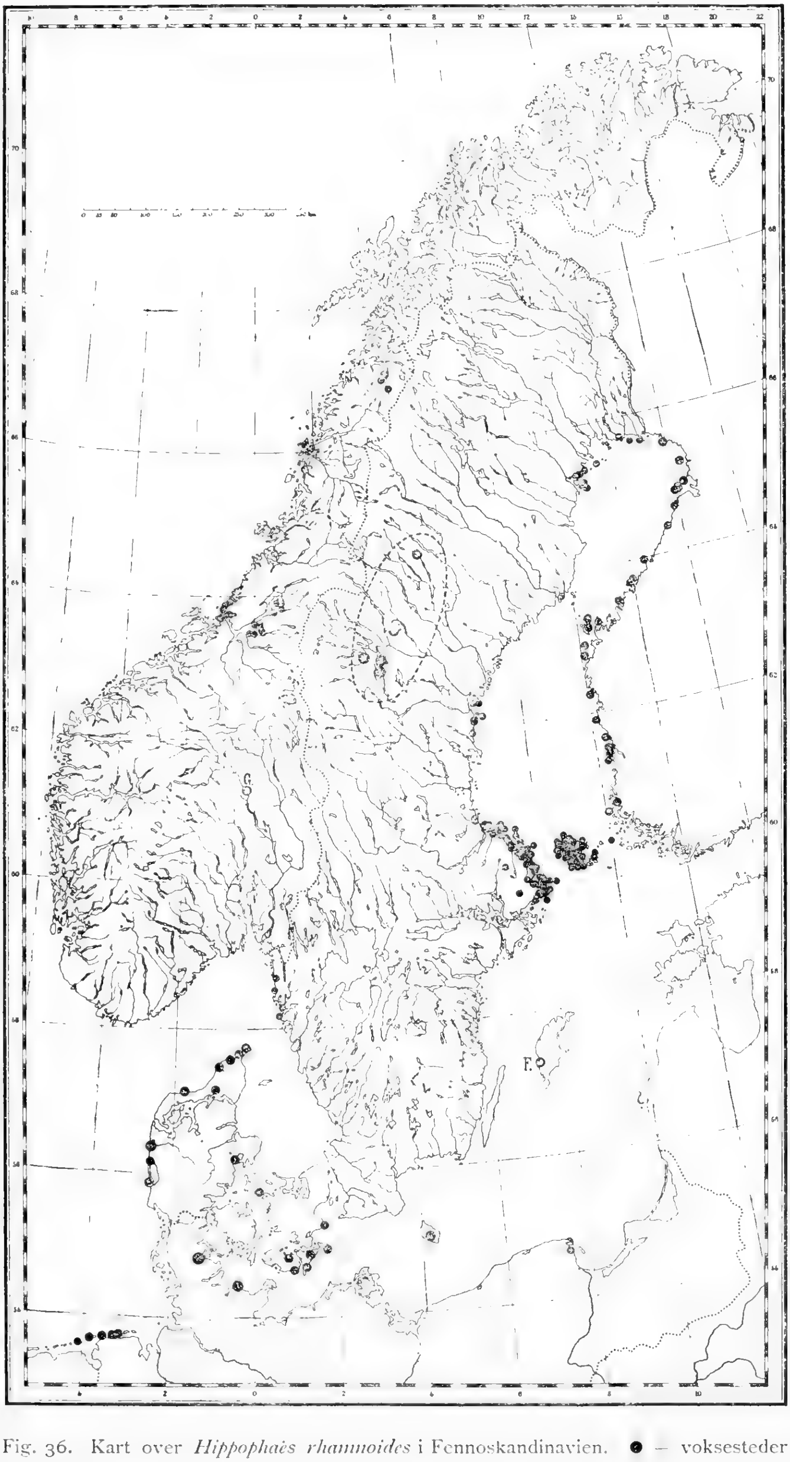

Fig. 36. Kart over *Hippophaës rhamnoides* i Fennoskandinavien. ● = voksesteder i nutiden. ○ = fossilforekomster. G. = Gillebu, F. = Fröjel paa Gotland.

SON l. c. vistnok spontan); Morlanda: Hermanön (PALMÉR Sv. Bot. Tidskr. 1920 p. 89)[1]. Denne oversigt er sammenstillet av Fil. mag. R. STERNER, Uppsala, som elskværdigst har stillet den til min disposition.

Utbredelse i Finland.

I Finland er *Hippophaës* nøie knyttet til den Bottniske Bugt, hvor den optrær paa strandkantene fra Torneå i nord til Alandsarkipelet i syd. Sydgrænsen paa fastlandet er Nystad, i skjærgaarden (Aland fraregnet) øen Enskär i Gustafs sogn i Åbo-skjærgaarden („regio aboënsis" efter Herbarium Musei Fennici's inddeling 1889). Lokalitetene er indlagt efter oplysningene i PALMGRENS monografi (1912), hvor al litteratur vedrørende *Hippophaës* i Finland citeres.

Utbredelse i Danmark.

I LANGE: Haandbog i den danske Flora (1886—88) anføres følgende om plantens forekomst: Strandklinter (paa ler og kalk) og sandklitter; i den nordlige del av Jylland alm., sjeldnere mot syd (Ris skov ved Aarhus) og paa øene. Fyen: Vedelsborg. Sjælland: Refsnæs, Lerchenborg, Stevns klint, Møens klint i stor mængde. Falster: Mellem Korselitze og Grønsund og mellem Tromnæs og Bøtø. Laalland: Oreby strand, Aalholm strandklint. Bornholm. WARMING (1907—1909) har en mængde oplysninger om *Hippophaës'* utbredelse og økologi. Følgende findesteder omtales her: Almindelig i klitterræng nord for Limfjorden, ogsaa ved dennes kyster, f. eks. ved Kaas, og inde i landet, f. eks. omegnen av Vildmosen, ved Tolne og Vogn bakker, Lerup kirke. Mot syd paa vestkysten mere spredt og sjelden, bl. a. i Nissum-Husby klitter, Holmslands klit, Nymindegab. Han omtaler den videre fra Skagens nordstrand, Uggerby og Tversted aaer og Rubjerg Knude vest for Hjørring. Videre: i mængde f. eks. paa Møens Klint, paa Refsnæs og paa nordøstkysten av Falster. Paa kartet er de av disse lokaliteter indlagt som jeg har kunnet fiksere nøiagtig.

Utbredelse i Norge.

S. Trøndelag og N. Trøndelag fylke: Inderøen: ved Borgenfjorden nær Sund (1/7 1918 I. JØRSTAD). SCHÜBELER anfører følgende: Paa Inderøen 5 m. høie trær. 2 stammetversnit maalte 13 cm. med 54 aarringer og 20 cm. med 44 aarringer (uten bark). — Værdalen: Helgeaaens bredder nær Hagagaard ved Nes (J. W. ZETT.). — Skogn: paa stranden mellem Tynes og Levanger i største mængde (J. W. ZETT.); Holme (A. BL.). — Skatval: i hammeren mellem Velvang og Olderen ved kalktuffen (juni 1915 ROLF NORDHAGEN). — Stjørdalen: Sutterøen (HOFFSTAD). — Frosta: Tautra m.

[1] Litteratur over *Hippophaës'* utbredelse i Sverige: BACKMAN, C. J., og HOLM, V. F.: Elementarflora öfver Västerbotten och Lapplands fanerogamer och bräkenartade växter. Upsala 1878. MARKLUND, E., Svensk Bot. Tidskrift 1917. COLLINDER, E., Medelpads Flora. Norrländskt handbibliotek III. Upsala 1919. WISTRÖM, P. W.: Förteckning öfver Helsinglands fanerogamer och pteridofyter. Wimmerby 1898.

alm. paa strandkanter (A. Bl.); Frosta ($^{11}/_{8}$ 1875 A. Bl.); Holmberget ($^{21}/_{6}$ 1915 I. Jørstad). — Strinda: Dævlehavnen og østover (1869 Storm); Saksvik (1876 Ove Dahl); Tinveden (Bl. 1897); Strinden (Oxaal); Trondhjem (M. N. Blytt). — Skjorn: Eid ($^{2}/_{7}$ 1915 I. Jørstad). — Ørlandet: mellem Fladnes og Hovde rikelig over den flate utmark (Norman 1883); Beian (Boeck & Koren. Herb. Kristiania); Berg og Østraat (1900 Hoffstad); Østraat (Koren). — Bjugn: nær grænsen til Ørlandet (Norman-Storm). — Aafjorden; Melem fleresteds; Kvengjerdet; Valdersund (Norman, Blytt); Hyldenesset (storvoksen) (Norman); Valsø (Norman); Lovø og Øian (1900 Hoffstad); Lysø (Ångström). — Stoksund: Hosen paa flyvesand (1900 Hoffstad). — Nærø: prestegaardstrakten (Norman 1883).

Nordland fylke: Alsten: Strandaasen nær Sandnessjøen (Ove Dahl 1911); Horvnesodden. — Tjøtta: Løvønesset, et helt litet krat av indtil mandshøie busker (Ove Dahl 1911). — Herø: Nordviken paa Dønna (Ove Dahl 1911). — Meisfjorden: Leines (Ove Dahl 1911). — Salten: Fiskvaagflauget (Sommerfelt; A. Landmark har senere fundet den her omtrent 100 m. o. h. ctr. Blytt 1892 l. c.); Kvitberget øverst i Jordbrudalen ca. 600 m. o. h. (Ove Dahl og R. Nordhagen $^{7}/_{7}$ 1920); Junkersdalsura (Fridtz, Bohlin, Dyring (1900), ipse!). — Bodø: nedenfor landskirken ved søen paa flaten dominerende busk, steril i 1876, blad 6,5 cm. langt (Sommerfelt, Norman). — Steigen: Engeløen ved Laskestad paa Prestkontindens fot i nøken grusbakke 111 m. o. h., 137 m. o. h. og 20 m. nedenfor birkefeltets midtlinje, undtagelsesvis i blomst $^{6}/_{6}$ 1867, steril i 1881 (Haukland, Norman, Notø $^{19}/_{7}$ 1912).

Fig. 37. Fra Junkersdalsuren. E. Häyrén fot.

Hippophaës' forekomst i Salten, det eneste omraade i Skandinavien hvor arten nu findes i indlandet og ikke paa strandkanter, er meget interessant og lærerik. I Junkersdalsuren blev den opdaget i 1889 av

R. FRIDTZ (DYRING 1900 l. c.). „Junkersdalsura“ er en storslagen kanjondannelse, noget over en halv mil lang, hvis nordside falder av mot elven i lodrette stup, som naar op til 500 m. o. h. Under disse findes der vældige urdannelser, som paa en række steder antar formen av imponerende, instabile rasmarker, hvor der vaar og høst gaar svære skred ut i elven. Paa disse steder, som befolkningen kalder „flaug“ (fig. 37), mangler vegetationen oftest helt, og de alternerer med mere stabile urpartier, hvor det kalkrike jordsmon og den heldige eksposition fremkalder en frodig og meget inter-

Fig. 38. *Hippophaës* paa en hylde i Junkersdalsuren. Utsigt mot vest. *Arctostaphylos uva ursi* i forgrunden. 5te juli 1920. Nordhagen fot.

essant plantevekst. Bjerk (baade *Betula odorata* og *verrucosa*), furu, heg, graaor (*Alnus incana*), rogn, selje o. fl. optrær skogdannende, og i bunden findes en lang række græs og urter, hvoriblandt mange sydlige relikter, som har gjort denne lokalitet berømt (ANDERSSON og BIRGER 1912 p. 120).

Hippophaës derimot optrær i ganske stort individantal netop paa et av de midtre flaug oppe i en svær rasmark, hvor andre trær og busker ikke kan trives. Voksestedet er for saavidt aldeles typisk: det er de lette konkurrencevilkaar som bevirker at planten her kan hævde sig. Selv formaar den trods det instabile substrat at holde sig, takket være den sterke vegetative formering som udmerker arten (rik skuddannelse paa røttene). Desuten findes *Hippophaës* ogsaa i en ganske liten koloni noget længer vest i uren paa en hylde allerøverst under selve den lodrette bergvæg, paa et næsten ubestigelig sted (fig. 38). Nedenunder strækker der sig en flere hundrede meter lang rasmark, kanske den farligste i hele uren. Den danner her et litet krat paa en 45° skraanende hylde i 4—500 m. høide. Sammen med den findes et par buskformede individer av *Betula odorata*, desuten *Dryas octopetala*, *Salix reticulata*, *Arctostaphylos uva ursi* (se billedet), *Rubus saxatilis* og *Campanula rotundifolia*, men intet sammenhængende dække. I juli 1920 var den her aldeles steril og ca. 0,5 m. høi.

Sammen med konservator Ove Dahl foretok jeg ogsaa samme sommer en ekskursion til den saakaldte Jordbrudal i Salten vest for Russaanes, hvor Russaaen over en længere strækning har underjordisk løp (kalksten). Vi besteg da det merkelige tempelformige „Kvitberget“ (fig. 39), som paa sin sydside har svære urdannelser av nedraset forvitringsmateriale. Paa denne ytterst gunstige lokalitet møter man tildels de samme arter som i Junkersdalsuren (*Cypripedium*, *Epipactis*, *Braya glabella* etc.), og det lykkedes mig ogsaa at opdage et litet bestand av *Hippophaës* øverst i den storstenete ur like ovenfor skoggrænsen (i 600 meters høide). Den var her ikke mere end 0,3 m. høi og steril.

Fig. 39. Kvitberget i Salten. *Hippophaës*-lokaliteten længst tilvenstre, øverst i uren. 7de juli 1920. Nordhagen fot.

Hippophaës maa utvilsomt tolkes som relikt paa disse forekomster (cfr. nedenfor). Specielt i Junkersdalsuren er skredene saa at si fast institution, som ikke viser tegn til ophør, og baade konkurrenceforholdene, den kalkrike bund[1] og ekspositionen er her gunstig for planten og letter dens kamp for tilværelsen. Paa Kvitberget fører den en mere hensyknende tilværelse.

Voksestedene paa Helgelandskysten er utelukkende kalkforekomster nær stranden, hvor vegetationen oftest er noget aapen, men artsrik. Den vokser fleresteds sammen med *Dryas* og andre fjeldplanter, som her optrær i havets nivaa paa kalk og dolomit (cfr. Ove Dahl op. cit.).

Forekomstene i Trøndelagen stemmer gjennemgaaende med danske og svenske lokaliteter. Interessant er findestedet Hosen i Stoksund, hvor Hoffstad fandt *Hippophaës* paa flyvesand saaledes som i Danmark. „Her dannede H. et krat af omkring 0,5 (op til 1) meters høide med aapne mellem-

[1] Om plantens forkjærlighet for kalk cfr. Palmgren l. c.

rum. Inde i krattet fandtes sterile skud af *Galium boreale & verum* rikelig, desuten spredt *Convallaria majalis* og *Vicia cracca*, hvilken sidstnævnte undertiden naaede op over H. buskene. Op gjennem krattet stak desuden *Festuca ovina*, men især *Centaurea Scabiosa*, enkeltvis ogsaa *Knautia arvensis* og *Elymus arenarius*." (HOFFSTAD 1900 l. c. p. 20.) Ved selve Trondhjemsfjorden fra Ørlandet og ind til Inderøen danner *Hippophaës* mere eller mindre aapne krat eller smaa bestander paa strandkantene. Paa Skatvalhalvøen har jeg set den i en brat hammer ca. 150 m. o. h. ved Velvang (kalkholdig underlag).

I BLYTT: Norges Flora anføres *Hippophaës* for „Indviken i Nordfjord paa strandbredder (ifølge KROGH)"; men den er senere aldrig omtalt herfra og ingen herbarieeksemplarer foreligger, saa forekomsten er meget tvilsom, men slet ikke usandsynlig.

PALMGREN har i sin store monografi over *Hippophaës* paa Ålandsøene git en detaljert skildring av artens utbredelse baade i Europa og Asien, samt diskutert plantens livskrav (forhold til lys, temperatur, nedbør, biotiske faktorer, specielt konkurrencen med andre arter o. s. v.), og plantens økologi maa nu i det hele tat siges at være tilfredsstillende utredet.

Om utbredelsen skriver PALMGREN følgende (l. c. p. 27—28): „Der Seedorn wird, an Flüssen und Bächen in Gebirgsgegenden sowie an Seen und am Meer auftretend, von der Mongolei im Osten bis nach England, Frankreich und Spanien im Westen angetroffen. Die Art ist am nördlichsten in Europa in Norwegen unter 67° 55′ nördlicher Breite, in Asien im südlichen Sibirien gefunden worden, während sie am südlichsten in Europa am Mittelmeer und in Asien am Himalaya unter etwa 30° nördlicher Breite vorkommt. In Europa steigt der Seedorn bis in eine Höhe von 2000 m., in Asien sogar bis 5000 m. über dem Meeresspiegel. In Europa umfaßt die Verbreitung des Seedorns ein südliches Gebiet, welches einen bedeutenden Teil der Gebirgsgegenden Mittel-Europas sowie Teile von Spanien, Italien, und der Balkanhalbinsel in sich schließt, und ein nördliches Gebiet, welches einen Teil der Küstenstrecken des Englischen Kanals, der Nordsee, der Ostsee und der Westküste von Norwegen umspannt. Innerhalb dieses nördlichen Verbreitungsareals ist der Seedorn eine ausgeprägte Küstenpflanze — — — —."

Om *Hippophaës*' merkelige utbredelse skriver KÖPPEN (l. c. 1888—89 p. 644):

„Die merkwürdige Verbreitung des Sanddornes läßt sich auf klimatische Ursachen durchaus nicht zurückführen[1]; denn er findet sich unter sehr verschiedenen Temperatur-Bedingungen und anscheinend auch unter sehr differenten Feuchtigkeits-Verhältnissen; so dürften die natürlichen Bedingungen unter denen er einerseits in Norwegen bis zum 68° n. Br. und andererseits auf der der Hami-Wüste zugekehrten

[1] Uthævet her.

vorderen Terasse des Nan-schan (unter dem 40° n. Br.) wächst, sich außerordentlich von einander unterscheiden; dort findet er sich in der ausgesprochensten maritimen, hier dagegen in der kontinentalsten Lage. Es scheint daß der Standort, den der Sanddorn bevorzugt, am ehesten seine eigentümliche Verbreitung erklären könnte. Ich habe Eingangs bemerkt, daß es die Meeresküsten und die Ufer der Gebirgsbäche hauptsächlich sind an denen dieser Strauch sich ansiedelt. Die geringe Entwicklung der Meeresküsten im europäischen Rußland (abstrahirt von dem klimatisch für den Sanddorn unzugänglichen Küsten des Eismeeres, desgl. des Weissen Meeres), so wie die fast vollständige Abwesenheit von Gebirgen auf dem kolossalen Raume, den die russische Tiefebene einnimmt, — diese beiden Factoren dürften hauptsächlich das Fehlen des Sanddornes auf der letzteren bedingen." PALMGRENS undersokelser paa Åland bekræfter fuldt ut hvilken betydning voksestedet og specielt konkurrenceforholdene har for *Hippophaës*[1]. Den taaler til en viss grad saltbund bedre end andre træer og busker, og langs den Bottniske Bugt, hvor der paagaar landhævning i nutiden og nyt land stadig dukker op, har den udmerkede betingelser, idet ingen andre vedplanter formaar at utkonkurrere den. Paa de længst fra strandlinjen liggende lokaliteter (de ældste) dør den efterhaanden ut og fortrænges av andre planter. I Uppland indtar den ogsaa et smalt spatium paa strandkantene, mellem den uroligste del av stranden (med koloniartet vegetation) og strandkrattene av or længer inde (SERNANDER 1905 l. c.). I det hele tat er der nu gjort saa mange iagttagelser i sakens anledning at man kan slaa fast følgende:

1. *Hippophaës* er indenfor temmelig vide grænser klimatologisk indifferent (baade hvad temperatur og nedbør angaar).
2. Planten optrær nu kun paa lysaapne voksesteder, hvis natur er saadan at en sluttet vegetation specielt av trær og busker er utelukket (stenet strand, flyvesand o. l. ved kystene; rasmarker, sandige elvebredder etc. i indlandet).
3. Desuten er *Hippophaës* noget kalkyndende.

ØYEN har i flere av sine nyere skrifter omtalt *Hippophaës*[2] og polemiserer her sterkt mot en række svenske forfattere som har ytret sig i anledning av *Hippophaës*-problemet. Han konkluderer selv med den bestemte mening, at plantens utbredelse, fremrykning og tilbakegang styres av klimatologiske lover, og henfører dens indvandringstid til sit *Pholas*-nivaa.

[1] Cfr. NATHORSTS uttalelser 1886 l. c. I september 1921 har jeg hat anledning til at iagtta *Hippophaës* paa utallige steder i Alperne, og mine erfaringer bekræfter fuldstændig ovennævnte tolkning. — SERVETTAZ synes i sin monografi over *Elaeagnaceae* (1909 l. c.) tildels at ha misforstaat *Hippophaës'* økologi; han hævder at naar planten formaar at spre sig til lokaliteter utenfor fugtige elvebredder, saa er det altid til kalkfattige voksesteder. Dette er fuldstændig misvisende, likeledes paastanden om at planten foretrækker fugtig bund (cfr. SIEGRIST l. c. p. 122).

[2] Videnskapsselskapets Skrifter og Svensk Bot. Tidskrift op. cit.

Da dette faunistisk set er av utpræget sydvestlig karakter, tolker han ogsaa *Hippophaës* som sydvestlig. „Den synes derfor at være paa det nøieste sammenknyttet med den her omhandlede periodes hele klimatpræg, der var av utpræget sydvestlig karakter“ (1920 l. c. p. 322).

Øyen indtar altsaa et standpunkt som er diametralt motsat Köppens, Palmgrens og andre botanikeres. Imidlertid synes Øyen ikke at kjende til disse hovedverker inden *Hippophaës*-litteraturen; han citerer dem ialfald ikke. Han berører ikke plantens biologi i nutiden, og nogen diskussion av forskjellige forklaringsmuligheter finder man ikke. Da jeg ovenfor tilstrækkelig har belyst spørsmaalet om *Hippophaës'* forhold til klimatiske faktorer, skal jeg her kun omtale plantens relation til Pholasnivaaet.

Da *Hippophaës* ved Gillebu er knyttet til bladtufbænken og denne av Øyen tolkes som „infraboreal“ og synkron med hans *Pholas-nivaa* (cfr. oversigten i avsnit III), er Øyens standpunkt forstaaelig.

Men ved Gillebu møter vi det merkelige fænomen, at *Hippophaës* faktisk har sit maksimum allerede i bladtufbænkens allerunderste del (tuffens underside). Den har været tilstede i store mængder netop da tufdannelsen begyndte; blokkenes underside viser os et avtryk av markens overflate paa dette tidspunkt. Man maa derfor anta at denne art har været tilstede eller indvandret allerede under den kontinentale periode umiddelbart efter isens avsmeltning, som gik forut for tufdannelsens begyndelse. Ialfald er der ikke levert noget bevis for at *Hippophaës* først er indvandret under den periode som udmerker sig ved bladtufdannelse. Heller ikke paa dette punkt virker Øyens fremstilling overbevisende.

Sammenholder man *Hippophaës'* fossile forekomst paa Gotland (G. Andersson 1895 l. c.), i Jemtlands kalktuffer, i Långsele sydligst i Lappmarken og ved Gillebu i Norge, kommer man til det resultat, at denne art maa ha hat en vid og vistnok temmelig sammenhængende utbredelse over hele den skandinaviske halvø i subarktisk og utover i boreal tid før furuskogene (i syd skoger av ædle løvtrær) begyndte at faa overtaket[1]. Dog er det mulig at den i indlandet har foretrukket kalktrakter. Allerede i boreal tid begyndte nedgangen, og litt efter litt døde den ut baade i det centrale Norge og i Jemtland—Lappmarken. Kun langs kystene og paa et par specielt gunstige indlandslokaliteter i Nordlands fylke har den evnet at holde sig til nutiden. Ved den Bottniske Bugt synes den at like sig bedst, takket være landhævningen i disse trakter. Det er ingen grund til at anta at denne kystutbredelse i og for sig er et sekundært fænomen. G. Anderssons fund av fossil *Hippophaës* paa Alnön i Medelpad i „littorinagyttja“ viser, som forfatteren selv gjør opmerksom paa (1895 p. 45), at den

[1] Cfr. G. Andersson 1896 p. 455.

i lang tid har været kystplante. At sænkninger av landplaten langs andre kyststrækninger i postglacial tid maa ha været skjæbnesvanger for *Hippophaës* og utryddet den over visse strækninger, har HALLE tidligere gjort opmerksom paa (l. c. p. 43).

Da *Hippophaës* i klimatologisk henseende er indifferent, er det bare naturlig at den i nutiden forandrer og utvider sit utbredelsesfelt og anlægger nye kolonier[1]. Hvis forekomsten i Bohuslän er av geologisk talt ung alder og staar i forbindelse med det danske utbredelsesfelt (cfr. kartet), hvilket enkelte forfattere har hævdet (ARNELL 1912 p. 232), kan det godt hænde at *Hippophaës* i fremtiden vil faa en renæssance langs Kattegat-Skagerakkysten.

Selv om problemet *Hippophaës* nu kan betragtes som løst i hovedsaken, er det faktiske billede vi for tiden kan gi av dens tidligere utbredelse, mangelfuldt. Men fremtidige fund vil nok utfylde hullene. Spørsmaalet om arten er indvandret til Jemtland fra Norge eller fra øst, to alternativer som HALLE diskuterer, staar fremdeles aapent. HALLE synes at helde til den første antagelse. Ialfald er det nu en kjendsgjerning at planten har vokset i det centrale Norge i subarktisk tid[2], og naar saa mange andre planter har vandret fra Norge ind i Sverige (cfr. SERNANDER 1910), kan dette ogsaa meget vel ha været tilfældet med *Hippophaës*.

Om denne art oprindelig fulgte efter det avsmeltende isdække fra syd eller øst eller fra flere kanter samtidig, er omdisputert[3]. SCHWELLENGREBEL betegner *Hippophaës* som en asiatisk steppeplante av østlig type (1905 l. c. p. 191). WARMING skriver (Dansk plantevekst II Klitterne 1907 p. 150) at den kunde „maaske være indvandret til Sverrig nord om den Botniske Bugt fra Stepper i Vestasien og Østrusland, mens den vel er kommet til Østersøens andre Kyster og til Vesterhavets fra Mellem-Europa, i hvis Bjerge og langs hvis Floder den vokser.“ Da denne sak er meget vanskelig at avgjøre, skal jeg her ikke diskutere den nærmere.

Alt i alt er *Hippophaës*' fossile forekomst meget interessant, idet den viser os at den a k t u a l i s t i s k e tolkning av denne art som en plante for hvem konkurrenceforholdene og derigjennem de edafiske forhold er de utslaggivende, er fuldstændig korrekt. Fortiden supplerer her nutiden og omvendt. Og naar ØYEN i *Hippophaës* mener at ha fundet et typisk

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[1] BUCHENAU har fra de østfrisiske øer omtalt hvorledes *Hippophaës* i slutten av det 19de aarh. har bredt sig østover; den har endda ikke naadd øene Spiekeroog og Wangeroog (Abh. naturw. Vereins Bremen XVII 1903).

[2] SMITH (1920 l. c. p. 139) antyder ogsaa en vestlig indvandringsvei for *Hippophaës* til Jemtland (cfr. denne forfatters pollenfund).

[3] SMITH (1920 l. c.) fremsætter den antagelse, at *Hippophaës* har overlevet den sidste istid paa Norges vestkyst. Dette er dog usandsynlig. Den høiarktiske fauna som er fundet paa Ørlandet, viser at klimatet paa nunatakker og isfrie omraader langs vestkysten maa ha været meget strengt. — Desuten viser forekomsten paa Gotland at *Hippophaës* her har fulgt efter isranden fra syd eller øst. Til Gillebu er den utvilsomt ogsaa kommet søndenfra.

eksempel paa hvorledes planteartenes utbredelse rent generelt styres av klimatologiske lover (l. c. p. 323), saa maa dette eksempel siges at være meget lite lykkelig valgt.

Hvis ikke *Hippophaës* hadde været kjendt i fossil tilstand, vilde meningene om dens indvandringstid og indvandringsveier utvilsomt ha været endda mere divergerende. Med utgangspunkt i hvad vi nu vet om denne art, kunde det sporsmaal reises, om vi ikke inden vor flora ogsaa har andre arter som endda ikke er fundet fossile, men hvis historie har faldt sammen med *Hippophaës'*. I Gudbrandsdalen maa man i denne forbindelse specielt tænke paa „klaariset", *Myricaria germanica*. Den er meget sterkt avhængig av de edafiske forhold og utkonkurreres meget let av andre trær og busker hvor bunden er stabil; kun paa sandige og stenete elvebredder som oversvommes i flomtiden, danner klaariset egne krat. Planten har i Skandinavien et nordlig utbredelsesfelt i Tromso—Finmark fylke og et centralskandinavisk fra Honefoss til Namdalen (med forgreninger over til Sogn og Nordfjord). Fra det trondhjemske har dette felt en utloper ind i Sverige (ialfald tilsynelatende), hvor *Myricaria* langs Indalselven naar frem til den Bottniske Bugt. Man maa anta at denne art i tiden efter isens avsmeltning og for furuskogenes tid har hat specielt gunstige livsbetingelser og rike spredningsmuligheter. Men desværre vet vi endda intet om dens indvandringstid[1]. I Central-Asien optrær den ofte sammen med *Hippophaës*[2]; saaledes skriver DRUDE: „*Hippophaës rhamnoides*, noch am Kuku-nor bis 3600 m. Höhe ansteigend, wird bis 20 Fuß hoch; oft begleitet ihn die in Hochtibet am höchsten steigende *Myricaria germanica*" (Handbuch der Pflanzengeographie 1890 p. 409).

En anden merkelig art av subarktisk præg er *Aster subintegerrimus* (RESV. & OSTENFELD), som i nutiden har et meget isolert utbredelsesfelt ved Aursunden nord for Roros. Ifolge dr. RESVOLL er planten sterkt avhængig av de edafiske faktorer; den er knyttet til et parti av den grusetsandige strand hvor skogen ikke gaar ned til sjøen[3]. Netop av denne grund frygter man for at reguleringen av Aursunden kommer til at bety plantens død; den magter nemlig ikke at trænge sig ind i sluttede naturlige samfund. — Hvis *Hippophaës* ikke hadde eiet sin merkelige klimatologiske plasticitet og sin evne til at taale en god portion salt i substratet, vilde den i nutiden utvilsomt ha fristet en ytterst kummerlig tilværelse. Den er utdød over milevide strækninger fra Øier og helt til Lappmarken.

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[1] Cfr. ANDERSSON & BIRGER 1912 p. 167.

[2] Dette er vistnok ogsaa tilfældet et par steder ved Trondhjemsfjorden og i nærheten av Sundsvall. For Tysklands vedkommende cfr. GRAEBNER: Die Pflanzenwelt Deutschlands 1909. I Schweiz optrær disse to arter ofte sammen, f. eks. i Tessin, hvor jeg mellem Mesocco og Bellinzona har set vakre blandede krat paa elvenes grusavleiringer.

[3] Cfr. TH. RESVOLL & OSTENFELD: Den ved Aursunden fundne Aster. Nyt Magazin f. Naturv. B. 54. 1916 p. 6.

Hvem vet om ikke *Aster subintegerrimus,* som synes at være daarlig rustet i kampen for tilværelsen (ialfald i nutiden), tidligere har hat en noget mere sammenhængende utbredelse? (Cfr. RESVOLL & OSTENFELD l. c. p. 6, hvor ogsaa denne mening fremsættes)[1]. Det nærmeste voksested ligger nu i det nordostlige Finland.

I denne forbindelse vil jeg ogsaa fæste opmerksomheten ved den merkelige ansamling av östlige planter som vi nu for tiden har i selve

Fig. 40. *Aster subintegerrimus* paa stenet sandstrand ved Aursunden. Desuten sees *Astragalus alpinus.* TH. R. RESVOLL fot.

Gudbrandsdalen. *Athyrium crenatum, Cystopteris sudetica* og *Atragene sibirica* har her hver for sig et isolert skandinavisk utbredelsesfelt (fig. 41). Eiendommelig nok „hopper" alle tre fra den finsk-russiske grænse og til Gudbrandsdalen.

1. *Athyrium crenatum:* Utbredelse i Finland—Rusland: fra Ponoj- og Imandra-Lappmarken i nord til Tavastehus i sydvest; ostover gjennem Ladoga-Karelen, den kareliske landstripe mellem Ladoga og Onega og Nowgorod (HERMANN: Flora 1912). Sibirien, Mongoliet, Sakhalin. Utbredelse i Norge: Sel: Rosten ovenfor Laurgaard (MOE). Nord

[1] En anden art som i biologisk-okologisk henseende minder om *Aster subintegerrimus,* er *Carex bicolor,* som foruten et nordlig utbredelsesfelt i Skandinavien har 2 meget isolerte forekomster i Centralskandinavien, nemlig i Foldalen i Norge (sandige elvebredder) og i Härjedalen.

for Kringen langs veien (M. N. Bl.). Kvam: Storuren (Norman Herb. Krist.). Ringebu: ved Laagen nedenfor Randklev bro fleresteds i mængde (Kaalaas); Elstad paa den anden side av elven like overfor gaarden (Orsanden if. A. Blytt). Den vokser her „ved foten av bergene paa skyggefulde muldete steder blandt raatne omstyrtede stammer ogsaa paa græsbund i selskap med subarktiske planter saasom *Polypodium Phegopteris*, *Stellaria nemorum*, *Aconitum*, *Geranium silvaticum*, *Ranunculus acer* etc." (haandskrevne notiser av A. Bl. i Bl. N. Fl.). — Mangler i det øvrige Europa.

2. *Cystopteris sudetica:* Rusland: Nowgorod (Hermann l. c.). Desuten i Karpaterne. Norge: ved Vinstraelven i Gudbrandsdalen ret overfor Kongsli, i dype vanskelig tilgjængelige klofter i selskap med *Cystopteris montana* og *Cinna pendula* (Kaalaas 1897).

3. *Atragene sibirica:* Finland Rusland: Onega-Karelen og Nowgorod og i lerkeskog i Onegadalen (Hermann l. c., Wille l. c. p. 251). Nord- og Mellemrusland, Ural, Sibirien, Mongoliet, Turkestan. Paa begge sider av sjøen Losna i Gudbrandsdalen (ved grænsen mellem Øier og Ringebu herreder), paa østsiden mellem gaardene Enge og Vedum, paa vestsiden ved Høglien og ved Rugakersætrene (op til over 900 m. o. h. Wille l. c. p. 243).

Alle tre arter er av subarktisk type og viser en ganske frappant overensstemmelse hvad utbredelsen angaar. Vi har her kanske en av de største gaader som vor flora gjemmer. Da alle tre er urteagtige eller ialfald visner ned som urter, er chancene for at finde fossile rester av dem uhyre smaa. Men et eneste fossilfund kan her si det avgjørende ord. For *Atragene sibirica*'s vedkommende har Wille (1917 l. c.) fremsat den anskuelse, at den er indkommet til Gudbrandsdalen ved tilfældig spredning i nyere tid, hvilket er meget vel tænkelig. Imidlertid mener jeg ogsaa de to andre arter maa tages med i ræsonnementet, og med henblik paa *Hippophaës* og dens utdøen over hele Centralskandinavien, maa man indromme, at der her foreligger muligheter for at ovennævnte arter, som nærmest er av subarktisk type, ogsaa kan ha hat en kompliceret historie i det lange tidsrum som ligger mellem isens forsvinden og nutiden. Men opfatningen paa dette punkt maa selvfølgelig bli subjektiv; noget videnskabelig bevis kan man jo ikke levere.

C. Den atlantiske tid.

Denne periode har i Gudbrandsdalen udmerket sig ved tætte furuskoger. Antageligvis har sydlige løvtrær spillet en viss rolle ialfald i dalens nedre del paa gunstige lokaliteter (hassel, alm, muligens lind)[1]. Av hasselnøttfund i torvmyrer vet vi at *Corylus Avellana* har hat en noget større utbredelse under den postglaciale varmetid i dalens sydlige del (cfr. Holmboe 1903). *Ulmus*-pollen, som det har lykkedes mig at paavise i smaa mængder i furutuffen ved Gillebu, er meget interessant, men gehalten er altfor ubetydelig til at kunne tillægges nogen større betydning.

Fundet av *Tofieldia palustris* i den atlantiske tuf ved Leine viser at enkelte fjeldplanter ogsaa under denne periode har hat tilhold i Leine-

[1] *Ulmus montana* har nu sin nordgrænse i Faaberg. Gaardsnavnet Alme i S. Fron viser ifølge A. M. Hansen (1914 l. c.) at den er i tilbakegang. *Acer platanoides* gaar til Faavang, *Corylus* og *Tilia* til Ringebu, men er meget sparsomme i sin optræden.

bakkene. Muligens har dette bare været tilfældet med alpine eller subalpine myr- og kildeplanter. *Dryas*, *Salix reticulata* og de øvrige som dominerte i boreal tid, er ialfald nu forsvundet. — Forekomsten av fjeldplanter i Jemtlands kalktuffer har SERNANDER oprindelig villet forklare som atlantiske nedvandringer (1899 l. c., 1916 l. c.). Imidlertid tyder HALLES undersøkelser, specielt paavisningen av den smale *Dryas-Hippophaës*-sone i bunden, paa at den mere sporadiske optræden av fjeldplanter høiere oppe i furutuffen paa de jemtlandske forekomster snarere er en reminiscens fra boreal tid.

Ved Leine rober *Fragaria vesca* og *Betula verrucosa* at klimatet har været gunstig, ialfald ikke daarligere end i nutiden.

HANSEN har med styrke fremhævet hvilken stor betydning den postglaciale varmetid med dens hævning av skoggrænsene har hat for fjeldvegetationen (1904 l. c.). Under denne tid er mangt et kontinuerlig utbredelsesfelt blit splittet ad og mange arktisk-alpine arter bukket under hvor fjeldene ikke var høie nok. Tuffene vidner tydelig om denne utryddelseskrig, specielt av fotofile arter under atlantisk tid (cfr. *Dryas* og *Hippophaës*).

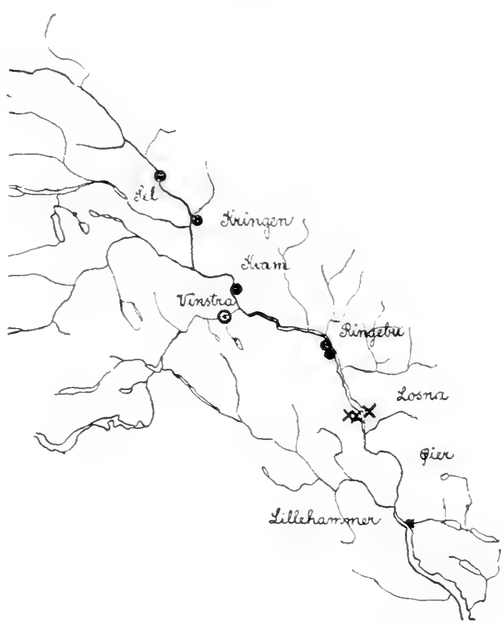

Fig. 41. Kart over Gudbrandsdalen med indlagte voksesteder for *Atragene sibirica* (×), *Athyrium crenatum* (●) og *Cystopteris sudetica* (⊙).

D. Den subboreale tid.

Om dette interessante tidsrum fortæller kalktuffene i dalen ikke andet end at kildene torket ind, og at der indtraadte en forvitring av den tidligere dannede tuf.

Som ovenfor omtalt er torvmyrforskerne kommet til det resultat, at det „postglaciale klima-optimum", altsaa selve varmetidens klimaks, har indtraadt efter atlantisk tid, nemlig under den tørre og varme subboreale periode. De marine avleiringer baade i Kristiania- og Trondhjemsfeltet viser ogsaa, som ØYEN har gjort opmerksom paa, at vi ingen grund har til at sætte Tapesnivaaet (sensu stricto) som kulminationspunkt; Trivia-nivaaets og delvis Ostræa-nivaaets fossilrike avleiringer vidner nemlig om ytterst gunstige klimatiske forhold, ogsaa efter Tapes-nivaaet. I avleiringer paa Frøoene, utenfor Trondhjemsfjorden, fra Trivia-nivaaet fandt jeg i 1915 foruten

Trivia europæa og en mængde andre sydlige typer ogsaa *Solecurtus candidus* Ren. Desh., en musling som nu for tiden ikke findes nordenfor den Irske Sjø (Nordhagen 1917 l. c.). Dette og andre tidligere fund i de norske marine avsætninger viser hvilke voldsomme forandringer og forskyvninger vi har at regne med i havets dyreverden i postglacial tid. Og landfloraen har gjennemgaat tilsvarende, om ikke større ændringer (cfr. Andersson 1902 l. c., Sernander 1908 l. c., Malmström 1920 l. c.).

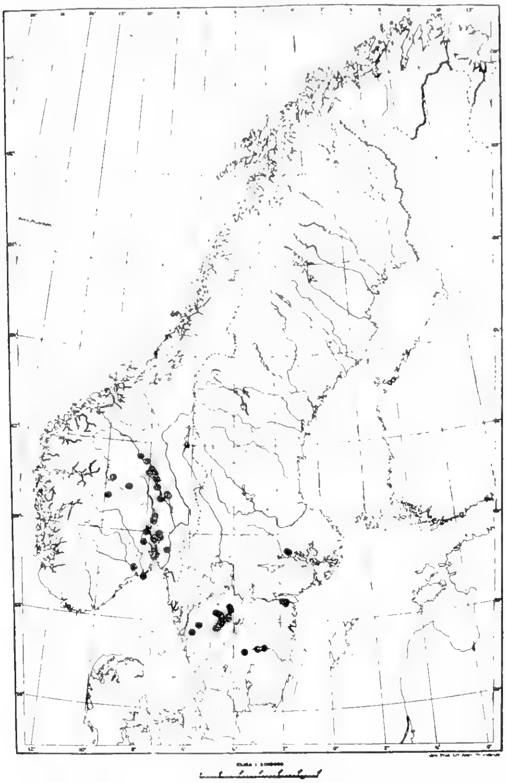

Fig. 42. *Dracocephalum Ruyschiana* i Skandinavien. Efter Sterner (1921). For Norges vedkommende er voksestedene sammenstillet av R. Nordhagen. Dette gjælder ogsaa *Brachypodium pinnatum*.

En række med plantearter av sydlig eller sydøstlig, varmekjær og kontinental type, som nu har sin nordgrænse i Gudbrandsdalen paa gunstige lokaliteter (sydskraaninger med kalkholdig og tør bund) er utvilsomt at opfatte som relikter fra subboreal tid. *Dracocephalum Ruyschiana* og *Brachypodium pinnatum* (fig. 42 og 43), to arter som Sterner (1921 l. c.) specielt har studert, hører til denne gruppe (cfr. den specielle del p. 9). Den sidste sætter ikke moden frugt ved Leine, saavidt jeg har kunnet konstatere; men den har rik vegetativ formering. Da Leinebakkene i nutiden huser saa mange rariteter, maa man anta at de i subboreal tid hadde en meget interessant vegetation. Desværre er der ikke opbevaret hverken tuf eller andre rester fra dette tidsrum[1].

E. Den subatlantiske tid.

Den merkelige Alnus-tuf og gruskeglen ved Gillebu vidner om store forandringer efter den subboreale tid. Fugtige orekrat lik de nuværende har udmerket Leinebakkene, men furuen har dog fremdeles været tilstede. Gillebutuffen fortæller intet om vegetationens karakter i Øier under denne periode.

[1] Jeg har tidligere omtalt de divergenser og vanskeligheter som knytter sig til betegnelsen „subboreal". Noget bidrag til denne periodes tidfæstelse kan kalktuffene i Gudbrandsdalen selvfølgelig ikke levere.

Man antar nu at granen indvandret til Norge i subboreal tid (HOLMSEN 1919 og 1920 l. c.), og det er for saavidt merkelig at rester av denne art mangler i den subatlantiske tuf ved Leine. I nutiden er dog granen sjelden i de øverste bygder i Gudbrandsdalen (f. eks. i Lesje, hvor den betragtes som en raritet og bindes til kranser, omtrent som barlind andre steder i landet). Den holder sig her mest til bakliene (HELLAND l. c.). Dette tyder paa en relativt sen fremtrængen i dalens nordre del, selv om kanske klimatiske forhold i nutiden ogsaa spiller ind. — Jeg har forøvrig tidligere præcisert at den negative kjendsgjerning at granrester mangler ved Leine, ikke behøver at bety saa meget. Da Alnus-tuffen er sterkt forvitret, ligger det nær at tænke sig at tufdannelsen i subatlantisk tid væsentlig har paagaat i periodens første del. Yngre lag er muligens ogsaa helt forvitret.

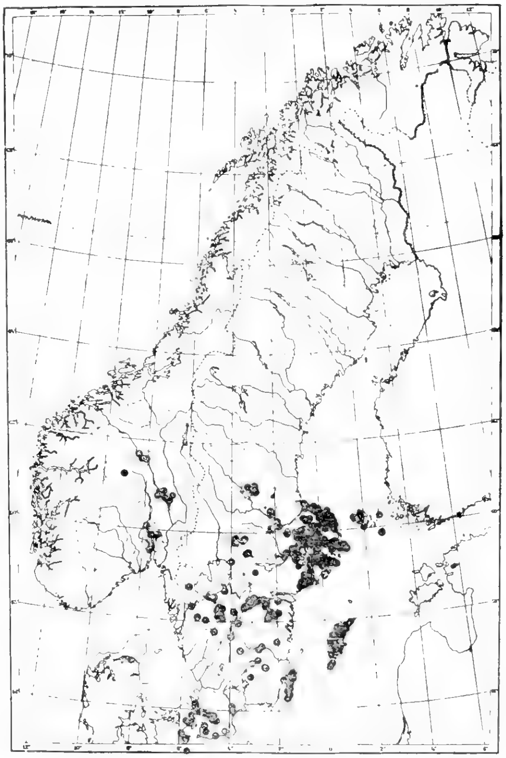

Fig. 43. *Brachypodium pinnatum* i Skandinavien. Efter STERNER (1921).

I subatlantisk tid rykket skoggrænsene paa fjeldene atter ned fra det høitliggende nivaa og til det nuværende. Regio alpina blev herigjennem sterkt utvidet, og nye spredningsmuligheter aapnet sig for fjeldplantene. De fjeldarter som vi finder i lerbakkene i Kvam i nutiden, er vistnok subatlantiske og recente nedvandrere. Lerskredene i nyere tid maa saaledes som tidligere omtalt, ha skapt gode vilkaar for fjeldplantene ved at blotlægge nye arealer og skape lette konkurrencevilkaar og rik lystilgang[1]. En art som *Dryas octopetala* har dog endda ikke formaadd at gjenerobre det tapte terræng.

Omvendt har sydlige typer under subatlantisk tid undergaat store forskyvninger. Naar dette gjælder arter som *hassel*, *Trapa natans* etc., saa maa man ha lov til at generalisere forholdet. Dog er det mulig at forskyvningene i den varme og lune Gudbrandsdal har foregaat i mindre skala end mange andre steder.

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[1] Denne aapne plantevekst i skraaningene er ogsaa hensigtsmæssig for de sydlige relikte typer, som her ikke har saa let for at bukke under i konkurrencen med andre arter.

I dalens vegetationshistorie har den subatlantiske tid været en av de allervigtigste, idet granskogene litt efter litt har presset sig frem, specielt paa furuens bekostning. Dette har været mere fremtrædende i dalens nedre del end i de øvre trakter, hvor granskogen væsentlig er knyttet til de fugtigere og skyggefulde baklier med nordlig og østlig eksposition.

Endelig har mennesket i historisk tid paavirket vegetationen paa utallige maater, likeledes vandflommene og lerskredene.

Alt i alt kan vi for Gudbrandsdalens vedkommende adskille tre epoker i skogenes historie:

1. Den første subarktiske bjerk-aspeskogs tid.
2. Furuskogenes tid.
3. Granskogenes tid.

Under den postarktiske varmetid har antageligvis ogsaa ædle løvtræer spillet en viss rolle paa gunstige lokaliteter, saaledes som ovenfor antydet.

Denne inddeling sigter kun til de dominerende træslag; det er saa at si en kvantitativ inddeling, og den falder ikke sammen med den oversigt som andre forskere opstiller paa grundlag av undersøkelser i Danmark, Syd- eller Mellemsverige og det sydlige Norge. Her har forholdene været anderledes, ikke alene kvantitativt, men ogsaa kvalitativt. I det hele tat er det umulig at fastsætte en viss postarktisk „norm" for hele Skandinavien grundet paa palæobotaniske principper, saaledes som ældre plantegeografer antok. Forholdene har variert betydelig i de forskjellige deler av Skandinavien, om end visse større geografiske provinser med et visst fællespræg i vegetationshistorien kan utskilles. For Norges vedkommende er disse spørsmaal endda lite studert.

Fortegnelse over de fundne plantearter og snegler.

Karplanter.

Equisetum variegatum ALL. Uhyre alm. i mosetufbænken ved Leine (BLYTT 1891); ogsaa i den undre Dryashorisont og i Dryastuffen.

Equisetum hiemale L. Furutuffen ved Leine, men især alm. i *Alnus*-tuffen. Nedre Dal i mængde i bladtuffen (BLYTT 1892), muligens ogsaa i furutuffen.

Pinus silvestris L. I furutuffen ved Leine, Gillebu og Nedre Dal i uhyre masser (naaler, bark, grener, kongler); i Dryastuffen ved Leine sparsomme naaler, nederst kortere og smalere, men allerede i Dryastufkompleksets midtre del lange og brede (cfr. BLYTT 1892). Sparsomme naaler i Alnus-tuffen ved Leine. Pollen i bladtuffen ved Leine og Gillebu og i bladtufblokkene ved Onset.

Picea excelsa (LAM.) LINK. Nogen naaleformige avtryk i et par smaa stykker fra Onset (BLYTTS samling) og i undertegnedes samling av løse tufbiter i jorden sammesteds tilhører vistnok denne art. — Mangler i Gudbrandsdalens tuffer. Kun ved analyse av forvitret furutuf fra Gillebutuffens øverste del har jeg set et par pollenkorn av gran, hvilket utvilsomt skyldes recent tilførsel med nedsivende vand.

Populus tremula L. Bladtuffen ved Leine, Gillebu og Nedre Dal (BLYTT 1892); Dryastuffen, furutuffen og *Alnus*-tuffen ved Leine; furutuffen ved Gillebu. Onset i bladtufblokkene (ØYEN 1920).

Salix capræa L. Ved Leine, Gillebu og Nedre Dal alm. i bladtuffen (BLYTT 1892). Ved Leine sparsomt i Dryastuffen, desuten i furutuffen og Alnustuffen sammesteds.

Salix nigricans SM. I bladtuffen ved Nedre Dal (BLYTT 1892); vistnok ogsaa i bladtuffen ved Leine og Gillebu; i bladtufblokkene ved Onset (ØYEN 1920).

Salix cfr. *phylicifolia* SM. I bladtuffen ved Leine og i Dryastuffen samt i bladtuffen ved Gillebu forekommer en del blader som maa henføres til denne art; men bestemmelsen av fossile *Salices* er meget vanskelig.

Salix arbuscula L. Ved Leine i den undre Dryashorisont, men især i Dryastuffen almindelig (BLYTT 1892). I et profil er den iagttat nederst i furutuffen. — Planche I, fig. 8. Foruten blader har jeg set smale ♀-rakler av denne art (planche II, fig. 2).

Salix hastata L. Et par blader fra bladtuffen ved Leine (BLYTT 1892). Denne bestemmelse er utvilsomt rigtig.

Salix glauca L. Bladtuffen ved Leine temmelig alm. (BLYTT 1892) Kollodiumavtryk av et vakkert opbevaret avtryk viser at epidermis har været sterkt haaret. Bestemmelsen er ganske sikker (planche I, fig. 6).

Salix cfr. *lanata* L. Et par mindre avtryk fra bladtuffen ved Leine tilhører muligens denne art, men bestemmelsen er meget usikker.

Salix reticulata L. Dryastuffen ved Leine (BLYTT 1892). BLYTT fandt bare to blader; men da jeg selv har fundet 13 avtryk, er arten neppe sjelden i dette lag (planche III, fig. 2).

Salix herbacea L. Av denne art har jeg fundet et fragmentarisk, men typisk bladavtryk (planche I, fig. 7) i Dryastuffen ved Leine. Karakteristisk for denne art er at bladets hovednerve (midtnerve) ikke løper distinkt ut til bladranden, men svækkes og blir mere utydelig et stykke fra randen. Den fine tanding og bladets smaa dimensioner stemmer likeledes med denne art.

Foruten de anførte arter har jeg fundet avtryk av andre *Salices*; men det er ikke mulig at bestemme dem med sikkerhet.

Betula odorata BECHST. Alm. i bladtuffen (og mosetuffen) ved Leine, Gillebu, Nedre Dal (BLYTT 1892). Ogsaa i Dryastuffen, og i furutuffen paa alle tre forekomster, desuten i *Alnus*-tuffen ved Leine. Onset i bladtufblokkene. — Foruten blader og bladfragmenter i store kvantiteter har jeg ogsaa fundet forkalkete ♀-rakler.

Betula verrucosa EHRH. BLYTT anfører et bladfragment fra furutuffen ved Leine (dobbelttandet, næsten lappet rand), dog under tvil, likeledes et langstilket blad fra furutuffen ved Nedre Dal (usikkert). — Jeg har selv i furutuffen ved Leine fundet et bjerkeblad med langt uttrukket spids og dobbelttandet rand, som maa henføres til *B. verrucosa*.

Betula cfr. *intermedia* THOM. „Dryastuffen ved Leine, meget usikker" (BLYTT 1892).

Betula cfr. *nana* L. „Et brudstykke av et blad, meget usikkert fra Dryastuffen ved Leine" (BLYTT 1892).

Betula cfr. *alpestris* FR. „Leine, den nederste del av birketuffen. Et eneste blad uten top, hvorfor bestemmelsen er usikker" (BLYTT 1892). — Jeg har selv hat anledning til at se de angjældende avtryk av *B. nana* og *intermedia* og finder dem høist usikre. I mine egne samlinger har jeg heller ikke fundet spor av disse former.

Alnus incana DC. BLYTT anfører et par fragmentariske bladavtryk fra birketuffen ved Leine som „cfr. Alnus incana"; men bestemmelsen er meget usikker da randen mangler. I *Alnus*-tuffen ved Leine uhyre alm., ogsaa en hel del ♀-rakler. Bladstørrelsen varierer adskillig (planche V). — Alm. i bladtufblokkene ved Onset (BLYTTS samling. ØYEN 1920).

Corylus Avellana L. Avtryk og hulhet efter en nøtt i et løst tufstykke i jorden ved Onset. Alder ubestemt.

Ribes cfr. *rubrum* L. BLYTT anfører et haandnervet blad fra birketuffen ved Leine. Noget usikker artsbestemmelse.

Sorbus Aucuparia L. I furutuffen ved Leine et bladfragment (planche II, fig. 3).

Cotoneaster integerrima MEDIC. BLYTT opfører et blad fra Dryastuffen ved Leine; men bestemmelsen er usikker.

Prunus Padus L. „Den nedre del av et blad 0,04 m. bredt paa midten, fra birketuffen ved Dal" (BLYTT 1892).

Dryas octopetala L. Blader og hele stammer med paasittende bladrester i store masser i Dryastuffen ved Leine (BLYTT 1892). Desuten i den undre Dryashorisont. Et enkelt blad i bladtuffen. Forskjellige eiendommelige kalkkjerner og avtryk (blomster i begyndende frugtstadium (planche I, fig. 1), blomsterbund med merker efter smaafrugtene (planche I, fig. 2, 3, 4, 5)) skriver sig ogsaa fra denne art.

Fragaria vesca L. I furutuffen ved Leine fandtes et mindre, trekoblet blad, som i ett og alt stemmer med jordbærblader. Desværre var bladet saa skjørt at det under transporten til Kristiania blev noget ødelagt. Av planche III, fig. 1 ser man at de tre deler er fossilificert i forskjellige planer. (*Ulmaria pentapetala, Ribes rubrum* og *Rubus saxatilis* er utelukket, hvilket den direkte sammenligning paa findestedet dengang avtrykket blev fremfundet, viste.)

Hippophaës rhamnoides (L.) ASCHERS. Bladtuffen ved Gillebu, i mængdevis i tufbænkens bund og paa dens underflate (ØYEN 1917, det. NORDHAGEN), sparsommere opad.

Pyrola cfr. *minor* L. I Dryastuffen og furutuffen ved Leine flere blader og en hel forkalket liten plante av en *Pyrola*, som stemmer godt med *P. minor*; men artsbestemmelsen er ikke helt sikker.

Vaccinium vitis idæa L. I furutuffen ved Leine m. alm. og Nedre Dal alm. (Blytt 1892); ved Gillebu sparsom baade i bladtuffen og furutuffen. Blytt anfører den ogsaa, om end noget usikkert, fra Dryastuffen ved Leine.

Vaccinium uliginosum L. I bladtuffen ved Nedre Dal et eneste blad (Blytt 1892). Furutuffen ved Leine flere blader.

Cfr. *Arctostaphylos uva ursi* (L.) Spreng. Blytt anfører et usikkert brudstykke (den nedre halvdel) av et blad fra Dryastuffen ved Leine. — Bestemmelsen er høist usikker; jeg har selv fundet smaa glatte bladavtryk i Dryastuffen som ligner baade *Cotoneaster* og andre arter med helrandete blader, men som vistnok bare er avtryk av *Salix arbuscula*, hvor det øverste kalklag (med nervaturavtrykket) er avspaltet eller utvisket.

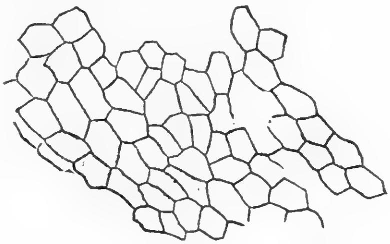

Fig. 44. Cellestruktur av *Pellia* sp., tegnet efter kollodiumavtryk av kalktuf.

Linnæa borealis L. Et blad i furutuffen ved Nedre Dal (Blytt 1892).

Cirsium heterophyllum (L.) All. Av denne art fandtes flere store kurver og en del bladfragmenter i furutuffen ved Leine; desværre er de største blit knust under transporten. En mindre kurv er avbildet paa planche II (fig.). Bestemmelsen er helt sikker.

Carex sp. En liten forkalket plante fandtes i Dryastuffen ved Leine. I *Alnus*-tuffen grove blader som vistnok skriver sig fra *Carices*.

Gramina. Ubestemmelige bladfragmenter og hulheter efter græs er alm. i tuffene. I Alnustuffen ved Leine flere grove græsblader.

Tofieldia palustris Huds. I furutuffen ved Leine i den sedentære sone fandtes flere vakre bladvifter (planche II, fig. 4). Kollodiumavtryk av epidermis viste at spalteaapningenes anordning og størrelse var som paa levende materiale. De eiendommelige smale og „ridende“ blader kan ikke forveksles med andre planters end *Narthecium*'s, som er meget bredere og grovere.

Moser.

Blytt anfører *Amblystegium falcatum* Brid. og *Mnium punctatum* Hedw. fra Leine samt *Hypna*, som ikke kan bestemmes med sikkerhet. — Baade ved Leine og Gillebu findes vakre mosetuffer, men artsbestemmelsen er meget vanskelig. Av *levermoser* har jeg kunnet identificere *Marchantia polymorpha* L. ved hjælp av kollodiumavtryk (cellestruktur paa oversiden og undersiden, „aandehuler“, bukskjæl. Cfr. planche I, fig. 9), desuten *Pellia* sp. (fig. 44). Den første fandtes i mosetufbænken ved Leine, den sidste i den undre Dryashorisont.

Lavarter.

I furutuffen ved Leine fandtes et eiendommelig avtryk i den sedentære sone (planche II, fig. 5). Ved kollodiumavtryk kunde jeg konstatere at det ikke er nogen levermos. Det er utvilsomt en lavart, antageligvis *Parmelia physodes* (L.) Ach., som optræer i enhver furuskog i store mængder. Størrelsen, lobernes form og avslutning stemmer godt med denne art. Ogsaa et par andre, men mere utydelige avtryk fra Leine skriver sig vistnok fra lavarter. Blytt fandt vakre avtryk av *Peltigera canina* (L.) Th. Fr. sparsomt i furutuffen ved Leine. Fossile lavarter er ellers meget sjeldne (cfr. Sernander: Subfossile Flechten. Festskrift til Stahl 1918 l. c.).

Characéer.

I mosetuffen i bunden av Leinetuffen optræer der en mængde fine smaa kalkrør, som tildels er kantet og forgrenet, og som utvilsomt skriver sig fra *Characéer.* Restene har en paafaldende likhet med Characékalk fra sjøer paa Gotland (Växtbiologiska Institutionens samling. Uppsala). Ogsaa grovere skud forekommer. En del smaa rør er avbildet paa planche I (fig. 10). Muligens *Nitella opaca,* men usikkert.

Snegler.

Bestemt av docent cand. real. F. Økland, Aas landbrukshøiskole. Blytts samling blev bestemt av avdøde frk. B. Esmark.

Clausilia nigricans (Strøm). Bladtufblokker ved Onset (det. B. Esmark, Øyen 1920).

Clausilia plicatula Drap. Sammen med foregaaende.

Cochlicopa lubrica Müll. Dryastuffen ved Leine (Blytt 1892); ogsaa i Alnustuffen sammesteds.

Conulus fulvus Müll. I moræneleren s øvre del, mosetuffen, Dryastuffen og furutuffen (Blytt 1892) ved Leine. Onset i bladtufblokkene (det. Esmark, Øyen 1920).

Helix arbustorum Less. I furutuffen og bladtuffen ved Nedre Dal (Blytt 1892).

Hyalinia radiatula Alder (incl. var. *petronella* Charp.). I Dryastuffen, furutuffen og Alnustuffen ved Leine (Blytt 1892). Bladtufblokkene ved Onset (det. Esmark, Øyen 1920).

Pupa muscorum Müll. Bladtuffen ved Nedre Dal (Blytt 1892).

Pyramidula ruderata Studer. Furutuffen ved Dal (Blytt 1892), Dryastuffen og Alnustuffen ved Leine. Bladtuffen ved Gillebu (Øyen 1920).

Sphyradium edentulum Drap. Mosetuffen ved Leine.

Succinea sp. Bladtuffen ved Gillebu (Øyen 1917, ipse!).

Valonia pulchella MÜLL. Bladtufblokkene ved Onset (det. B. ESMARK, ØYEN 1920).

Vertigo alpestris ALDER. Alnustuffen ved Leine.

Vitrina pellucida MÜLL. Moræneleréns øverste del, samt i furutuffen ved Leine (BLYTT 1892). Bladtuffen ved Nedre Dal (BLYTT 1892).

Limnæa truncatula MÜLL. Moræneleréns øvre del, Leine (det. Dr. N. ODHNER, Stockholm).

Hydrobia Steini v. MART. Alnustuffen ved Leine.

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TEKST TIL PLANCHENE.

I.

1. Blomst av *Dryas octopetala* i begyndende frugtstadium. (3 ×).
2. og 3. Avtryk og kalkkjerner, vistnok blomsterbund og basaldelen av Dryasblomster (set nedenfra). (4 ×).
4. Blomsterbund av *Dryas* med nischer efter smaafrugtene. (3 ×).
5. Hulrum efter smaafrugter av Dryas. (3 ×).
6. Blad av *Salix glauca*. (1/1).
7. Bladfragment av *Salix herbacea*. (2 1/2 ×).
8. Blad av *Salix arbuscula*. (1/1).
9. Avtryk av undersiden av *Marchantia polymorpha* (merke efter bukskjællene). (2 ×).
10. Kalkrorfragmenter efter Characéer. (3 ×).

II.

1. Kurv av *Cirsium heterophyllum* (med undersiden op og den avbrukne stilk tilhoire). (2 ×).
2. Rakle (♀) av *Salix arbuscula* med aapnede kapsler. (3 ×).
3. Bladfinne av *Sorbus Aucuparia*. (1/1).
4. Bladvifte av *Tofieldia palustris*. (2 ×).
5. Avtryk av en lavart, vistnok *Parmelia physodes*. (4 1/2 ×).

III.

1. Blad av *Fragaria vesca*, Leine. (1 1/2 ×).
2. *Dryas octopetala* og *Salix reticulata*, Leine. (1 1/2 ×).
3. En fuglefjær, Leine. (1 1/2 ×).
4. *Hippophaës*, *Salix capræa*, *Betula odorata*, Gillebu. (1/1).
5. Forgrenet dvergstamme av *Dryas* med bladrester, Leine. (1/2).

IV.

1. Forvitret furutufstykke fra profil XXI, Leine, med avtryk efter tre kongler av *Pinus silvestris*. (1/2).
2. Bladtuf med anrikning av blader av *Salix* cfr. *nigricans*, Leine. (1/2).

V.

Alnus-tuf fra Leine. Bladavtryk og kvister av *Alnus incana*. Det overste stykke 1/2, de nederste 1/1.

RETTELSER OG TILFØIELSER.

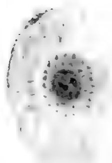
Side 46, linje 8 ovenfra: Schroeter, læs *Schröter.*
„ 84, „ 22 ovenfra: *M. tenerrima* utgaar.
„ 84, „ 24 ovenfra: H. Bambergi, læs *H. Bambergeri.*
„ 84, note 1: Olivcorona, læs *Olivecrona.*
„ 96, linje 3 ovenfra: leret, læs *leren.*
„ 84. Da forfatteren har læst korrektur paa avhandlingen under en reise i Mellemeuropa og for længere tid ad gangen har været avskaaret fra videnskabelig litteratur, er desværre nomenklaturen for de i avhandlingen omtalte moser helt negligeret. Da Dr. Hj. Möller, som har bestemt mine prover, tildels anvender en nomenklatur som avviker meget fra den mellemeuropæiske, anfores nedenfor autorsnavn og synonymer for de anførte mosarter:

Amblystegium filicinum De Not. = *Cratoneuron filicinum* (L.) Roth.
— *protensum* Lindb. = *Campylium protensum* (Brid.) Kindb.
Ditrichum flexicaule (Schleich.) Hampe.
Leucodon sciuroides (L.) Schwgr.
Mollia æruginosa Lindb. = *Gymnostomum rupestre* Schleich.
— *tortuosa* Schrank = *Tortella tortuosa* (L.) Limpr.
Myurella apiculata (Hüben) Br. eur.
— *julacea* (Vill.) Br. eur.
Hypnum Bambergeri Schpr. = *Stereodon Bambergeri* Lindb.
— *sericeum* L. = *Homalothecium sericeum* (L.) Br. eur.
Swartzia montana Lindb. = *Distichium capillaceum* (Sw.) Br. eur.
Leersia contorta Lindb. = *Encalypta contorta* (Wulf.) Lindb.

Trykt den 9. november 1921.

1

4



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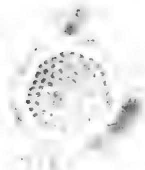

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R. Nordhagen delin.

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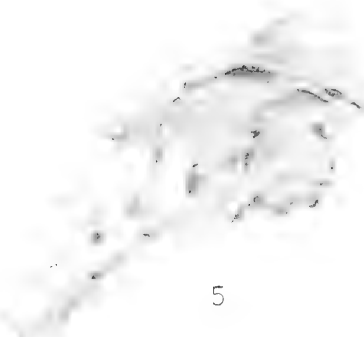

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R. Nordhagen delin.

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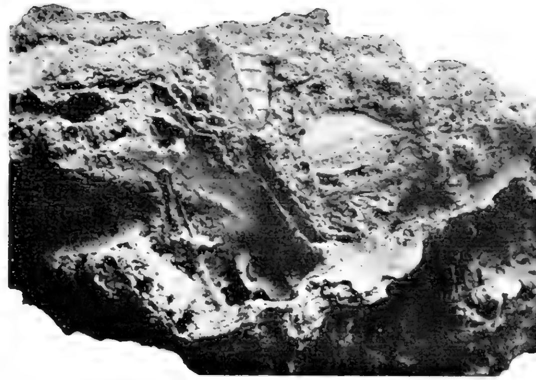

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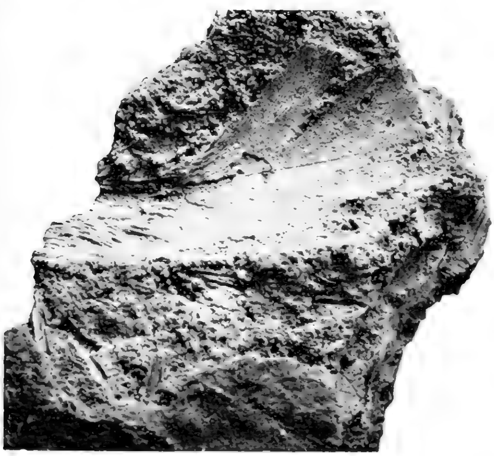

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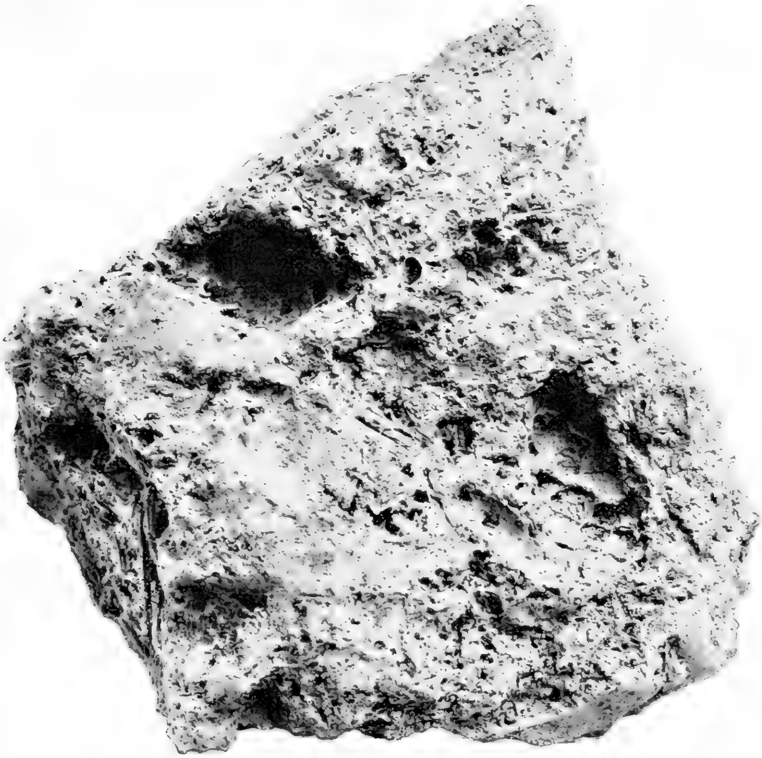
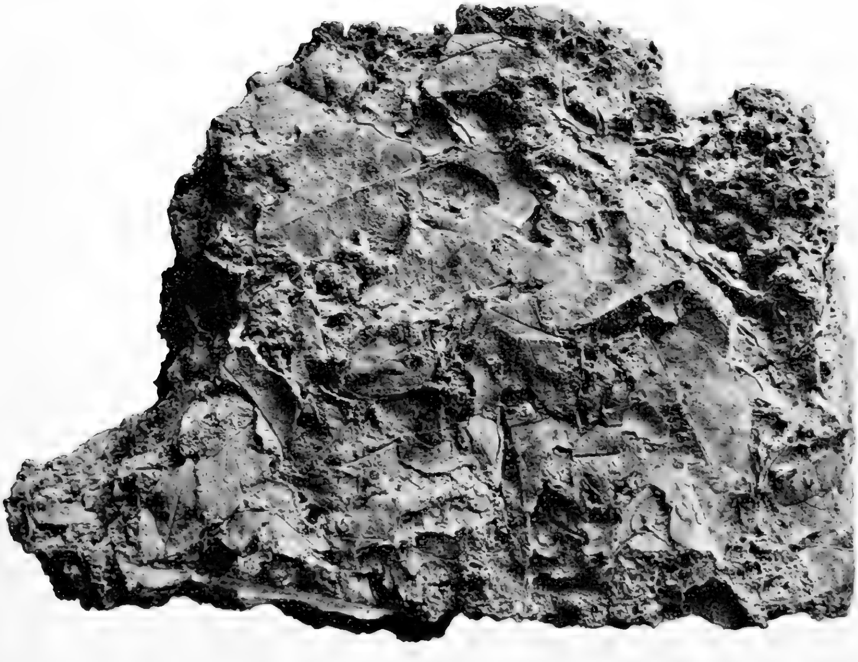
B. Larssen fot.





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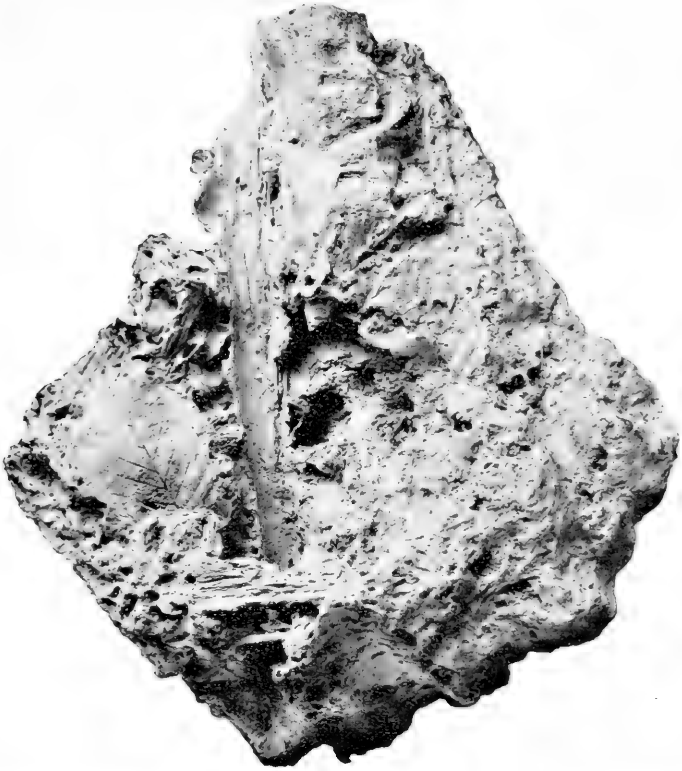

ÄQUIVALENTE DER UNTERSILURISCHEN EULOMA-NIOBEFAUNA BEI PLZENEC IN BÖHMEN

VON

J. V. ŽELÍZKO

MIT 5 TAFELN, 1 KARTENSKIZZE UND 1 TEXTABBILDUNG

(VIDENSKAPSSELSKAPETS SKRIFTER. I. MAT.-NATURV. KLASSE. 1921. NO. 10)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
IN KOMMISSION BEI JACOB DYBWAD
1921

Fremlagt i den mat.-naturv. klasses møte den 3dje juni 1921 av prof. Johan Kiær.

A. W. BRØGGERS BOKTRYKKERI A/S

Vorwort.

Als mir im Jahre 1908 Herr Prof. C. v. PURKYNĚ eine größere, bekanntlich von ihm für die geologisch-paläontologischen Sammlungen des städtischen historischen Museum in Pilsen erworbene Menge untersilurischer Fossilien der Stufe d 1 γ aus der sogen. *Černá stráň* (= Schwarze Lehne) oder *Hůrka*[1] an dem rechten Ufer des Uslavaflusses bei Plzenec (Pilsenetz), zur wissenschaftlichen Bearbeitung anvertraute, ahnte ich nicht, daß die betreffende Gegend später ein willkommener Gegenstand meiner einige Jahre dauernden Forschungen sein wird.

Im Jahre 1910 besuchte ich Hůrka zum ersten Male, wo ich teilweise für das historische Museum in Pilsen, teilweise für die geologische Reichsanstalt weitere, größtenteils neue Fossilarten aufsammelte, dann setzte ich auch im Jahre 1911 meine Forschung fort, sodaß die Anzahl der Fossilien wiederum stieg, wie auch aus dem tabellarischen Verzeichnis PURKYNĚ's[2], wo einige von mir nachträglich festgestellten Arten angeführt sind, ersichtlich ist.

Außerdem bleibt noch eine Reihe zur Bearbeitung vorbereiteter Versteinerungen wie: *Orthoceren*, *Pteropoden*, *Gastropoden* und *Lamellibranchiaten*

Schließlich veröffentlichte auch C. KLOUČEK einen Beitrag zur Kenntnis der Fauna der Stufe d 1 γ von Hůrka[3].

Aus dem oben angeführten geht am besten hervor, daß diese meistens schwer zugängliche steile Lehne viel besser durchgeforscht war als man eigentlich annimmt[4].

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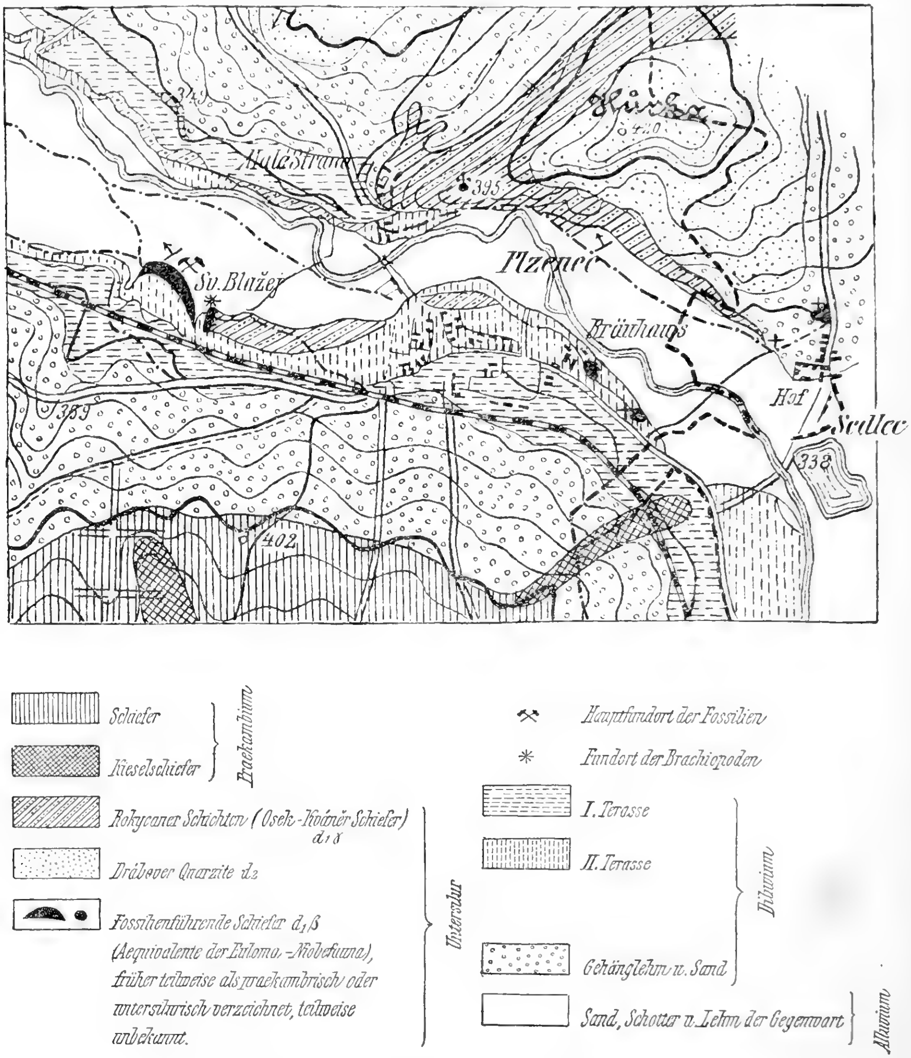
[1] I. V. ŽELÍZKO. *Faunistische Verhältnisse der untersilurischen Schichten bei Pilsenetz in Böhmen.* Verhandl. d. k. k. geol. Reichsanstalt. Nr. 3. Wien 1909. *Zpráva o zvířeně spodního siluru od Plzence.* Sbornik historického musea v Plzni. Jg. I. Pilsen 1909. — *Zur Frage über die Stellung der Hyolithen in der Paläontologie.* Centralblatt für Min., Geol. u. Pal. N. 12. Stuttgart 1908. — *Zwei neue Conularien aus dem älteren Paläozoicum von Böhmen.* Ibid. 1913.

[2] C. RYTÍŘ PURKYNĚ. *Geologie okresu Plzeňského.* S. 53—57. Pilsen 1913.

[3] C. KLOUČEK. *O geologickém horizontu rudního ložiska na Karýzku.* Rozpravy České Akademie. Ig. XXII. N. 9. Prag 1913.

[4] *Derselbe. O vrstvách D 1 γ, jich trilobitech a nalezištích.* Ibid. Ig. XXV. N. 39. 1916.

Vor PURKYNĚ war die Lokalität faunistisch sehr wenig durchgeforscht, denn das Museum der k. k. geologischen Reichsanstalt hat von da nur drei von LIPOLD mitgebrachten Fossilarten (*Strophomena primula, Paterula bohemica,* und *Lingula sp.*).



Geologische Kartenskizze der Gegend von Plzenec.

1 : 30 000. Nach C. Purkyně, ergänzt v. J. V. Želízko.

I. KREJČÍ und K. FEISTMANTEL [1], die sich auch mit den geologischen Verhältnissen der Umgebung von Plzenec befaßten, sprechen nirgends von Versteinerungen.

[1] *Orographisch-geotektonische Übersicht des silurischen Gebietes im mittleren Böhmen.* Archiv der naturwiss. Durchforschung von Böhmen. Bd. V. No. 5. Prag 1890.

Als ich nach Beendigung meiner Forschung auf der Hůrka im Jahre 1912 bei Plzenec zufällig Schiefer der Komorauer Stufe (d 1 β) mit überraschender, meistens bisher unbekannter Fauna[1], welche der Hauptgegenstand der vorliegenden Arbeit ist, entdeckte, besuchte ich anläßlich der Durchforschung neuer Lokalitäten Plzenec noch im Jahre 1913 und 1915.

Daß ich die Forschung mit solchem Erfolg zustande brachte, wie später gezeigt wird, dafür bin ich in erster Reihe dem löbl. *Verwaltungsausschusse des Museums des Königreichs Böhmen,* welcher mir zu diesem Zwecke im Jahre 1913 eine Subvention aus dem Barrande'schen Fonde gewährte, verpflichtet.

Die Schloenbachstiftung der *k. k. geol. Reichsanstalt* ermöglichte mir dann im Jahre 1914 eine Studienreise nach Skandinavien zur Besichtigung dortiger altpaläozoischer Ablagerungen, sowie der diesbezüglichen, zum Vergleich der von mir bei Plzenec festgestellten Fauna wichtigen Sammlungen.

Während meiner Anwesenheit in Plzenec war Herr Ing. Rud. Císař stets ein opferwilliger Teilnehmer meiner Arbeiten, wofür ich ich ihm an dieser Stelle herzlich danke.

Gleichfalls danke ich dem p. t. *Gemeindeamte* in Plzenec für die Erlaubnis zur Durchforschuug der der Gemeinde gehörenden Lokalität »U Blažeje«.

Ferner ist es mir eine angenehme Pflicht, Herrn Prof. C. Ritter von Purkyně für die allseitige, meinen Forschungen im westlichen Böhmen jahrelang gewidmete Unterstützung zu danken.

Schließlich bin ich Herrn Prof. Joh. Kiær in Kristiania, welcher sich meiner Publikation freundlichst annahm und dieselbe zur Veröffentlichung in »Videnskapsselskapets Skrifter« empfahl, besonders zum innigsten Dank verpflichtet.

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[1] I. V. Želízko. *Neuer Beitrag zur Geologie der Gegend von Pilsenetz in Böhmen.* Verhandlung der k. k. geolog. Reichsanstalt. No. 5. 1913.

Schiefer der Bande D—d 1 β deren Liegendes und Hangendes.

a) Die Schiefer »U Blažeje«.

Westlich von Plzenec, an dem linken Ufer der Uslava, zieht sich eine aus der Ferne gut sichtbare Lehne, genannt »U Blažeje«, welche mit einer ziemlich hohen felsigen, nordwestlich streichenden Böschung endet.

In einer Schlucht der betreffenden Lehne, an dem rechten Ufer eines unweit des Eisenbahnwächterhauses No. 269 fließenden Bächleins treten dünngeschichtete, verwitterte Schiefer zu Tage, die bei flüchtiger Besichtigung an die Schiefer der Osek-Kváňer Stufe (d 1 γ) erinnern, welche bekanntlich auf der gegenüberliegenden Hůrka vertreten sind und scheinbar auch auf das linke Uslavaufer übergehen.

Diese Schichten, welche teilweise von Diluvialablagerungen bedeckt sind, hat Herr Prof. Purkyně in seiner Karte [1] ursprünglich als der Osek-Kváňer Stufe angehörend verzeichnet, später jedoch [2] die Ansicht ausgesprochen, daß dieselben wahrscheinlich dem Eulomahorizonte der Stufe d 1 β zuzurechnen sind.

Bei näherer Untersuchung der besprochenen Schiefer fand ich, daß der petrographische Charakter derselben ein anderer ist, als die typischen schwarzen Schiefer von Hůrka aufweisen.

Das Gestein besteht im frischen Zustande aus graugrünem, feinkörnigem, glimmerigem und festem Schiefer, welcher verwittert eine lichte, graue oder gelblichbraune Farbe aufweist. Die Flächen der Schieferplatten sind häufig von Eisenhydrooxyd verschiedenartig gefärbt.

Genannter Schiefer erinnerte mich schon auf den ersten Blick an einen ähnlichen, den ich im J. 1906 bei Klabava, zwischen Pilsen und Rokycan sah, von wo ein Jahr früher Herr Prof. B. Horák einige neue Versteinerungen für das städtische Museum in Rokycan erworben hat, und welche mir zur späteren Bearbeitung zugesandt waren. Als dieses Material bald

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[1] *Geologická mapa zastupitelského okresu Plzeňského,* 1 : 30 000. Pilsen 1910.

[2] *Geologie okresu Plzeňského.* S. 52. Pilsen 1913.

darauf durch die Aufsammlungen Holubs bedeutend vermehrt wurde, habe ich auf Ansuchen des Herrn Holub, welcher die Zugehörigkeit der Funde zu einem für Böhmen neuen Eulomahorizonte nachgewiesen hat[1], ihm den betreffenden Teil zur Bearbeitung überlassen.

An der Exkursion nach Klabava im J. 1906 habe ich mit Herrn Prof. Horák und Purkyně ausschließlich zur Untersuchung der geologischen Verhältnisse der Lokalität teilgenommen, denn zum Suchen nach Fossilien war damals die nötige Zeit nicht vorhanden, infolgedessen konnte man natürlich von diesem Ausflug keinen besseren Erfolg erwarten[2].

Die auffallende petrographische Übereinstimmung des Schiefers von Klabava mit dem des Fundortes »U Blažeje« bei Plzenec veranlaßte mich zu emsigerem Suchen nach Versteinerungen, was tatsächlich nicht ohne Erfolg blieb. Auf diese Weise wurde neuerdings bestätigt, daß es nicht immer richtig ist, den petrographischen Charakter eines Gesteines zu unterschätzen, welches nach dem oberflächlichen Ansehen nicht fossilführend zu sein scheint.

Nach längerem geduldigem Suchen im neuen Fundorte gelang es mir endlich überzeugende Beweise zu gewinnen, daß die hier zutage tretenden Schichten auch faunistisch mit jenen von Klabava übereinstimmen, d. h. daß sie eine *Fazies der Stufe d1β bilden.*

In teilweise festem, teilweise halbverwittertem, tonigem Material wurden neben undeutlichen *Graptolithen* auch mehrere Stücke von *Brachiopoden*, die den bereits von Barrande angeführten *Linguliden*, und zwar der *Lingula sulcata*[3] und der *Lingula rugosa*[4] und anderen verwandten Formen angehören.

Barrande bezeichnete als Fundort beider Arten *Klabava* (»Vallon de la Klabava — d 1 — au nord de Rokitzan«).

Außer diesen Versteinerungen kommen im neuen Fundorte bei Plzenec auch bekannte enge, den Orthoceren ähnlich gegliederte Bildungen, und undeutliche Trilobitenreste vor.

Noch besser aufgeschlossen findet man fossilienführende Schiefer einige Schritte nordwestlich von der obenerwähnten Stelle, nämlich hinter dem Kreuz »U Blažeje«, wo die Lehne in einer ziemlich steilen Böschung abläuft. Da an dieser Stelle das Gestein öfters zum Schottern ausgebrochen wurde, sind die besprochenen Schichten überall gut zugänglich.

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[1] K. Holub. *Nová fauna spodního siluru v okolí Rokycan.* Rozpravy České Akademie. Jg. XX. Nr. 15, Prag 1911. — *Doplňky ku fauně eulomového horizontu v okolí Rokycan.* Ibid., Ig. XXI, Nr. 33, 1912.

[2] K. Holub. Nová fauna etc., pag. 1.

[3] *Système Silurien.* Vol. V, Pl. 106, Fig. III (2, 3).

[4] Ibid. Pl. 152, Fig. V (2, 3).

Dieser Teil der Lehne wurde vom Herrn Prof. PURKYNĚ als präkambrische Schiefer aufgenommen.

Auf der alten, handkolorierten Karte der k. k. geol. Reichsanstalt (Z. 7 C. IX. Pilsen und Blowitz) ist der an dem linken Ufer des Uslavaflusses liegende Schichtenkomplex überhaupt als präkambrischer (Příbramer) Schiefer B bezeichnet.

Das Gestein in dem nordwestlichen Zipfel der Lehne »U Blažeje« bildet nordwestlich zwischen 30—40° einfallende, feste und unregelmäßig mächtige Bänke, die besonders gegen NW allmählich in ganz dünne blättrige Schichtchen übergehen.

Auch an dieser Stelle glückte es mir nach längerem Suchen einige schön erhaltene Versteinerungen im gelbbraunen halbverwitterten, sowie im festen, graugrünen Schiefer zu gewinnen. Während meiner dreijährigen Forschung fand ich hier zahlreiche *Brachiopoden*, einige *Orthoceren*, *Pteropoden*, namentlich aber schön erhaltene *Graptolithen* in Form von bis über 40 cm. langen Büscheln und Ruten (Taf. V), mit deren Bearbeitung sich soeben Herr Dr. PERNER beschäftigt. Am besten erhaltene Exemplare haben große graugrüne Schieferplatten geliefert. Schließlich sollen noch einige neue *Trilobiten* als Seltenheit erwähnt werden.

Die Schichten der Stufe d 1 β an dem linken Uslavaufer sind von Diluvialablagerungen der III. Terrasse PURKYNĚ's bedeckt. Dieselben kann man von dem Hauptfundorte »U Blažeje« auch noch gegen WSW, sowie gegen O, wo sie quer über den Fahrweg etwa in halber Entfernung zwischen der Stelle »U Blažeje« und Plzenec an einigen Punkten zum Vorschein kommen, verfolgen.

b) Die Schiefer in Plzenec.

Dieselben untersilurischen Schiefer der Stufe d 1 β wie in der Lehne »U Blažeje« kommen auch an einigen Stellen in Plzenec, wie z. B. hinter dem Bräuhaus und südöstlich von diesem auf der Stelle »U křížku« (= beim Kreuzchen) noch an dem linken Uslavaufer vor. Das Gestein ist aber größtenteils verwittert und an der Fläche rostig gefärbt.

Das Liegende der oberwähnten untersilurischen Schiefer des linken Uslavaufers bilden die präkambrischen Schiefer, welche überhaupt südöstlich von Plzenec einen ausgedehnten, häufig von Lydit- und Spilitstreifen und Inseln durchtretenden Komplex einnehmen.

Sie sind entweder von Diluvial- oder Alluvialablagerungen bedeckt, und da sie leicht verwittern, verwandeln sie sich oft in mächtige eluviale Tonschichten. Ein solches Beispiel liefert am besten die Umgegend von Spálené Poříčí (Brennporitschen) südöstlich von Plzenec, wo man Schiefer in eine beträchtliche Tiefe so stark zersetzt fand, sodaß es oft schwer ist das ursprüngliche Gestein durch einige feste Bruchstücke nachzuweisen[1].

Das eigentümliche Aussehen dieser tonigen Schichten lockte vor einigen Jahren verschiedene Privatunternehmer zur Schürfung nach Kohle in unmittelbarer Nähe von Spálené Poříčí, was, wie sich denken läßt, erfolglos blieb. Die mir damals zugesandten ca. 26 m. in die Tiefe reichenden Bohrproben zeigen wenigstens in wie weit der Zersetzungsprozeß der Schiefer vorgeschritten ist, wie folgt:

1. Probe.	Vollkommen zersetzter, in grauen, sandigen Ton verwandelter Schiefer	bis	15 m.
2. —	Derselbe von einer dunkleren Farbe	»	16 »
3. —	Derselbe von schwarzgrauer Farbe	»	17 »
4. —	Grauer, sandiger Schiefer	»	18 »
5. —	Schuppen von schwarzen glänzenden Schiefer mit Quarzkörnern	»	19 »
6. —	Dunklere Schiefermasse mit größeren Schieferbruchstücken	»	20 »
7. —	Dieselbe mit kleinen Quarzkörnern	»	21 »
8. —	Gemisch aus Bruchstücken des schwarzen Schiefers, Grünsteines und Quarzes	»	22 »
9. —	Schwarzer Schiefer mit Quarz und vielem Pyrit .	»	23 »
10. —	Bruchstücke des festen schwarzen Schiefers . . .	»	24 »
11. —	Grauschwarzer Schiefer	»	25 »
12. —	Fester, schwarzer, glänzender Schiefer	»	26 »

c) Die Schiefer bei Sedlec.

Daß man Schiefer der Stufe d 1 β auch an dem rechten Uslavaufer verfolgen kann, davon kann man sich bei Sedlec, einem ca. 1.5 km. östlich von Plzenec entfernten Dorfe überzeugen.

Nördlich von dem genannten Dorfe, beim Kreuz auf der linken Seite der nach Timákov führenden Straße, sowie an einigen anderen Punkten in Sedlec selbst, kommen meistens verwitterte, dünngeschichtete gelbbraune, nw. bis nww. unter einem 35—40° einfallende Schiefer zum Vorschein. Da dieselben in einer ziemlichen Tiefe zersetzt sind, konnte ich darin bloß undeutliche *Graptolithenspuren* und Bruchstücke von einer *Lingula*, und einigen länglichen Konkretionen finden.

Die besprochenen Schiefer der Stufe d 1 β bilden die Unterlage der konkordant liegenden schwarzen Schiefer der Stufe d 1 γ von Hůrka.

[1] F. KATZER. *Geologie von Böhmen*, pag. 636—637.

Die genaue Grenze zwischen beiden Stufen festzustellen, verhindern die die Schiefer bedeckenden Diluvialablagerungen.

Es scheint, daß die in den Schluchten des südöstlichen Teiles von Hůrka, näher gegen Sedlec, später gefundenen Versteinerungen wahrscheinlich jenen Schichten angehören, auf welchen unmittelbar Schiefer der Stufe d 1 β ruhen. Die fossilienführenden Schiefer des südöstlichen Teiles von Hůrka sind stark verwittert und zerfallen in dünne, durch Eisenoxyd rostig gefärbte Blätter und Plättchen. Die Farbe derselben ist meistens schmutziggrau, im Gegensatz zu den dunklen und festen Schiefern aus der höheren Lage der Hůrka.

Wie es der Erhaltungszustand der Versteinerungen zuläßt, habe ich folgende Arten bestimmt:

I. *Trilobiten.*

Placoparia Zippei BOECK. *sp.*

Einige kleine, vollkommen erhaltene Exemplare, isolierte Kopfschilder und häufige Thoraxteile.

Das Vorkommen dieses Trilobites ist um so merkwürdiger, da derselbe in der zwar reichen Fauna von Plzenec[1] in keiner der höheren Lagen d 1 γ bisher nachgewiesen wurde.

Aeglina rediviva BARR.

Ein größeres und ein kleineres Pygidium.

Aeglina cf. sulcata BARR.

Ein Abdruck und der Gegenabdruck eines kleineren Pygidiums.

II. *Cephalopoden.*

Orthoceras expectans BARR.

Einige Bruchstücke.

III. *Brachiopoden.*

Strophomena primula BARR.

Einige Exemplare.

Paterula bohemica BARR.

Zwei Exemplare.

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[1] l. c. 1, l. c. 2 pag. 3.

IV. *Gastropoden.*

Pleurotomaria (Lophospira) viator Barr.

Einige Exemplare.

Pleurotomaria (Lophospira) nov. sp.

Ein negativer Abdruck eines etwas größeren Exemplares als ich im J. 1909 anführte (*Faunistische Verhältnisse der untersilurischen Schichten bei Pilsenetz in Böhmen.* Verhandl. d. k. k. geolog. Reichsanst. No. 3).

Helicotoma ? nov. sp.

Ein Abdruck und der Gegenabdruck mit erhaltener feiner Schalenskulptur.

Außerdem noch einige Reste wahrscheinlich verschiedenen *Pleurotomarien* angehörend.

V. *Pteropoden.*

Hyolithus sp.

Ein Abdruck und Gegenabdruck eines seitlich gepreßten, längs der Schale mit feinen Rippen verzierten Exemplares.

Conularia exquisita Barr.

Einige kleine Bruchstücke und ein Fragment eines größeren Exemplars mit gut erhaltener Skulptur.

VI. *Lamellibranchiaten.*

Leda bohemica Barr.

Ein Bruchstück einer Doppelschale und ein kleines, vollkommen erhaltenes Exemplar.

VII. *Crinoiden.*

Einige undeutliche Stengelreste.

Die oben beschriebene Fauna liefernden Schichten gehören wahrscheinlich ein und demselben Horizonte d 1 γ der nördlich liegenden Lokalitäten bei Ejpovic [1] an, wo wie bekannt *Placoparia Zippei* als häufigstes Fossil vorkommt.

[1] I. V. Želízko. *Weitere neue Beiträge zur Kenntnis der Fauna des böhmischen Untersilurs.* Verhandl. d. k. k. geolog. Reichsanst. No. 2. 1902. — *Zur Paläontologie der untersilurischen Schichten in der Gegend zwischen Pilsen und Rokycen.* Ibid. No. 16. 1908.

Das Liegende der Schiefer der Stufe d 1 β bilden bei Sedlec die auf den präkambrischen Schiefern ruhenden Krušnáhoraschichten (d 1 α).

Zum Schluß möchte ich noch bemerken, daß die Verbreitung der Schiefer d 1 β in der Gegend von Plzenec viel größer ist als in dieser Publikation behandelt wird, dafür sprechen meine neuerlichen Forschungen, über welche ich anderorts berichten werde.

Paläontologie der Bande D—d 1 β.

Trilobiten.

Asaphellus bohemicus Žel.

(Taf. I, Fig. 1, Taf. II, Fig. 1, 2.)

Es liegen zwei große, fast vollständig erhaltene Exemplare vor, worunter ein im positiven sowie im negativen Abdruck vorhanden ist.

Zu derselben Art gehört auch ein Gegenabdruck eines Rumpfes mit Pygidium und ohne Kopfschild. Alle Stücke sind durch Schichtendruck einigermaßen gepreßt, sodaß manche Merkmale schwer nachweisbar sind, dessen ungeachtet läßt sich doch ihre Gattungszugehörigkeit bestimmen.

Das erste vollständige Exemplar (Taf. I) ist 12 cm. lang. Das halbkreisförmige, mit kurzen Wangenstacheln endende Kopfschild ist mit einem sehr breiten, flachen und glatten Randsaum umgeben, und fast doppelt so breit wie hoch, denn seine Breite beträgt 83.5 mm. und die Höhe 42 mm. Die Grenze zwischen den Wangen und Glabella ist schwach angedeutet. Die halbmondförmigen, ursprünglich erhobenen, ziemlich großen Augen sind abgewetzt.

Die Glabella ist leider größtenteils abgeschält, sodaß sich ihre gleichmäßig breite, oben abgerundete Form nur nach dem Umriß feststellen läßt. Der Abstand zwischen der Stirn und dem Oberrand ist ziemlich beträchtlich.

Der aus acht Segmenten bestehende Thorax samt Pleuren stimmen in ihrer Form mit denen bei verschiedenen Asaphiden-Gattungen überein.

Das Pygidium ist halbelliptisch, mit sehr breitem und glattem Randsaum umgeben, 69 mm. breit und 43 mm. hoch. Die beschädigte Axe ist lang, ziemlich schmal und erstreckt sich kaum in zwei Drittel des Pygidiums. Die ursprüngliche Segmentierung der Axe und der Seitenlappen ist verwischt, nur bei dem zweiten, fast genau so großem Exemplare (Taf. II) ist dieselbe sehr schwach angedeutet. Bei diesem aus einem Abdruck und einem Gegenabdruck bestehenden Asaphellus nimmt die lange, schmale Axe mehr als ein Fünftel der Gesamtbreite des Pygidiums ein.

Das im negativen Abdruck erhaltene Pygidium samt den aus fünf Segmenten und Pleuren bestehenden Thoraxteilen des bereits oben angeführten dritten Exemplares, weist gleichfalls dieselbe Form und Größe auf, wie die zwei vorher beschriebenen Stücke.

Von dem Kopfschild der beiden Abdrücke des zweiten Exemplares hat sich bei dem negativen Abdruck (Taf. II, Fig. 1) nur ein Teil der linken Wange mit dem Stachel und ein undeutlicher Abdruck der Innenseite vom Hypostom erhalten, die übrigen Teile waren abgelöst.

Bei dem positiven Abdruck (Taf. II, Fig. 2) sind beide Wangen und ein fast tadelloses Hypostom vorhanden, bekanntlich eines der wichtigsten Merkmale zur genauen Bestimmung dieses Trilobites. Das in situ befindliche Hypostom ist 25.5 mm. lang, hat einen eiförmigen, gegen den Oberrand verschmälerten Umriß und ziemlich breite Randsäume.

Die eigentliche Einbuchtung in der Mitte des Hinterrandes scheint vorhanden zu sein, jedoch ist die genannte Stelle zufällig so mangelhaft erhalten, daß eine präcise Feststellung schwer durchführbar ist. Nach allem aber war die Einbuchtung nicht zu groß. Die übrigen Merkmale lassen sich aus unserem Bilde, wo der Umriß mit weißer Farbe angedeutet ist, am besten erkennen.

Der Form nach erinnert unser Hypostom am meisten an den von *Asaphellus Homfray var.* aus dem Untersilur (Tremadoc) von *Cape Breton* in *Britisch-Amerika,* wo derselbe nach Matthew [1] in den sogen. Bretonian (c_2-*Asaphellus*-Zone) vorkommt.

Das mehr als um ein Drittel kleinere Hypostom der amerikanischen Art weist einen fast kreisförmigen Umriß und ziemlich breite Randsäume auf, die in der Mitte des Unterrandes eine mäßige Einbuchtung bilden. Der von Matthew abgebildete vollständie *Asaphellus Homfray var.* (l. c. 1902 und 1903, Pl. XVIII, Fig. 10 a), welcher mehr als um eine Hälfte kleiner ist als der von Plzenec, ähnelt diesem insofern, daß sein Kopfschild und das Pygidium die gleiche Form besitzen, während die Randsäume beider Körperteile schmäler sind, infolgedessen die Stirn bedeutend mehr zum Oberrand des Kopfschildes und die schwach segmentierte Axe mehr zum Hinterrand des Pygidiums geschoben sind.

Die Glabella ist ebenfalls fast gleichmäßig breit, hat eine abgerundete Stirn und das Kopfschild mäßig lange Wangenstacheln.

Das Hypostom des *Asaphellus Homfray* aus den sogen. »*Shineton shales*« von *Shropshire* in *Wales,* dessen oberer Teil faunistisch dem norwegischen

[1] G. F. Matthew. *Additional notes on the Cambrian of Cape Breton.* Bulletin of the Natural History Society of New Brunswick, Canada, No. XX, Vol. iv, Part v. —*Report on the Cambrian Rocks of Cape Breton.* Geological Survey of Canada, 1903.

Euloma-Niobe-Horizonte entspricht, hat dieselbe Form wie der gleichnamige amerikanische *Asaphellus*[1].

Als Begleitfauna des amerikanischen *Asaphellus* ist unter anderen *Parabolinella, Triarthrus, Bellerophon* angeführt.

Der von Salter beschriebene typische *Asaphellus Homfray* Salt.[2] aus dem englischen Untersilur (Upper Tremadoc) von *Wales* stimmt nur teilweise mit dem von Plzenec überein.

Das Hypostom des *Asaphellus bohemicus* erinnert auch an einige von Brøgger bei den skandinavischen *Megalaspiden* beobachteten Hypostome[3], welche durch ihre Form den *Asaphellus*-Hypostomen ähneln, eine zur Bestimmung der Untergattung des *Asaphellus* maßgebende Charakteristik, wie auch beim *Asaphellus bohemicus* neuerdings bestätigt wurde.

Was die Stellung der *Asaphiden* (*Asaphus, Ogygia, Niobe*) anbelangt, soll hier vor allem auf die Studie Brøggers »*Über die Verbreitung der Euloma-Niobe-Fauna* (*der Ceratopygenkalkfauna*) *in Europa*«[4] hingewiesen werden. Die neueste amerikanische Literatur Raymonds zur genaueren Definition der *Asaphiden* ist mir leider infolge des Weltkrieges nicht eingelangt.

An unseren *Asaphellus bohemicus* erinnert ferner einigermaßen der mit breitwangigem Kopfschild versehene riesige *Asaphellus glabratus* Salt., welchen Frech aus dem *Asaphus*-Schiefer (Mittleres Untersilur) von *Cabrières* in Frankreich abbildete[5], der aber einen ausgesprochenen *Asaphellus*-Habitus aufweist. Da in demselben Schiefer (vom Alter des Llandeilo-Flags) auch *Placoparia Tourneminei* Rouault vorkommt[6], welche der böhmischen *Placoparia Zippei* nahe steht, entspricht der betreffende Horizont der böhmigen Stufe d 1 γ.

Der von Frech aus zwei verschiedenen Exemplaren kombinierte *Asaphus glabratus* ist durch kurze Wangenstachel und deutlich segmentiertes Pygidium gekennzeichnet.

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1 Ch. Callaway. *On a new Area of Upper Cambrian Rocks in South Shropshire, with a Description of a new Fauna.* The Quarterly Journal. S. 663. Pl. XXIV. Fig. 1 London 1877.

2 I. W. Salter. *A Monograph of the British Trilobites.* S. 165—166. Pl. XXIV, Fig. 6—12. London 1864—1883.

3 W. C. Brøgger. *Ueber die Ausbildung des Hypostomes bei einigen skandinavischen Asaphiden.* Sveriges geologiska Undersökning. Afhandlingar och Uppsatser. Ser. C. No. 82. K. Svenska Vet. Akad. Handlingar. Bd. 11. No. 3. Stockholm 1886.

4 Nyt Magazin for Naturvidenskaberne. Grundlagt af Den Physiographiske Forening in Christiania. Bd. 36. 1897—1898.

5 F. Frech. *Ueber die Entwickelung der silurischen Sedimente in Böhmen und im Südwesten Europas.* N. Jahrb. f. Min., Geol. u. Pal. Jg. 1899. Bd. II.

6 F. Frech. *Die palaeozoischen Bildungen von Cabrières (Languedoc).* Zeitschr. d. deutsch. geolog. Gesellschaft. S. 395. Berlin 1887.

Von den bisher bekannten *Asaphiden* aus dem böhmischen Untersilur entspricht überhaupt keiner dem *Asaphellus bohemicus* von Plzenec.

Asaphellus insignis Žel.

(Taf. III, Fig. 2.)

Eine 46 mm. lange Form, welche durch einen sehr breiten gleichmäßigen Randsaum des halbkreisförmigen Kopfschildes mit langen abstehenden Wangenhörnern gekennzeichnet ist. Die übrigen Merkmale des Kopfschildes sind verwischt, nur die Wangennähte sind schwach angedeutet.

Die acht Segmente und Pleuren des deformierten Rumpfes sind schlecht erhalten.

Das kreisförmige, abgerundete Pygidium ist gleichfalls teilweise beschädigt. Die in die Hälfte des Pygidiums reichende Achse nimmt kaum ein Viertel seiner Breite ein. Die Segmentierung ist nirgends sichtbar.

Daß es sich um eine neue Asaphellusart handelt, verrät schon auf den ersten Blick die eigentümliche Bildung des Kopfschildes und die Form des Pygidiums.

Asaphellus sp.

(Taf. III, Fig. 1.)

Einen isolierten Abdruck und ein Gegenabdruck der linken Wange mit einem sehr langen Stachel.

Ob dieselbe einem großen Individuum von *Asaphellus bohemicus* oder vielleicht einer anderen Form angehört, läßt sich auf Grund des fragmentarischen Körperteiles schwer nachweisen.

Niobe (Ptychocheilus) sp.

(Taf. III, Fig. 3.)

Ein Abdruck des rechten Teiles eines abgebrochenen Kopfschildes mit einigen deutlichen Rumpfsegmenten und Pleuren.

Die Glabella ist abgeschält.

Die Form des Randes mit vorhandenem schmalem und schräg abstehendem Wangenstachel, sowie der Verlauf der schwach angedeuteten Wangennähte erinnern an eine *Niobe,* wie sie z. B. Novák-Perner[1] aus der Stufe d1γ von *Nové Dvory* abbildeten.

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[1] *Trilobiti pásma D—d 1 γ z okolí pražského.* Palaeontographica Bohemiae. S. 47. Taf. III, Fig. 1. Nr. IX. Česká Akademie, Prag.

Cephalopoden.

Orthoceras tenuis Zel.

(Taf. IV, Fig. 6.)

Eine schlanke, auf die Art der Hyolithen ziemlich scharf zugespitzte, ca. 50 mm. lange Form, wie sie unsere Tafelabbildung darstellt.

Dieselbe war möglicherweise noch etwas länger; ihre Oberfläche ist glatt, die Wohnkammern reichen von der Spitze fast in die Hälfte der vorhandenen Schale.

Außer diesem Stück wurde noch ein Fragment mit fehlender Spitze und ohne Wohnkammern gefunden, von welchem man unmöglich sagen kann ob es auch der obigen Form angehört.

Die Oberfläche beider Stücke ist teilweise vom Eisenoxyd rostigbraun gefärbt.

Brachiopoden.

Von den zahlreichen größeren und kleineren *Linguliden* und anderen *Brachiopoden* habe ich nur folgende herausgenommen, welche eine nähere Bestimmung zulassen.

Lingulella sulcata Barr.

(Taf. IV, Fig. 1, 1 a, 2, 2 a, 3, 3 a.)

Diese bereits von Barrande (Syst. Sil. V Pl. 106) aus der Stufe d1β von Klabava angeführte Art, welche neuerdings nach Holub (l. c.) in dem Euloma-Niobe-Horizont bei Rokycan nachgewiesen wurde, kommt auch bei Plzenec ziemlich häufig vor, und zwar in dem halbverwitterten lichtgrauen Schiefer unterhalb des Kreuzes »U Blažeje«, sowie in den festen graugrünen Graptolithenschiefern des am westlichen Ende der Lehne sich befindlichen Steinbruches.

Es sind schön geformte, mit feinen Radialrippen versehene Exemplare oder glatte Steinkerne vorhanden, deren Wirbel mehr oder weniger zugespitzt ist. Die konzentrischen Lamellen sind nur bei einigen Exemplaren erhalten (Fig. 1 a, 2 a). Die Schale ist schwarz und glänzend, der halbkreisförmige Stirnrand hie und da mit einem engen Saum versehen.

Die Form der von Barrande von Klabava abgebildeten Exemplare (Sys. Sil. V, Pl. 106, Fig. III, 2, 3) scheint mir mit den Originalen, die ich seinerzeit untersuchte, nicht genau übereinzustimmen.

Lingulella rugosa BARR.
(Taf. IV, Fig. 4, 4 a)

Es finden sich meistens Steinkerne mit nur teilweise erhaltener Schale. Dieselbe ist breit und verhältnismäßig kurz, der Wirbel abgestumpft. Die Oberfläche weist eine Reihe scharf hervortretender, schütter situierter Radialrippen auf; konzentrische Lamellen sind nicht überall entwickelt.

Kommt in beiden Lokalitäten »U Blažeje« vor. BARRANDE führt diese Art gleichfalls von Klabava (Syst. Sil. V Pl. 152) und HOLUB aus derselben Gegend an.

Lingulella amygdala ŻEL.
(Taf. IV, Fig. 5, 5a.)

Die Schale der vorhandenen Art unterscheidet sich von beiden oben beschriebenen Linguliden durch eine mandelartige Form.

Der Stirnrand ist breit, halbelliptisch abgerundet, die Schale allmählich verschmälert und mit einem stumpfen Wirbel endend.

Es sind nur einige Stirnkerne mit stellenweise erhaltener Schalenkruste vorhanden. Sonst ist die ursprüngliche, aus feinen Radialrippen und konzentrischen Lamellen bestehende Skulptur ziemlich gut sichtbar.

Kommt in beiden Punkten »U Blažeje« vor.

Lingulella pusilla ŻEL.
(Taf. III, Fig. 8, 8a, 9, 9a).

Von den bei Plzenec häufig vorkommenden kleinen Linguliden sind hier zwei typische Exemplare abgebildet.

Die ca. 3—5 mm. lange Schale ist schmal, glänzend und mit spärlichen Lamellen, welche nur unter der Lupe sichtbar sind, versehen.

Der Umriß ist elliptisch oder schwach verschmälert, eiförmig, die Schale flach gewölbt oder gegen den Wirbel zu ein wenig erhöht.

Die besprochene Art wurde nur in den graugrünen Schiefern »U Blažeje« gefunden.

Acrothele? nov. sp.
(Taf. III, Fig. 7, 7a, 7b.)

Eine fast kreisrunde, ziemlich hoch gewölbte Schale, in einem Durchmesser von 8 mm., deren Oberfläche hornig, glatt, glänzend und unregelmäßig konzentrisch gestreift ist.

Eine kleine Einbuchtung des Schloßrandes erinnert, wie aus unserer vergrößerten Abbildung (Taf. III, Fig. 7) ersichtlich ist, an eine ähnliche schlitzförmige Öffnung bei der *Discina* oder *Trematis*.

Daß das hier beschriebene Fossil jedenfalls zu der Familie *Discinae* gehört, ist auf den ersten Blick sichtbar.

Dasselbe stammt gleichfalls aus dem graugrünen Schiefer.

Obolus? sp.

Zwei sehr kleine an *Obolus minimus* Barr. (Syst. Sil. V, Pl. 5) erinnernde Individuen aus demselben Fundort »U Blažeje«.

Spirifer sp.

Ein ca. 6 mm. langer und 7 mm. breiter, hoch gewölbter Steinkern, welcher dem Habitus nach wahrscheinlich der oberwähnten Brachiopode anzugehören scheint.

Dieselbe stammt aus dem lichtgrauen Schiefer unterhalb des Kreuzes »U Blažeje«.

Pteropoden.

Conularia pygmaea Zel.

(Taf. III, Fig. 5.)

Eine sehr kleine, unvollständig erhaltene Art, deren Länge ca. 17 mm. und die Breite bei der Mündung ca. 7 mm. beträgt.

Die ursprüngliche Epidermis hat sich nur in einer Partie bei der Spitze erhalten. Sie besteht aus nur unter der Lupe sichtbaren, gleich großen und gleichmäßig aneinander situierten Wärzchen rundlicher Form. Diese Wärzchen waren senkrecht aneinander, also mit der vorhandenen parallel laufenden Medialfurche gereiht. Der den Abstand zwischen den Wärzchenreihen bildende Raum längs der Schale ist schmal, jedoch ist derselbe durch den Umstand, daß die Wärzchen gleichmäßig dicht geordnet sind, gut sichtbar.

Durch die geschilderte Schalenskulptur ist die *Conularia pygmaea* von allen aus dem älteren Paläozoikum Böhmens bekannten Formen sofort zu unterscheiden.

Conularia sulca Žel.

(Textabbildung. Taf. III, Fig. 4.)

Auf demselben Gestein, wo sich die oben beschriebene Art befindet, kommt neben derselben ein Bruchstück einer 14 mm. langen Schalenwand vor, deren Skulptur aus einer Reihe auftretenden Querrippen besteht, die in einem kaum 1 mm. messenden Abstand voneinander getrennt sind. Zwischen den Rippen findet man keine Granulation oder sonstige Verzierung. Diese Skulptur stimmt mit der mir im Jahre 1906 von Herrn

Prof. Horák zur Bestimmung geschickten Conularia aus den bereits angeführten d 1 β-Schichten von Klabava überein.

Da dieses Fossil bisher weder beschrieben noch abgebildet ist, möchte ich dasselbe hier kurz behandeln.

Es ist ein Abdruck und ein Gegenabdruck einer teilweise erhaltenen, ziemlich großen Schale mit deutlicher Skulptur vorhanden. Die Verzierung besteht aus groben, ziemlich tiefen Querfurchen, welche in Abständen von 1—1.5 mm. von einander entfernt sind. Die Granulation oder andere Verzierungen fehlen. Dem Schalenumrisse nach scheint, daß das vollkommene Exemplar 8 cm. hoch war und seine Breite bei der Mündung höchstens 3 cm. betrug.

Eine ähnliche, aus Querrippen und Furchen bestehende Skulptur wie sie das Schalenfragment von Pilsenetz und das Exemplar von Klabava aufweist, besitzt auch die von mir seinerzeit beschriebene *Conularia Purkyněi*[1] von Sirá-Cekov (d 1 γ).

Die erwähnten Rippen und Furchen, welche gleichfalls einfach und ohne Verzierung sind, treten sehr scharf hervor, und je mehr sie der Spitze zulaufen sind sie feiner und seichter. Bei der Mündung entfallen von diesen 15—17, bei der Spitze 28—30 auf 5 mm. Stellenweise fließen auch zwei Rippen in eine länglichrunde Leiste zusammen.

Gleichfalls die von Osek (d 1 γ) bekannte *Conularia robusta* Barr[2] weist nur teilweise ähnliche Schalenskulptur wie unsere neue Form von Plzenec auf.

[1] *Neue Pteropoden des älteren Paläozoikums Mittelböhmens.* Jahrb. d. k. k. geol. Reichsanst. 1911. Bd. 61, p. 45. Taf. III, Fig. 1 a, 1 b.

[2] *Syst. Silur.* Vol. III, p. 51. Pl. 16, Fig. 10—11.

Conularia sp.

Ein zerdrückter positiver und negativer Abdruck einer unvollständigen, 24 mm. langen, nach vorn gekrümmten Schale. Die Seitenleisten sind gut sichtber, die Medialfurche sowie die aus ursprünglich rundlichen Querstreifen bestehende Skulptur ist nur schwach angedeutet Dieselbe Skulptur fand man auch bei einem Bruchstücke eines anderen Exemplars.

Außerdem wurde noch ein Abdruck eines kaum 1 cm. langen Gehäuses mit erst unter der Lupe erkenntlichen Seitenleisten und Medialfurche gefunden.

Orthotheca? n. sp.
(Taf. III, Fig. 6.)

Ein stark zerdrücktes, 17 mm. langes Gehäuse ohne Spitze. Der Mundrand ist abgebrochen, die Längsleisten sichtbar und die Oberfläche glatt.

Ein daneben befindliches isoliertes, 4.5 mm. langes und 2 5 mm. hohes Operculum scheint demselben Stücke anzugehören. Dasselbe bildet ein gleichschenkeliges Dreieck mit abgerundeten Ecken. Was die anderen Merkmale des Deckelchens, dessen Innenseite vorhanden ist, anbetrifft, ähnelt dasselbe dem von Novák abgebildeten[1], aus verschiedenen Fundstellen des böhmischen Obersilur und Devon herrührenden Orthothecen am besten.

Obwohl die untersilurische, aus den Quarzkonkretionen der $d1\gamma$-Schichten von Šárka stammende *Orthotheca Šárkaensis*[2] von Novák als fraglich bezeichnet wurde, so ist es doch nicht ausgeschlossen, daß die Verbreitung dieser von Novák gestellten neuen Pteropodengattung auch in das Untersilur hineinreicht.

Da unser Exemplar allerdings vielmehr Verwandtschaft mit der *Orthotheca* als mit den aus dem böhmischen Untersilur bisher bekannten *Bactrotheca*- oder *Hyolithus*gattungen aufweist, so habe ich dasselbe auch provisorisch zur *Orthotheca* gestellt.

Schließlich sei noch bemerkt, daß es nicht ausgeschlossen ist, daß der von Brøgger[3] aus dem norwegischen Kambrium angeführte *Hyolithus plicatus* nach Novák[4] zur Gattung *Orthotheca* gehören kann, weshalb diese Gattung auch schon in primordialen Ablagerungen vertreten wäre.

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[1] *Zur Kenntnis der Fauna der Etage F—f 1 in der palaeozoischen Schichtengruppe Böhmens.* Sitzungsber. der königl. böhm. Gesellsch. d. Wiss. Prag 1886.

[2] *Revision der palaeozoischen Hyolithiden Böhmens.* Abhandl. d. k. böhm. Ges. d. Wiss. VII. Folge, 4 Bd. Math.-nat. Cl. No. 6, p. 44. Prag 1891, und l. c. Taf. II, Fig. 29.

[3] *Om paradoxides-skiferne ved Krekling.* Nyt Mag. for Naturvidenskaberne. XXIV. Christiania 1877.

[4] l. c.

Graptolithen.

Unter allen Fossilien der d 1 β-Schichten bei Plzenec sind die Graptolithen am häufigsten vertreten.

Wie ich schon vorn angeführt habe, kommen dieselben besonders in dem nordwestlichen Teile der Lehne »U Blažeje« im festen, graugrünen Schiefer vor, dessen große spaltbare Platten mit langen, schön entwickelten, ruthenförmig verzweigten oder buschigen Exemplaren bedeckt sind.

Da ich das ganze Material meinem Freunde, Herrn Dr. PERNER zur Bearbeitung übergab, möchte ich nur im Kurzen auf einige Graptolithen hinweisen, die ich seinerzeit Herrn Prof. S. L. TÖRNQUIST in Lund zur Vergleichung mit schwedischen, dem ältesten Ordovician entstammenden Arten eingesandt habe. Durch die Güte des Herrn TÖRNQUIST wurden folgende Arten bestimmt:

Didymograptus. Scheint zwischen *Didymograptus balticus* LAPW. oder *Didym. artus* ELLES AND WOOD zu stehen, ohne mit dem einen oder dem anderen identifiziert werden zu können. Nahestehende Formen kommen in schwedischer Zone mit *Didymograptus balticus* TULLBERG vor[1].

Jener von PERNER in seiner Monographie über die Graptolithen des böhmischen Untersilurs von Sárka und Osek (d 1 γ) beschriebene *Didymograptus nanus* weist einen anderen, von unser Art ganz abweichenden Charakter auf.

Tetragraptus quadribrachiatus HALL und außer diesem entweder *Tetragr. serra* BRONGN., nach der Auffassung TÖRNQUISTS (= *Tetragr. Ami* ELLES AND WOOD[2]), oder *Tetragr. serra* BRONGN., ELLES AND WOOD[3]. Vielleicht ist es auch eine andere nahestehende Form.

Eine verwandte böhmische Art *Tetragraptus caduceus* SALTER beschreibt PERNER von Klabava (d 1 β).

Außer diesen Graptolithen wurden bei Plzenec auch Fragmente entweder von einem gabelförmigen *Didymograptus* oder *Bryograptus* gefunden.

Nach der vorläufigen Mitteilung des Herrn dr. PERNER überwiegt in dem ihm von Plzenec eingesandtem Material *Dichograptus* und *Holograptus*

---

1 SVEN LEONH. TÖRNQUIST. *Researches into the Graptolites of the Lower Zones of the Scanian and Vestrogothian Phyllo-Tetragraptus Beds.* I. Lunds Universitets Årsskrift. Bd 37. Afdeln. 2. Nr. 5. Königl. fysiografiska sällskapets handlingar. Bd. 12. Nr. 5. Lund 1901.

2 I. PERNER. *Studie o českých graptolitech. Část II. Monografie graptolitů spodního siluru.* Palaeontographica Bohemiae. N. III b. Prag 1895.

3 SV. LEONH. TÖRNQUIST. *Researches into the Graptolites etc.* II. Lund 1909. — *Derselbe. Några anmärkningar om indelninger inom Sveriges kambro-silur.* Geolog. Fören. Förhandl. Bd. 35. H. 7, p. 416. Stockholm 1913.

(Temnograptus); siehe Taf. V. Außerdem findet man darin *Holograptus (Trochograptus) sp. off. Deani* Lapw. und einige schwer bestimmbare Reste, die an *Loganograptus* und *Azyograptus* erinnern.

Die aus der Bande d — d 1 β angeführten Fossilien.

Trilobiten.

Asaphellus bohemicus Žel.
Asaphellus insignis Žel.
Asaphellus sp.
Niobe (Ptychocheilus) sp.

Cephalopoden.

Orthoceras tenuis Žel.

Brachiopoden.

Lingulella sulcata Barr.
Lingulella rugosa Barr.
Lingulella amygdala Žel.
Lingulella pusilla Žel.
Acrothele? nov. sp.
Obolus? sp.
Spirifer sp.

Pteropoden.

Conularia pygmaea Žel.
Conularia sulca Žel.
Conularia sp.
Orthotheca? n. sp.

Graptolithen.

Didymograptus.
Tetragraptus quadribrachiatus Hall.
(? *Tetragraptus serra* Brongn. (= *Tetr. Ami* Elles and Wood) oder *Tetr. serra* Brongn. Elles and Wood).
Dichograptus.
Holograptus (Temnograptus) sp.
Holograptus (Trochograptus) sp. off. Deani Lapw.

Schlussfolgerungen.

Die unmittelbar unter den schwarzen Schiefern der Stufe d1γ mit vorherrschenden *Placoparia Zippei* bei Sedlec auftretenden d1β-Schichten bilden stratigraphisch sowie faunistisch einen selbständigen Horizont der Bande D — d1β.

Nach der in der Lokalität »U Blažeje« festgestellten Fauna scheint dieser Horizont jünger zu sein als der *Euloma*-Horizont bei Rokycan[1]. Deshalb wird es bei weiterem Studium der Ablagerungen der Stufe d1β notwendig, eine ähnliche Zonengliederung derselben vorzunehmen, wie solche KLOUČEK[2] in den d1γ-Schichten durchführte und für deren Aufnahme für die d1β-Schicheten auch die Graptolithenstudien PERNERS[3] sprechen.

Diesbezüglich können uns auch die von mir Herrn Dr. PERNER zur Bearbeitung übergebenen Graptolithen von Plzenec gewiß ein positiveres Resultat liefern.

Was einen vorläufigen Vergleich der seinerzeit von Herrn Professor TÖRNQUIST von Plzenec untersuchten Graptolithen mit jenen von Schweden anbelangt, geht aus dem nachstehenden, mir von Herrn Prof. TÖRNQUIST zur Verfügung gestellten schematischen Gliederung des ältesten schwedischen Ordovician am besten hervor:

Unterer Didymograptus-Schiefer	d) Zone mit *Isograptus gibberulus* NICH. c) — » *Phyllograptus densus* TÖRNQ. b) — » *Didymograptus balticus* TULLBERG. a) — » *Tetragraptus phyllograptoides* LINRS.
Niobe-Euloma-region, auch Dictyonema-region genannt	Ceratopygenkalk als Kalkfazies und Dictyonemaschiefer als Schieferfazies.

Der von Plzenec angeführte *Tetragraptus serra* kommt in der Zone *a* und *Tetragraptus quadribrachiatus* in der Zone *b* vor.

Nach den vorhergehenden Erörterungen scheinen die fossilführenden Schiefer von Rokycan und Plzenec teilweise dem obersten Niveau des unteren Didymograptusschiefer (Zone *a* und *b*) zu entsprechen.

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[1] l. c.

[2] C. KLOUČEK. *Předběžná zpráva o dvou nových horizontech v pásmu D—d1γ.* Věstník král. čes. spol. nauk. Prag 1908. — *O vrstvách D1γ, jich trilobitech a nalezištích.* Rozpravy České Akademie. Ig. XXV. N. 39. 1916.

[3] I. PERNER. *Studie o českých graptolitech. II. Monografie graptolitů spodního siluru.* České Akademie. Prag 1895.

Daß die in Rede stehenden Schichten vom stratigraphischen und paläontologischen Standpunkt aus *älter* sind als die der Bande D — d 1 γ und *jünger* als die der Bande D — 1 β, dafür sprechen unsere bisherigen Erfahrungen bei Plznec und noch besser die Fossilienfunde Holubs[1] aus der Gegend von Rokycan. Holub fand hier, wie bekannt, eine den Übergang zwischen dem obersten Kambrium und untersten Silur bildende Fauna, die Brøgger als *Euloma-Niobefauna* bezeichnete[2]. Außer *Brachiopoden* (auch *Lingula sulcata* und *L. rugosa* wie bei Plzenec), neuer bisher noch nicht bestimmter *Graptolithen, Pteropoden* und underen Fossilen, sind aus der Gegend von Rokycan bis heute folgende *Trilobiten* beschrieben: *Agnostus splendens, Agnostus consors, Asaphellus Perneri, Aspidaeglina miranda, Euloma Bohemicum, Euloma inexpectatum, Lichas praecursor, Megalaspides cuspidatus, Nileus pater, Aeglina Bröggeri* und *Barrendei primula.*

Holub, welcher die böhmische Fauna mit der norwegischen, französischen, englischen und bayrischen verglich, bemerkt, trotzdem sich die von ihm bei Rokycan gefundene Fauna mit der alten skandinavischen Euloma-Niobefauna nicht vollkommen identifizieren läßt, ist es doch notwendig, dieselbe als ein Äquivalent der übrigen europäischen Eulomaschichten zu betrachten.

Dasselbe gilt auch der von mir entdeckten Fauna bei Plzenec.

Aus den Forschungen Brøggers und Törnquists geht gleichfalls hervor, daß wir nur an wenigen Punkten der Erde eine mit der nordischen *Euloma-Niobe-Fauna näher* übereinstimmende Fauna vorfinden, nämlich:

in Shropshire in den Shineton shales,
» North Wales in den Tremadoc-Schichten,
» Bayern die Leimnitz-Schichten bei Hof[3],
» Südfrankreich die Schichten von Caunes
und St. Chinian in Languedoc.

Aus dem Grunde, daß in Böhmen Äquivalente der *Euloma-Niobe-Fauna* jetzt nachgewiesen wurden, muß natürlich die alte Definition Brøggers[4], *»daß ein unzweifelhaftes Äquivalent zu der Euloma-Niobe-Zone (Ceratopygenkalkzone 3 a) des skandinavischen Nordens in Böhmen bis jetzt nicht nachgewiesen ist und deshalb zu fehlen scheint«*, entfallen.

Brøgger selbst war nicht der einzige, der an die Existenz der älteren ordovicischen Ablagerungen in Böhmen zweifelte.

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[1] l. c. 1, p. 7.

[2] l. c. 4, p. 14.

[3] I. Barrande. *Silurische Fauna aus der Umgebung von Hof in Bayern.* 1868. — I. F. Pompecnj. *Ein neuentdecktes Vorkommen von Tremadoc-Fossilien bei Hof.*

[4] *Über die Verbreitung der Euloma-Niobe-Fauna* p. 224.

Schon LINNARSSON im J. 1873 hat auf die fehlende Übereinstimmung zwischen den böhmischen und nordischen Ablagerungen aufmerksam gemacht; er sucht dies teils auf eine mögliche Landsperre zwischen den böhmischen und dem nordosteuropäischen Silurmeer während der Zeit dieser Ablagerungen zu beziehen.

Auch TÖRNQUIST hat sich dafür ausgesprochen, daß Böhmen mit Frankreich, Portugal und Spanien, während dieser Zeit ein von dem nordischen ordovicischen Meer getrenntes Absetzungsgebiet ausgemacht haben muß, *während aber die Graptolithen beweisen, daß jedenfalls bisweilen »das nordeuropäische Graptolithenmeer« sich auch über dies Gebiet ausdehnte*[1].

Diese Vermutung hat sich jetzt durch die Funde bei Rokycan und Plzenec tatsächlich bestätigt.

Bezüglich der Entwickelung der silurischen Sedimente in Böhmen und im Südwesten Europas sei hier auf die gleichnamige Arbeit FRECHS[2] bzw. auf die Monographie BRØGGERS[3] hingewiesen.

Obwohl die Trilobitenfauna von Plzenec gegen die von Rokycan bis zum heutigen Tage nicht so mannigfaltig ist, scheint mir wenigstens das Vorkommen des *Asaphellus bohemicus* für den betreffenden Horizont nicht ohne Bedeutung, denn, wie bekannt, die ersten Vertreter der Asaphiden sind für die untersilurischen Ablagerungen ebenso charakteristisch wie z. B. *Agnostus, Paradoxides* und *Olenus* für das Kambrium. Deshalb repräsentiert *Asaphellus bohemicus* auch bei Plzenec ein charakteristisches Leitfossil ähnlich wie der gleichaltrige *Asaphellus Homfray* in den Shineton Shales in Shropshire, und in dem Lower u. Upper Tremadoc in North Wales, sowie im Tremadoc von *Cape Breton* in Britisch-Amerika und *Asaphellus Wirthi* in den Leimnitzschichten bei Hof.

Jedenfalls aber ist es wünschenswert die d 1 β-Schichten bei Plzenec einer weiteren Durchforschung zu unterziehen, was nach meinen bisherigen Erfahrungen eine längere Zeit in Anspruch nehmen wird, wenn die Fossilienliste um weitere für die betreffenden Schichten ebenso charakteristische Trilobitenformen vermehrt werden soll.

Wie schon oben erwähnt wurde, bilden die Ablagerungen der Stufe d 1 β bei Plzenec einen faunistisch scharf abgesonderten Horizont gegenüber den schwarzen fossilienreichen d 1 γ-Schiefern, die als Hangendes der grünlichgrauen d 1 β-Schiefer zu betrachten sind.

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[1] Ibid. p. 223.

[2] Neues Jahrbuch für Min., Geol. und Pal. Jg. 1899. Bd. II. — Auch *Die geographische Verbreitung und Entwickelung des Cambrium*, von demselben Autor. Congrès géologique international, 7me session Russie 1897. St. Petersbourg 1899.

[3] *Die silurischen Etagen 2 und 3 im Kristianiagebiet u. s. w.* Kristiania 1882.

In welchem Verhältnisse die letztgenannten Schiefer zu den Krušná Hora Schichten (d 1 α), welche neuerdings eine häufigere Fauna lieferten [1], stehen, das festzustellen wird wiederum eine andere Aufgabe sein.

Zum Schluß dieser Arbeit fühle ich mich verpflichtet, Herrn Direktor Prof. A. Jelínek in N. Bydžov, für den größten Teil von ihm aufgenommenen Originale meinen herzlichsten Dank auszusprechen.

Wien, November 1917.

[1] C. Klouček. *Novinky z Krušnohorských vrstev.* I—III. Rozpravy České Akademie 1915 u. 1917.

Erklärung zu den Tafeln.

Tafel I. *Asaphellus bohemicus* Žel. Natürliche Größe.

„ II. Fig. 1. *Asaphellus bohemicus* Žel. Negativer Abdruck.

„ 2. *Asaphellus bohemicus* Žel. Positiver Abdruck mit erhaltenem Hypostom Natürliche Größe.

„ III. Fig. 1. *Asaphellus sp.* Isolierter Abdruck der linken Wange. Natürliche Größe.

„ 2. *Asaphellus insignis* Žel. Natürliche Größe.

„ 3. *Niobe (Ptychocheilus) sp.* Natürliche Größe.

„ 4. *Conularia sulca* Žel. Eine vergrößerte Schalenpartie.

„ 5. *Conularia pygmaea* Žel. Eine vergrößerte Schalenpartie.

„ 6. *Orthotheca? n. sp.* Ein wenig vergrößert.

„ 7. *Acrothele? n. sp.* Natürliche Größe.

„ 7a. *Dieselbe* ein wenig vergrößert.

„ 7b. *Dieselbe* vielfach vergrößert.

„ 8—9. *Lingulella pusilla* Žel. Dorsalschale. Natürliche Größe.

„ 8a—9a. *Dieselbe* ein wenig vergrößert.

„ IV. Fig. 1—3. *Lingulella sulcata* Barr. 1—2 Dorsalschale, 3 Dorsal- und Ventralschale. Natürliche Größe.

„ 1a, 2a, 3a. *Dieselbe* vergrößert.

„ 4. *Lingulella rugosa* Barr Dorsalschale. Natürliche Größe.

„ 5. *Lingulella amygdala* Žel. Dorsalschale. Natürliche Größe.

„ 5a. *Dieselbe* vergrößert.

„ 6. *Orthoceras tenuis* Žel. Natürliche Größe.

„ V. *Holograptus (Temnograptus)* Holm. Auf dem Original sind die einzelnen Hydrothecae gut sichtbar. $^6/_7$.

Gedruckt 29 Oktober 1921.

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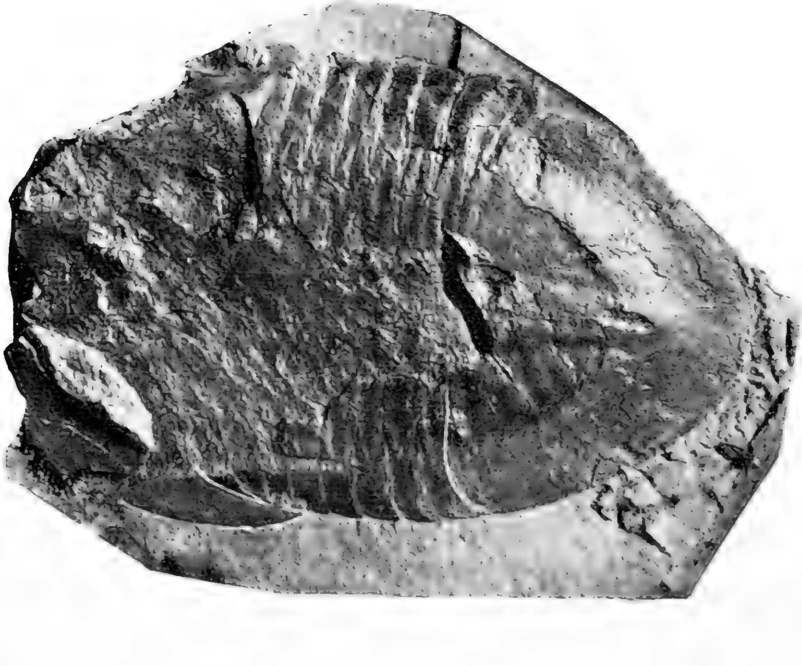

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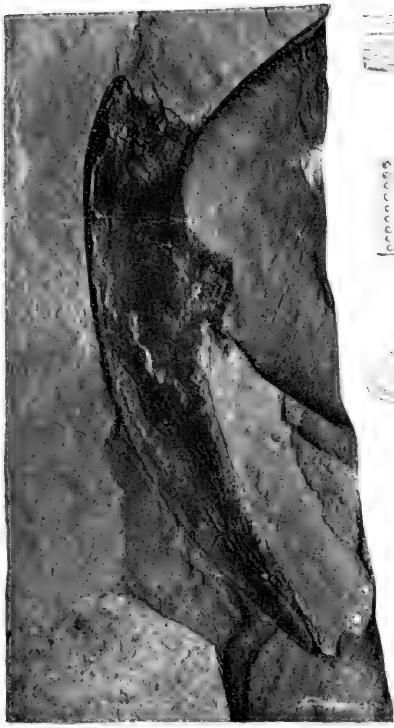

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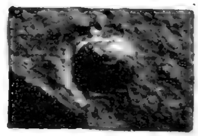

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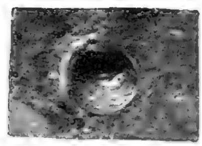

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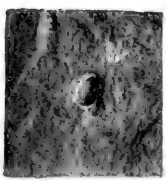

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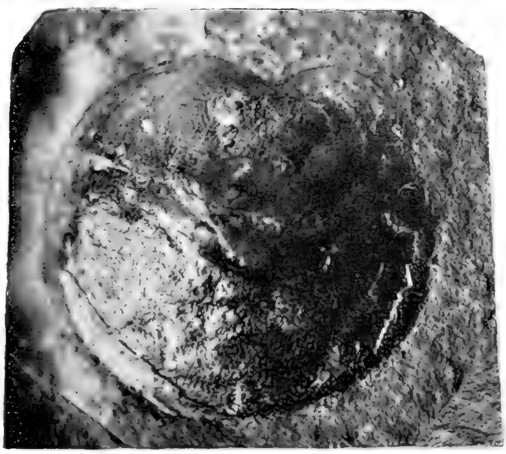

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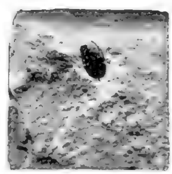

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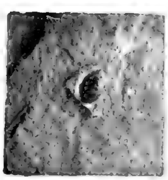

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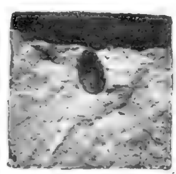

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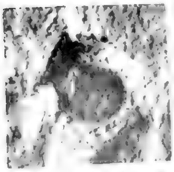
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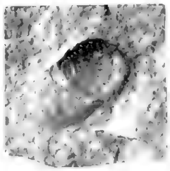
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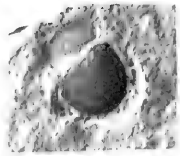
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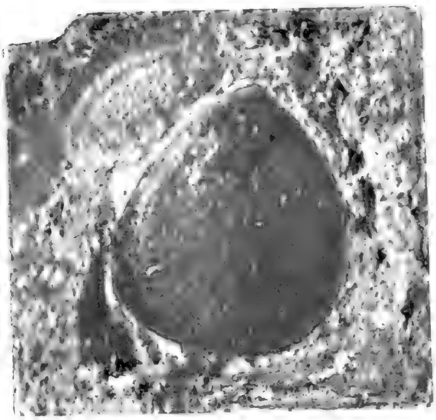
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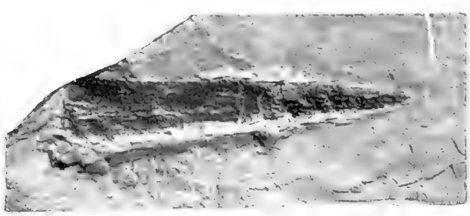
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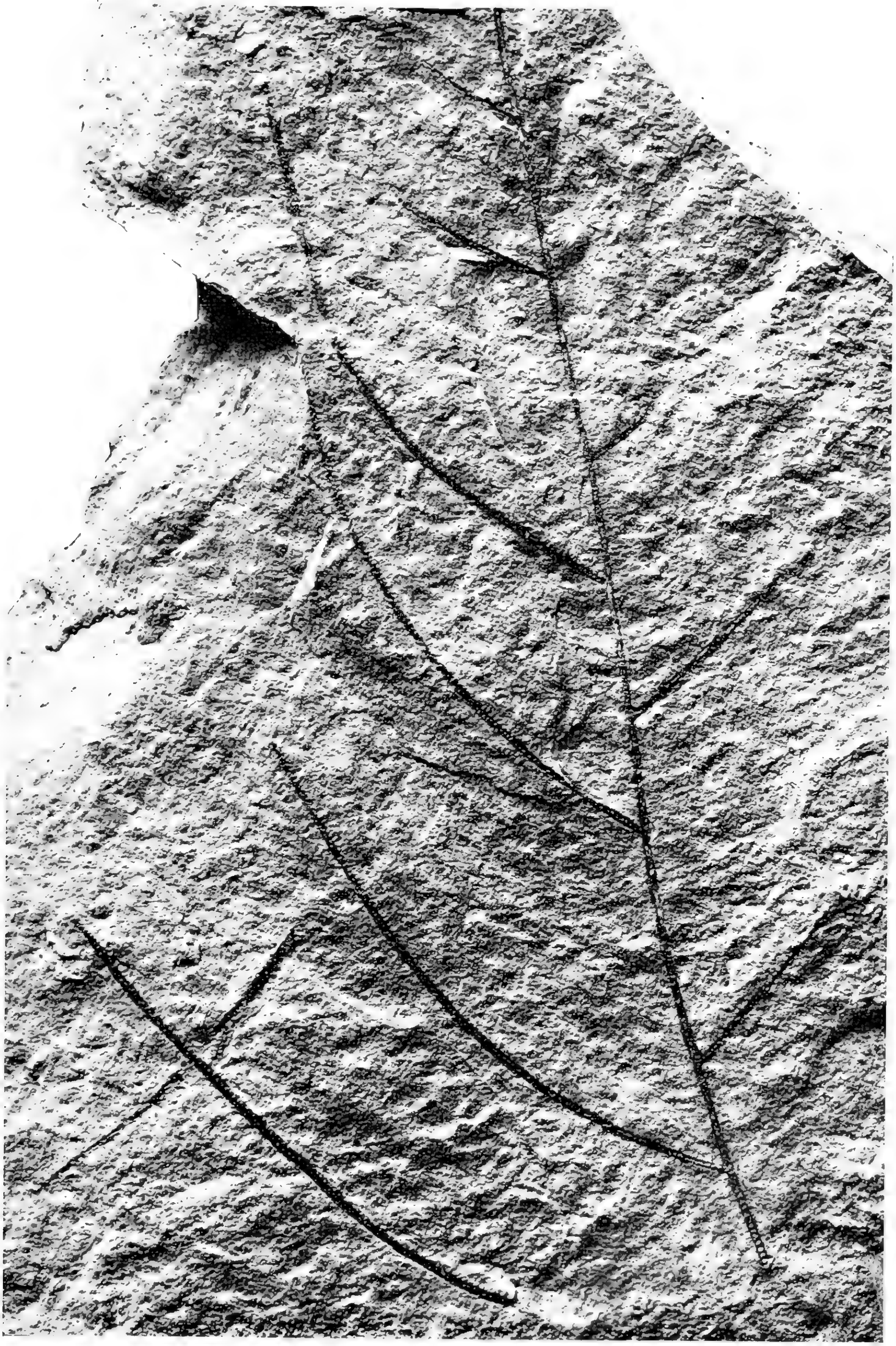


THE STRANDFLAT AND ISOSTASY

BY

FRIDTJOF NANSEN

(WITH 170 ILLUSTRATIONS AND MAPS IN THE TEXT)

(VIDENSKAPSSELSKAPETS SKRIFTER. I. MAT.-NATURV. KLASSE. 1921. No. 11)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
I KOMMISSION HOS JACOB DYBWAD
1922

Fremlagt i den mat.-naturv. klasses møte den 3. juni 1921.

A. W. BRØGGERS BOKTRYKKERI A-S

To

Dr. Hans Reusch

who first described the Norwegian Strandflat
as a distinct geographical
feature

in memoriam

FOREWORD.

The author much regrets the late appearance of this treatise. It has been written and printed with many interruptions due to various circumstances over which he had no control. The greater part of the manuscript was ready for the press more than eighteen months ago.

He wishes to express his sincere gratitude especially to the Norwegian geologists Professor Jacob Schetelig, Professor V. M. Goldschmidt, and Mr. Adolf Hoel, University Reader in geology, also to the Swedish geologist Professor A. G. Högbom, for much valuable information and advice.

A special word of thanks is also due to the publisher Jacob Dybwad by whose courtesy a number of illustrations from the author's book "En Ferd til Spitsbergen" are reproduced here.

The letter ø used in Norwegian names is equivalent to oe and is pronounced somewhat similarly to the letter o in the English words "son" or "work".

Lysaker, December 1922.

CONTENTS.

Fig. 1. Strandflat at Lille Molla (535 metres high, to the right) and Skråven (281 metres, to the left), south side of Lofoten. (July 2nd, 1912.)

I. INTRODUCTION.

The Norwegian "strandflat" extends as a low flat foreland, and an often broad belt of thousands of low islands, skerries, and rocks (the "Skjærgård") in front of the high, mountainous land, along the west and north-west coast of Norway, from Lindesness to Finmarken. It is backed by the escarpment of the mountains which often ascend abruptly from the inner margin of the strandflat to altitudes of hundreds of metres.

The width of this strandflat may vary much, from a few kilometres in some regions to 60 kilometres (37 miles) in the region of Hitteren and Frøia, and 46 to 50 kilometres (29 to 31 miles) in Helgeland (region of Hærøi, Dønna, and Træna).

The degree of development of the strandflat may also vary a great deal. Along great parts of the coast it is extremely conspicuous and sharply defined, but in other regions it is less striking, and in some places it may even be difficult to trace out or to distinguish from the low hills of the land inside.

Where it is well developed, its characteristic features are: (1) the remarkably horizontal plane formed by the flat summits of its thousands of low skerries, islets, and peninsulas, rising to a certain low height above the sea, looking at a distance as if they had been cut off and planed down to this level along a ruler. (2) The horizontal and sharply defined incision which this plane forms in the mountain side of the land, often oversteepened and rising abruptly from the inner margin of the plane.

Fig. 2. Strandflat on Årsteinen, east of entrance to Raftsund, Lofoten. (July 2nd, 1912.)

(3) Hills, or mountains, or mountainous masses, surmount here and there the plane of the strandflat as more or less isolated 'stacks' or 'monadnocks', often with very steep sides.

No observant travellar can avoid being struck by this peculiar formation so dominant in many regions, and Norwegian geographers long ago, *e. g.* H. Mohn [1877], called attention to it. But Hans Reusch was the first geographer in literature [1894] who described it as a uniform and important morphological feature in the topography of the Norwegian coast and propounded a general theory of its genetic origin. He gave it the name "strandflat" (*i. e.* shore plane).

The English term "coastal plain" I do not consider appropriate for this formation, because, as a rule, it is not a plain, and in my opinion never has been. It is, and always was, composed of numerous low islands and peninsulas, separated by sounds and fjords of varying, often considerable depth. Moreover, any plain in the coastal region, also formed more or less of loose material formerly deposited in off-shore water, is often called coastal plain.

"Coast platform" might be a better term, but I consider it to be preferable to keep the Norwegian "strandflat" as a name for this formation, so characteristic of the Norwegian and other northern coasts, but which does not occur in its typical form outside regions which have formerly been glaciated or exposed to severe climates.

After Reusch's important paper of 1894, much attention has been paid to the strandflat in scientific literature, and a lively discussion has been going on about its nature, origin, and age. A brief account of the literature concerning this subject has been given recently by Hans W:son Ahlmann [1919, pp. 93—98].

Prof. W. C. Brøgger, who in 1893 accompanied us as far as Tromsø on our way out with the Fram-Expedition, was struck by the peculiar, flat formation of the many low islands along the coast of Nordland. He gave a lecture on the subject in the Geological Club of Christiania on December 14th, 1893, and expressed the view that this level formation is a plane of marine denudation.

During the Fram-Expedition the writer also found that an extensive and strikingly flat, low foreland is a very dominant feature of the topography along the north coast of Sibiria, especially the west, north, and east coast of the Taimyr Peninsula. In a later report [Nansen 1904, pp. 20, 39, 42, 71, 75, 90, 102 ff.] the strandflats of northern lands were described and discussed at some length.

Since that time I have occasionally studied the strandflat in various regions. During cruises with my yacht "Veslemøy" in the summers of 1904 and 1909 along the south and west coast of Norway as far as the region of Ålesund, observations of the strandflat were made, although the main object of the cruises was oceanographic research.

Fig. 3. Strandflat near Kunna (593 metres high), Northern Helgeland. View north-eastwards from off Meløivær. (September 9th, 1912.)

In the summer of 1911 a cruise was made with the "Veslemoy" along the south and west coast of Norway, as far as the region of Sogne Fjord, and also to Shetland, with the special purpose of studying the strandflat and measuring its heights.

A cruise with the "Veslemoy" in 1912 along the coast of Norway to Bear Island and Spitsbergen, gave an opportunity of studying the strandflat in those northern regions.

An expedition from Norway through the Kara Sea to the Yenisei river in 1913, gave a new opportunity of studying the coast formations in those regions.

In the following report I shall try to give the results of the observations concerning the strandflat, made during these cruises, especially that of 1911. I regret that other work has prevented that this was done before. Much that was in mind when the many observations were made, has certainly faded from memory now so many years afterwards. But nevertheless, I venture to hope that the observations as they are, may still be of some interest to geographical students. In a recent book on the cruise to Spitsbergen in 1912 [1920, 1921] I have already described some results of my study of the strandflat on Bear Island and Spitsbergen.

II. THEORIES OF THE GENETIC ORIGIN OF THE STRANDFLAT.

The views as regards the genetic origin of the strandflat have varied much, and have chiefly been the following:

Reusch explains the strandflat as being a plain of marine abrasion, chiefly due to wave erosion, but the general subaërial denudation, immediately near sea level, has also been of some importance. The plain was formed chiefly in Tertiary time along a but slightly dissected coast, but it was also to some extent formed during "that portion of the glacial period when our country was comparatively free from ice".

E. Richter [1896] also maintained very decidedly that the strandflat was formed by wave erosion, but in interglacial time.

J. H. L. Vogt [1900, 1907] is strongly in favour of the view that the strandflat has been formed by wave erosion along a practically undissected coast. He thinks that in Helgeland (and northern Norway) the strandflat was cut in this manner into the massive block of land to a width of about 45 kilometres, long before this land was dissected by the numerous deep valleys, fjords, and channels now existing. The layer of solid rock thus cut away, had a thickness of at least 400 metres along the inner zone of the strandflat, and in some regions even more. Vogt assumes that the development of the strandflat may have gone on ever since the time of the Jurassic dislocation on Andøi till the beginning of the first Ice Age.

The view that the strandflat is a plain of marine abrasion (wave erosion) has also been held by Davis [1899], Rekstad [1912, 1915], Sahlstrøm [1917], D. W. Johnson [1919], and others.

Andr. M. Hansen [1894, 1898] assumed that the Norwegian strandflat had been formed during the later part of the first Great Ice Age, partly by wave erosion and partly by the scouring of the drifting ice along the shores of the sounds. The coast had then already been dissected by numerous fjords and channels, greatly increasing the line of attack. The mode of formation of the strandflat was supposed to be practically the same as that of the shore-lines. The broad strandflats are simply several shore-lines which have met and united, advancing from different sides of the islands and peninsulas.

Hansen considers that the glacial erosion has also been of much importance, particularly for the denudation of the low level surface of the skerries. He also pointed out that during the time mentioned, when the margin of the first inland ice still remained in the fjords, the climate greatly favoured subaërial erosion.

Amund Helland, and later F. Nussbaum [1909], maintained that the strandflat and the low skerries have been formed by the erosion of the inland ice, advancing over the outer coast.

A view different from most others is held by Gerard de Geer [1912] who considers dislocations to have been of great importance for the formation of the strandflat. This theory has been carried still further by J. J. Sederholm [1913] who sees dislocations everywhere along the inner margin of all shore-planes, and he tries to explain the 'stacks', surmounting the plane of the strandflat, as horsts bounded by numerous lines of dislocations, in a most artificial and complicated manner. But strandflats do with certainty occur in many regions where there are no traces of dislocations near their inner margin, and Høgbom [1913] has in several places in Nordland been able to trace conspicuous layers, with gentle seaward dip, from the mountain slopes and on the sharply defined plane of the strandflat without any break, which proves finally that the formation of a strandflat is not conditioned by dislocations. On the other hand, investigations of Norwegian geolists have proved that dislocations may often occur within the region of the Norwegian strandflat, without showing any relation to its limitation, or to the border lines of the stacks On the contrary the plane of the strandflat often continues across the lines of dislocation without a break.

By bringing weaker rocks in the shore-region in level with more resistant rocks further inland, dislocations may naturally fascilitate the formation of sharply defined shore-planes, but they cannot form them.

In the report [1904] mentioned above, and in a later paper [1905], the present writer maintained that the Norwegian strandflat had been formed by the joint action of subaërial denudation and marine denudation, after the time when the coast had been dissected by the numerous fjords and channels, which now split it up into its innumerable peninsulas and islands. The subaërial denudation was supposed to have been of the greatest importance for the denudation of the coast land, while the marine denudation had been important for the levelling of the strandflat. During the glacial periods the subaërial denudation of the coast land was essentially increased by the disintegrating effect of the frost on land. The marine denudation was due to wave erosion and also to the disintegrating effect of frost on the shore that was wetted by tide and waves. The transport of matter by ice, formed on the beach, was also of some importance.

It was emphatically maintained that a broad strandflat, like that of northern Norway (Helgeland), cannot have been formed by wave erosion, during a reasonable time, before the coast had been dissected by deep fjords and channels, but it must have been formed after that time. This was especially for two reasons:

On the one side, the erosive effect of the waves on the shore would be much reduced in the extremely shallow sea over a submerged, nearly horizontal strandflat, along an undissected coast, where the waste would have a difficult way to travel in order to reach deep water. While along a dissected coast the line of attack of the marine denudation is immensely increased, and the waste is easily washed into the deep channels and fjords. The subaërial denudation is also much increased because on all islands and peninsulas the waste has got a short way to travel to reach the sea.

On the other side, the total quantity of rock that had to be worn away from the small islands and peninsulas of a dissected coast, like the present one, would be only a small fraction of the quantity that must have been cut away from a high and solid coast.

For the above reasons, I reached the conclusion that the Norwegian strandflat cannot be of preglaciale age, but must have been developed especially before, during and after each glacial period when the rough moist and cold climate highly favoured an active subaërial denudation, as well as an active marine denudation.

Although I shall later go more fully into this question, let me here at once correct what I consider to be a mistake. The development of the strandflat cannot, as a rule, be assumed to continue during the late part of a glacial period, when the glacial margin is retreating from the coast, and not for a considerable period after that time, because, near the end of a glacial period, the land along the greater part of our coast, has most certainly been depressed by the weight of the extensive ice-sheet, far below any level of the strandflat, and it took a long time before the land had again returned to its natural level.

Let me in this connection also correct another mistake. It was assumed that the slow oscillation of the shore-line during the glacial periods may have been of importance for the formation of the strandflat. These oscillations were "caused by the isostatic movements of the land under the pressure of the ice-caps" as well as "by the accumulation of water in the ice-caps by which the volume of the ocean was altered; and also, though slightly, as a result of the raising influence exerted on the sea-level by the attraction of the ice-masses on land" [1904, p. 109].

A characteristic feature of the strandflat is, however, the great width and the nearly perfect horizontality of its levels, which indicate that it must have been formed during several long periods, when the level of the shore-line remained fairly stable. It has not been formed during periods of isostatic movements of the land due to the load of the ice-caps, when, however, the raised beaches were formed. A characteristic difference between the strandflat and the raised beaches is that, the former is horizontal, and indicates stable levels which the land has had during long periods, while the latter are *tilting* and indicate the levels of the shore-line during a temporary submergence of the land.

As being of importance for the development of the strandflat it was also pointed out that by each advance of the glaciers of the glacial periods the waste was carried away seawards from the land and the shores, leaving bare rock surfaces for attack when the glaciers retreated.

I still hold similar views on most points regarding the nature and formation of the strandflat, as I did at that time; but I now am of the opinion that the shore-erosion by frost is of even much greater importance for the marine denudation of the strandflat than I thought then.

Nearly the same views regarding the nature and genetic origin of the strandflat, as put forth in my report, have also been held by Thorolf Vogt [1912, 1914], Otto Nordenskjøld [1912, 1914], A. G. Høgbom [1913], and others. In his admirable paper, Høgbom proves, by numerous convincing evidences, the untenability of the above mentioned tectonic theory of De Geer and Sederholm, explaining the strandflat as formed by dislocations. He points out that the coast land must have been dissected by the fjords before the strandflat was developed, and had been so much lowered by subaërial denudation that there was not very much left for the marine abrasion to cut away in order to form the strandflat. He thinks that this last quantity of rock may thus have been at most ten per cent of the quantity calculated by J. H. L. Vogt as having been cut away by marine abrasion. I would be inclined to reduce even this figure considerably.

In his recent publication "Geomorphological studies in Norway" [1919] Hans W:son Ahlmann has discussed the nature and genetic origin of the Norwegian strandflat. As his views in this respect differ from those of previous writers I shall have to mention them at some length [1].

Ahlmann arrives at the somewhat startling conclusion that a Norwegian strandflat (or "coastal plain" as he calls it) does not really exist. In the first part of his paper he assures us that the formation, previously called so, has nothing to do with marine denudation. It is a base-levelled plain formed solely by subaërial denudation, in some places assisted by glacial erosion. He therefore thinks that the name of "coastal plain", or strandflat, for this formation is inadequate, and proposes to call it "the distal base-levelled plain".

[1] Just as this manuscript is going to press I have received from Prof. A. G. Høgbom a paper [1920] discussing Ahlmann's views. Høgbom's points are to a great extent the same as mine, but he has also mentioned some other sides of the subject which I have not paid attention to.

There seems, however, to be no sufficiently weighty reason for such a change of name, even if there had been some probability in favour of A.'s theory of the genetic origin of the strandflat, which is not the case according to the view of the present writer.

A.'s theory is not so revolutionary as he seems to think. Some previous writers, especially A. G. Högbom [1913] and the present writer [1904, 1905], had suggested that the strandflat had been formed chiefly by the conjoint action of subaërial denudation and marine denudation. and also to some extent glacial erosion. By far the greater part of the denuding work was supposed to have been accomplished by subaërial denudation, while the marine denudation was supposed to have finally planed off the low coastal zone of islands and peninsulas, and had thus developed that nearly horizontal plane of the strandflat which is so very conspicuous in many regions of the coast. Now A. postulates that this finishing planing by the marine denudation is not necessary, as the subaërial denudation alone may have accomplished the whole work. His evidences are, however, hardly convincing, as we shall see.

Like most geomorphologists A. considers marine denudation to be solely due to wave erosion, and as, according to his view, the waves cannot possibly cut very broad and nearly horizontal plains along an open undissected coast, nor can have much erosive force along the protected shores in narrow sounds, inlets, and fjords, a strandflat or "coastal plain" cannot be formed by marine denudation.

His argument is that the formation of a strandflat in this manner would be such an extremely slow process, that, during the long time required, the coast land would be planed down to base level by subaërial denudation. He therefore considers it to be probable that, what is called the strandflat, has been formed in the latter manner, during preglacial time before the coast had been dissected by the many deep fjords and channels, deepened during the glacial periods, and now traversing this plain.

Already on this point A. seems to come into a serious conflict with himself, in as much as, in the last part of his treatise [1919, pp. 237—239], he describes very broad and nearly horizontal plains in northern Norway, in the regions of Værøi, Røst, and probably Træna, which he thinks are "unmistakable results" of marine denudation (*i. e.* wave erosion). On Værøi, these plains are cut as much as two or three kilometres landwards, into the mountain side, forming cirques one kilometre and a half broad.

He says [1919, p. 239] that on Røst "marine abrasion and other atmospheric agencies of destruction have broken down all land so that only isolated parts survive". He thinks that this "took place during the last Ice Age outside the inland ice. At that time too the subaërial destructive agencies in the regions, situated just outside the inland ice, were undoubtedly extraordinarily powerful. The land area was rapidly broken down through the combined force of atmospheric weathering and marine abrasion".

A.'s views as regards the formation of these coast platforms are obviously identical with the views of the formation of the Norwegian strandflat held by the present writer [1904] and by Hogbom [1914] and are expressed almost in the same words. It is, however, hard to see why A. assumes that the joint action of marine denudation and atmospheric weathering, so effective in this special region, and during so short a time as the last glacial period, should have had practically no effect during the same period, not to speak of the much longer preceding glacial periods, along the rest of the Norwegian coast, where he assumes that there was also a border lying "outside the inland ice". We may naturally ask, what have these agencies, so effective on Værøi, Røst, and Træna, been doing in other regions during all that time with climatic conditions favourable for erosion? Is it conceivable that they should have left no traces of their activity?

As far as I can see, no answer to this question can be found in A.'s paper. He assures us that Værøi Røst, and Træna are very like each other, and are "markedly different from the rest of the coast region of Norway" without explaining what this marked difference chiefly is. If it is an exceptional evenness of the strandflat, this might seem to be sufficiently explained by the fact, also pointed out by A., that these islands were probably not covered by ice, or have at least not been much attacked by ice erosion, during the last glacial period, while other regions of the strandflat have been more or less eroded by glaciers. And what is then to be said about other parts of the Norwegian strandflat, which are also very level — *e. g.* on Sandøi, south of the mouth of Sogne Fjord, or in the regions of Smølen and Frøia, Brønøi, Herøi, Dønna etc.?

It is also difficult to see any marked difference between the strandflat of the Lofoten Islands, Fig. 1 and 2, and the strandflat along the coast of the mainland, Fig. 3.

A.'s views as regards the importance of marine denudation, do not, however, seem to be quite consistent, for mentioning the region of Smølen. west of Trondhjem Fjord, he says that he does not "wish to deny that abrasion has at some time occurred here, but only as a final smoothing process. The inland ice has also been of great importance in the planing of the ground" [1919, p. 197]. The question is how great the importance of this "final smoothing process" has been? It can hardly have been insignificant if it is chiefly of preglacial age, and has been able to survive the erosion of the glacial periods. But it is very difficult to understand why the marine denudation has only occurred "at some time", if it is due to wave action? One would expect that the waves have always been at work along the coast of Norway, where it was not covered by ice. It also seems highly improbable that the inland ice has had a planing effect upon the ground. As a rule its effect has been the other way, as will be mentioned later.

In his anxiety not to admit too much to the effect of marine denudation, A. assumes that only "the innermost part" of the strandflat ("shelf") on Værøi (and Røst) has been thus formed, while "the extensive outer part, which now lies beneath the surface of the water" is a perfectly different formation, due to subaërial denudation, and belonging "to the initial topography as a foreland, equivalent to that round the islands of Vesterålen and Lofoten" [1919, p. 238].

How is this to be understood? Is the outer part of the strandflat a preglacial formation while the inner part is late glacial, and is it to be supposed that the levels of these two platforms, formed in so entirely different manners, and during periods so remote from one another, should coincide to such a degree, that the one platform forms a direct continuation of the other? This does certainly not sound very probable. Or is it after all so that this initial foreland has also been "smoothed" by marine denudation? If so the effect of this smoothing process may have been quite considerable, unless we assume that the level of the shore-line during the long preglacial time happened to be nearly the same as, or slightly lower than, that of the late-glacial shore-line.

In order to avoid misunderstanding it may at once be pointed out that I do not attribute so much planing effect to the wave erosion as A. does in the case of Værøi and Røst, and probably Træna. Though important the erosion of the waves may have been during the enormously long time they have had to work in, still I hold that during the glacial periods, and during the cold time preceding them, the shore erosion by frost has been much more effective for the planing of the strandflat along the Norwegian coast, while the chief importance of the wave action has been its transport of débris from the shores.

The topography of the low and flat Radøi, north of Bergen, which Ahlmann describes in much detail, is in his opinion a convincing evidence proving that the strandflat is a base-levelled plain formed by subaërial denudation, without the aid of marine erosion. He describes, however, two distinct levels of this strandflat which is in conformity with what has been observed in other regions of the Norwegian coast, and these levels are in some places very conspicuous as will be described later.

Quite apart from the improbability that planes, as horizontally level as these, can be formed by subaërial denudation alone, it is hard to see how two such distinctly different levels, in some regions appearing as nearly horizontal benches cut in solid rock, have been formed by base-levelling. If we imagine that the shore-line has remained fairly stationary during very long periods (in preglacial time?), first at the upper level, and later at the lower, and obviously younger level, it might be expected that the subaërial denudation, while base-levelling the land towards the lower level, would wear away more or less the traces of the upper level, and would produce a gradual transition from it towards the lower one. But this is not the nature of the two levels.

By marine denudation, working conjointly with subaërial denudation, we get a simple explanation of the two levels of the strandflat. The plane of the lower one is cut backwards under the upper one, and both may exist simultaneously, because the latter one will not disappear till it is entirely cut away by the lower level; and a more or less abrupt transition between them may be found, unless it has been much modified by later erosion.

An important reason why A. thinks that the Norwegian strandflat has not been formed by marine denudation, is that a plane thus formed could not slope so very gently from its inner margin, at the foot of the mountains, towards the outer skerries, as does the strandflat. Its inclination must have become steeper, for else the waves would not have got sufficiently deep water to work in. Nevertheless he thinks that the innermost parts of the very flat platforms on Værøi, Røst, and probably also on Træna, are formed by wave erosion. A. is obviously right in his view that wave erosion alone cannot, as a rule, form wide planes sloping as gently as these; but he has not considered the effect of shore erosion by frost. Where this process, as described later, plays the leading rôle in marine denudation, wide and nearly horizontal planes, like those of the Norwegian strandflat, may certainly be formed along a much dissected coast.

On the other hand A. objects that, because in some places, *e. g.* in the region of Rorvik, north of the Trondhjem region [1919, p. 197], the low coastal border-land is not flat, there is no strandflat. For if this "had been formed, wholly or mainly, through marine abrasion, the plain would everywhere have the same main character," but "at Rørvik, and at many other places, there occur, in complete contrast to this, all stages from the most broken topography to the groups of small level islands."

This is, however, just what might be expected to be a characteristic feature of a strandflat formed by the joint action of subaërial denudation and marine denudation, and also glacial erosion, along a much dissected coast. Its degree of evenness will naturally depend on the degree of maturity to which it has been developed. The less mature the more ridges, hills, and stacks will surmount the general marine level. Where the rocks are relatively resistant, or where initially relatively great masses of rock surmounted sea-level, many islands and hills may remain more or less incompletely levelled, and their summits may vary much in height.

On the whole, the surface of the strandflat may seem to be remarkably level, considering that it has also been exposed to considerable glacial erosion, perhaps during several periods, which has scoured the islands and hills, rounding off their edges and summits, and also considering that the strandflat has been developed during long periods, with different levels of the shore-line.

A most characteristic feature in the topography of the Norwegian strandflat, is its incision into the mountain side of the land behind, forming an often sharply marked line of demarkation between the level strandflat and the mountains ascending abruptly and steeply, often hundreds of metres. As far as I have seen, Ahlmann has made no serious attempt to explain how such a horizontal incision could have been formed by the vertically working subaërial denudation, although this would naturally have been of essential importance, if his theory should have been made more plausible. Nor does he try to explain how the vertically working subaërial denudation alone can possibly develope such extremely flat, and nearly horizontal planes, as occur *e. g.* in Smølen, Frøia, Herøi, Donna, Risvær, and Solvær. In the case of Smølen he himself has obviously had a notion that it was necessary to open some opportunity of a finishing touch by a horizontally working agency, the marine denudation, as was mentioned on a previous page (9), but, as if to weaken the effect of this admission, he also draws in the erosion of the inland ice, as having a planing effect, which I consider very unfortunate, as will be discussed in a later chapter.

If the assumption that the strandflat is a base-levelled plain, due to subaërial denudation, be correct, we might expect that this process would have had the greatest facilities in developing a broad strandflat in southern and south-eastern Norway, where the initial land was low, and sloping gently towards the coast, — while it would require infinitely longer time on the initially high west coast, especially if it be assumed, with A., that his "distal base-levelled plain" was mainly formed before this coast was dissected by the many deep fjords, channels, and valleys of the glacial periods, *i. e.* at a time when a very much greater mass of rock had to be worn away before the land could be base-levelled.

We find, however, just the contrary: an often broad and well developed strandflat along the steep and high west coast of Norway, while there are only slight indications of such a formation along the southern and south-eastern coast.

It is, however, not always easy to grasp what A. exactly means by his base-levelled plain, for in some regions, *e. g.* in southern Norway, it may have a relief of a hundred metres above the sea, and in that case it would still be much rock to plane away before we reach the strandflat.

If the Norwegian strandflat is solely a "base-levelled plain," it would also be extremely difficult to understand why subaërial denudation has not developed similar strandflats along any old coast, where the coast-line has remained stationary during a time necessary for base-levelling, and why it is that, on the contrary, typical strandflats occur chiefly in regions that have been covered by ice-caps, or have at least had very cold climates

We might have expected to find this "distal base-levelled plain" most perfect in those milder regions, where its surface has not been attacked by glacial erosion. A. has made no attempt to help us out of this serious difficulty.

It might be objected that along the east coast of India there is a very broad (up to 75 kilometres broad), extremely flat and low plain, backed by steep mountain walls. But unfortunately, this is just a region with very little rain-fall, and where therefore the subaërial denudation has been so insignificant that this magnificent plain of marine abrasion could be developed so perfectly, and remain relatively undisturbed, and backed by oversteepened hills, because it was only sligthly attacked by subaërial denudation.

A.'s views as regards the formation of his "distal base-levelled plain" has been well expressed in his description of the region of Smolen, where he says [1919, p. 197]: "On the mainland opposite Smolen there occurs a broad denudation surface with about the same height above sea-level as that on the island, and abruptly attached to a steep fell-side about 500 m. high. In certain places this surface seems to continue in islands and terraces at the side of fjords, which towards the east pass into a mature valley-generation." From this he draws the conclusion that the broad denudation surface of Smolen and the mainland has been formed by base-levelling in the same manner as the floor of his base-levelled valley generation, which he describes so well. His view is obviously that the broad valley floors have joined together in front of the high land and have "formed a peripheric base-levelled plain" [1919, p. 221].

To me it would have seemed more logical to argue that, the low islands and ledges along the sides of the fjords have obviously been levelled by the same process as the flat and very even surface of the strandflat of the coast outside, and that this process has been marine denudation of some kind, because the islands and ledges in the fjords have, in most cases, little resemblance to what might have been expected to be remnants of the floors of base-levelled valleys, that have been exposed to the erosion of several glacial periods. Besides in several places the floor-level of A.'s preglacial valleys differs distinctly from the level of the strandflat in the same locality, *e. g.* in Sogne Fjord, as will be mentioned later.

Another difficulty is also connected with A.'s views as regards his base-levelled valleys. For the same reasons which the present writer has pointed out [1904, pp. 44 f., 54 ff., 151 ff. etc.] A. also assumes that the preglacial fluvial valleys of the land has been continued across the floor of the now submerged continental shelf, *e. g.* outside the coast of Romsdal, Trondhjem Fjord, and Helgeland, at a time when the land stood about 250 to 300 metres higher than now. A. is obviously of the opinion that these valleys too were base-levelled; but if so how is this fact reconcilable with his theory of the valleys and strandflat as having been base-levelled at about present sea-level? If, after that great elevation (250—300 metres higher than now) when the valleys were base-levelled on the continental shelf, the land was submerged, the valleys were naturally also more or less submerged, and their floors would be below sea-level near the coast. There would thus be no possibility of base-levelling the valleys in this coast zone, as they were already deepened below base-level.

It might then be assumed that the elevation of the land occurred after the valleys of the present land-surface had been base-levelled and 'the distal base-levelled plain' had been formed. But if so the land must have stood at that higher level for a considerable time, sufficiently long for the base-levelling of the fluvial valleys of the shelf, and after that the land has again sunk to its previous level, or the shore-line has returned to the same level which it had during the very long period when A.'s old valley generation was base-levelled. But what kind of movements is it that has changed the level of the shore-line in this peculiar way, and after such a long time brought it back to its original level? A. cannot be seen to have considered this difficult question, which his theory must inevitably raise.

There is also another difficulty which he does not mention. He thinks that the inner part of the continental shelf "constitutes an immediate continuation of the coastal zone, thus belonging to the peripheric base-levelled plain" [1919, p. 211]. But how is this to be understood? Was the plain of the continental shelf base-levelled at the same time as his old valley generation further inland was base-levelled? But the level of the latter, is now near present sea-level, and is considerably higher than that of the former. How then could extensive formations, so sharply marked as the strandflat, and the floors of his old valley generation, be so well developed at this base-level, when there was also another lower base-level (before or after?), represented by the inner part of the continental shelf? A.'s ideas do not seem to be very clear on this point.

His views of the genetic origin of the continental shelf shall not be taken up for discussion here. A factor of much importance for this and other questions dealt with in A.'s treatise, is the isostacy of the earth's crust, which, however, he does not mention.

The conclusions arrived at concerning Ahlmann's views of the nature of the Norwegian strandflat, may be summarized as follows:

A. is right in assuming that the subaërial denudation (*i. e.* atmospheric weathering, frost disintegration, and fluvial erosion) has been of chief importance for the denudation of the Norwegian coast land, as well as for the land slope within. This is in full accordance with the views of several previous writers.

A. is wrong in assuming that the Norwegian strandflat, forming often a sharply marked horizontal incision in the mountain slope, has been developed solely by base-levelling of the subaërial denudation, without the aid of marine denudation.

A. is also wrong in assuming that the present strandflat has been formed mainly in preglacial time before the coast land had been dissected by the numerous fjords and channels now traversing the strandflat.

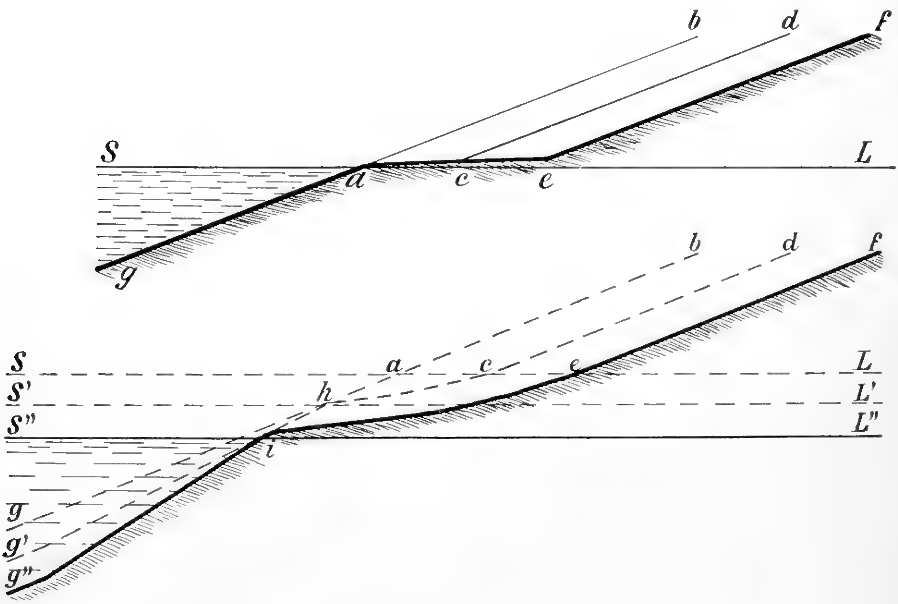
Profiles of the strandflat and the high land behind it, like those given in Chap. VII and VIII, and also the numerous profiles given in my report of 1904 [Pl.s XII—XX], demonstrate how very level the strandflat may be in some regions, and what sharply defined horizontal incision it may form in the steep mountain side of the land. It is hardly conceivable that level planes like these, can have been formed exclusively by a vertically working process, like the subaërial denudation. We must assume that they have been finally levelled by some process working horizontally.

The writer has recently [1920, 1921, Chap. VIII] mentioned several processes that may have a planing effect upon a land surface, even above sea-level. But their levelling effect is small compared with that of marine denudation in cold regions, where an active shore erosion is produced by the disintegrating activity of the frost, in and just above the shore-line, as will be described later.

Let us, however, first examine more closely what importance the various denuding processes may have for the denudation of the coast land and for the development of the strandflat.

III. THE EFFECT OF THE SUBAËRIAL DENUDATION IN THE COASTAL ZONE.

If a land-surface sloping gradually towards the coast, be exposed to subaërial denudation during sufficiently long periods, and without being disturbed by other processes, it is obvious that a base-levelled plain may finally be developed along the coast, and according as the sloping land-surface is denuded, this plain will extend landwards. Fig. 4 demonstrates very roughly the development. *S L* is sea-level and *g a b* the initial land slope, which by subaërial denudation is lowered to *c d*, and then to *e f*, and the base-levelled plain *a c e* is thus developed. It is here supposed that the rate of subaërial denudation as well as the resistance of the rocks have been the same in all regions of the land slope, which of course is, not the case, as a rule. The transition between the land slope and the base-levelled plain would naturally be very gradual, and there would not be a sharp break as in the figure.



Figs. 4 and 5.

It has, however, to be considered that the subaërial denudation is working, not only in the coastal region, like the marine denudation, but over the whole land surface simultaneously. As will be mentioned in a later chapter, the resulting removal of rock from this great area, will necessarily cause a corresponding isostatic elevation of the land, and this will change the above process. In stead of the three stages *a b, c d,* and *e f* of Fig. 4, we will find that when the land surface was denuded, from *a b* to *c d* the land would be elevated very nearly the same height, *i. e.* the shore-line in Fig. 5, would stand at $S'L'$ in stead of at $S\ L$, in relation to the land, and the coastal plain would be developed to form the profile *c h*. The rock-surface would then follow the line $g'h\ c\ d$.

When the land surface is denuded to *e f*, the land will rise so much that the shore-line will be lowered to $S''L''$ in relation to the land. The coastal plain will be developed to form a slope as indicated by the line *i e*. As the sea floor has not been eroded, it should not be elevated, only its inner part $g''i$ will be raised with the rising coast, owing to the rigidity of the earth's crust.

The final result will be that the slope of the land, the coastal plain, and the slope of the sea floor will be something like what is represented by the line $g''i\ e\ f$ with sea-level at $S''L''$.

It might be objected that the coastal region $g''i\ e$ will thus be elevated above its earlier level. It has, however, to be considered that this zone is lifted with the whole land, and the surplus of mass elevated in the coastal zone, above and below sea-level, is more than compensated for by the defeceit of mass elevated in the region of the land inside.

The coastal plain resulting from this process will rise inland, and will be continued in the land slope with a perfectly gradual transition between them, as demonstrated by Fig. 5.

A last upheaval of central and western Norway, in relation to sea-level, may perhaps have ocurred in early Tertiary time (Eocene), or may have been finished in Miocene. During the many millions of years since then, the subaërial denudation has been working continually on the surface of Norway.

During this long time the coast land has probably been much denuded, and a plain with a fairly gentle slope may have been more or less developed by the process described above. But a low foreland, similar to the strandflat, could not be developed in this manner, except perhaps in regions where the coastal border is built up of rocks with relatively little power of resistance. But even there the surface could hardly be planed so very flat by this process alone.

If the shore-line oscillated vertically during this long preglacial time, and provided that there had been no marine denudation, the slope would become steeper in the outer coast land which by submergence had been less exposed to the subaërial denudation.

During the glacial periods a great change was, however, produced in these conditions. The valleys were much deepened by the glacial erosion, the coast land was much dissected by fjords and sounds, and the outer coast was cut up into narrow peninsulas and thousands of islets. The subaërial denudation was also very much increased by the conditions of the glacial climates.

The result must be have been that, when the much dissected coast land was not covered by the inland ice, the subaërial denudation, before and during each glacial epoch, had a greatly increased power to denude the many islets and narrow peninsulas towards sea-level. The climatic conditions then greatly favoured the denudation, because the temperature was low, the frost was very active destroying the rocks, and was assisted in its disintegrating work by small local accumulations of snow in the hollows of the rocks on the coast land, remaining during a great part of the summer, and keeping the joints and fissures of the surrounding rocks always filled with melting-water which would split the rocks when again freezing during the frequent daily oscillations of temperature above and below freezing point in this region of melting snow and cold sea.

As I have pointed out before (cf. p. 6), the waste would comparatively easily be carried away down the often steep slopes on these small islands and peninsulas of the much dissected coast, where the distance to the sea is very short. In addition to the transport of the waste by running water, there may also have been a considerable transport of matter by the downward movement of the soil, consisting of water-soaked mud or gravel or even stones, along the slopes. This movement is caused by the freezing and melting of the water in the soppy soil and gravel. This transport is very common in Arctic lands, as has especially been described by Joh. Gunnar Andersson and Bertil Hogbom [1914], and may often be considerably more effective than the transport of waste by running water.

In this manner the rock surface of the dissected coast land has been covered by comparatively little waste, and was therefore continually exposed to fresh attacks of the subaërial denudation, especially that caused by the frost.

All these processes mentioned above may now be studied in full activity on Spitsbergen.

It has obviously also been of great importance that each time the inland ice or the local glaciers of the glacial periods advanced over the coast land all waste and loose material on the land, as well as in the fjords and sounds, would be carried away seawards, and when the glaciers again retreated all valleys and sounds had been reopened and fresh rock surfaces were exposed to new attacks of a vigorous subaërial denudation. During the various glacial epochs, while the margin of the inland ice was standing near the outer coast land, there were probably many such oscillations of the glaciers [cf. Nansen, 1904, pp. 109, 113].

The final denuding effect of the subaërial erosion during the glacial periods must therefore have been comparatively very great in the much dissected coastal regions, and the islands and peninsulas were comparatively rapidly denuded towards sea-level.

It may also be possible that this effect of the subaërial denudation, was somewhat greater in the coastal regions than farther inland. But it is hardly possible that, under otherwise equal conditions, an abrupt break in the land-slope could thus arise along the boundary between the coastal region and the mountains of the land inside. A strandflat with a practically horizontal level, like what we now find along the Norwegian coast, could therefore not be formed in this manner without the effective assistance of other processes.

IV. GLACIAL EROSION.

The Erosion of the Glaciers of the Inland Ice.

If we shall try to form some idea as to what the importance of the glacial erosion may have been for the development of the strandflat, it would be necessary to examine the mode in which the glaciers erode under different circumstances, and their erosive effect upon the land surface in different regions. There will be no opportunity of making such a comprehensive investigation here. We must limit ourselves to some points of importance for our special subject.

There is a striking difference between, on the one hand, the remarkably small denuding effect which the inland ices of the glacial periods have had on the relatively level surfaces of central and eastern Norway, and the greater part of Sweden, where, in many places, the depth of glacial erosion may only amount to several metres, and, on the other hand, the considerable dissecting work performed by the glaciers of the ice ages in the coastal regions of Norway, where the valleys and fjords have been deepened hundreds of metres.

This remarkable difference of effect must be chiefly due to differences in the velocities with which the eroding ice has moved over the rocks, and not appreciably to differences in its thickness and the pressure thereby exercised on the underlying ground.

A. G. Høgbom [1910, p. 435 f.] and other writers are obviously right in assuming that the erosive power of a moving glacier is much less due to its scouring effect upon the underlying rock than to its power of breaking loose (plucking) stones from the rocky ground, and this power obviously increases rapidly with the velocity of the ice motion. The erosive effect of a glacier will also to some extent depend on its power to move and transport stones and rocky material along the ground. Moreover, a sufficiently thick glacier will have a disintegrating effect on the underlying rock by the alternate melting and freezing of water on its under side, caused by the frequent changes in the stress and pressure of the ice moving over the rough rock surface.

I have tried to investigate quantitatively the various manners in which moving glaciers may erode the underlying ground. The results of these investigations will be given in a later paper. It is difficult to estimate the total erosive power of glaciers, as it will greatly depend on the tectonic structure of the underlying rock. Where the rock surface is relatively easily smoothed, and few edges and projecting stones are left for the flowing ice to attack, the erosive work will to a great extent be reduced to grinding, the effect of which will depend on the quantity of stones and grit transported by the glacier along its under side.

The erosive effect will in that case be very much less than in places where the rock surface remains rough, and where there are always projecting rocks to be attacked and broken loose by the flowing ice.

I have come to the conclusion that, on the whole, the erosive power of a moving glacier may increase approximately with the third power of the velocity of the motion at its under side.

Hence we may expect that if this velocity be increased ten times, the erosive power of the glacier may be increased about a thousand times. A glacier which, with a velocity of ten centimetres in 24 hours, was able to denude the underlying ground to an average depth of ten centimetres during a certain long period, would then be able to excavate a hundred metres of rock during the same period, if its velocity be increased to one metre in 24 hours, and provided that the glacier were working only vertically.

The observed velocities of the moving glaciers of Norway and the Alps are generally between 0.1 and 0.4 metre in 24 hours, while on the big glaciers of the Himalaya velocities of between 2 and 3.7 metres in 24 hours have been observed during the summer. At the end of the big glaciers of northern Greenland, however, velocities of as much as 20 to 30 metres in 24 hours have occasionally been measured by Amund Helland, Stenstrup, Hammer, and Ryder, during the summer. The normal movement during the whole year is less, but still very considerable. There must consequently be an enormous difference between the erosive powers of these various glaciers.

If we take a European glacier, moving with a velocity as great as 0.5 metre in 24 hours, and a Greenland glacier, moving with an average velocity of 10 metres in 24 hours, we find that, while the former is able to erode 10 centimetres of rock, the latter will erode 800 metres.

This explains why the inland ice has had so remarkably little erosive effect in its more central areas, in Norway and Sweden [cf. Høgbom, 1910], while its outflowing glaciers have had such enormous effect in the narrow valleys and fjords of the coast land, just outside these regions.

We also understand why there are so sudden and striking differences between, on the one hand, the great deepening effect of the glaciers in the narrow fjords where they may have eroded a thousand metres of rock or even more, and, on the other hand, the quite insignificant erosive effect of the inland ice which covered the high land on the sides of these deep fjords, where the initial preglacial ("palæic") mountain surface may still be recognizable.

In the above manner we also obtain a natural explanation why the fjords are so very narrow, deep, and often winding, in regions of hard and resistant Archæan and igneous rocks, in western Norway and in Greenland, while in regions with weaker rocks, they are wider, less deep, and often radiating out from the central region of the land, as they do on Iceland, in Finmarken, and partly on Spitsbergen.

In regions composed of resistant rocks, the big, moving glaciers of the glacial periods eroded chiefly vertically. The horizontal erosion, by frost on their sides, has been comparatively small. They were guided by the initial preglacial valleys, formed by the subaërial denudation greatly along lines and zones of fracture and weakness. The glacial erosion followed the same lines. As the outflow from the inland ice converged into these narrow channels, the velocity of their ice streams became very great, and the vertical erosive power of the latter enormously intensified.

In regions of less resistant rocks, the initial preglacial valleys were broader, the glaciers would be more able to take their own course, and their erosion would not be so exclusively vertical, but also to some greater extent horizontal, especially because the mountain slopes on their sides were much more rapidly destroyed by frost. The glaciers would thus widen out, be less deep, and would obtain much smaller velocities.

A common effect of this erosion in such regions will therefore be that the fjords become comparatively shallow and wide, and they often, as on Iceland and in Finmarken, become wider towards their mouth, while in regions of resistant rocks they are generally narrower towards their mouth than further inland, where they are excavated into much deeper troughs, or true rock basins.

It has already been pointed out on a previous page that the glacial erosion has been of much importance for the development of the strandflat by dissecting the coast and splitting it up into innumerable peninsulas, islands, and skerries. Thus the coast line, or the line of attack, has been enormously increased, and the subaërial denudation, as well as the marine denudation, have been greatly facilitated.

Otherwise the erosion of the inland ice, and its outflowing glaciers, can have been of no direct importance for the planing of the horizontal level of the strandflat, as far as I can see.

When the big glaciers carved or deepened the fjords and sounds traversing the present strandflat, the islands and peninsulas between them may also have been denuded to some small extent where they were covered by the moving ice. But the general denudation thus accomplished, cannot have been considerable, as the movement of these marginal ice-sheets between the glaciers of the deep channels must have been relatively slow. As the velocities of this motion must have varied much locally, the depth of this erosion must also have varied very much; and no plane could be developed in that manner.

It has been maintained that the many low skerries of the strandflat may have been planed off to their present level by the inland ice. There is, however, no reason why this erosion should stop at sea-level.

It has been a quite common mistake amongst geologist to assume that the erosive power of a glacier should be reduced by a partial submergence of the glacier into the sea, because the pressure of the ice on the sea floor, as compared with that on dry land, should be reduced by the boyancy of the submerged volume of the glacier. But, as was pointed out by G. K. Gilbert [1904, pp. 10 f.] and myself [1904, p. 163, footnote], the pressure of the ice on the underlying ground will naturally be the same whether the ice be submerged or not, and provided that the velocity of its movement be the same, there can be no difference in the erosive power of the glacier, as long as it actually rests on the ground. The difference will come in the moment that the glacier begins to float in the sea, and a layer of liquid water actually intervenes between the under side of the glacier and the sea floor. The chief effect of submergence will otherwise be that the outward pressure in the mass of the glacier will be counteracted by the pressure of a layer of sea-water equal in depth to that to which the glacier is submerged, and its velocity may thus be reduced.

Provided, however, that the velocity of its motion remains unaltered, a glacier will have the same erosive effect upon the underlying ground, whether above or below sea-level, down to a depth below the latter equal to nearly nine tenths of the thickness of the ice, at which depth the glacier begins to float and is lifted from the sea floor.

This erosion cannot therefore be limited by any definite level, except that determined by the depth at which the glaciers float. But as this depth must have varied much, owing to the varying thickness of the glaciers, no horizontal level of erosion, like that so distinctly exhibited by the skerries and islets of the strandflat, could possibly be produced by this glacial erosion.

On the whole, it is hardly conceivable that an inland ice can have a planing effect, even where it moves over a fairly flat land surface. It may break away projecting rocks, and more or less smooth the rock surface; but it will soon move with greater velocities along certain lines than along others, especially along the initial fluvial valleys, even though they may be ever so broad and shallow. As the erosive power of the moving ice increases so much with its velocity, this will lead to a deepening of these depressions or valleys, with an increasing rate as time goes on. The final result will be that the initially flat land surface is dissected by deep glacial valleys and channels.

In the region of the Norwegian strandflat a planing effect of the moving inland ice seems to me to be especially impossible. The inland ice

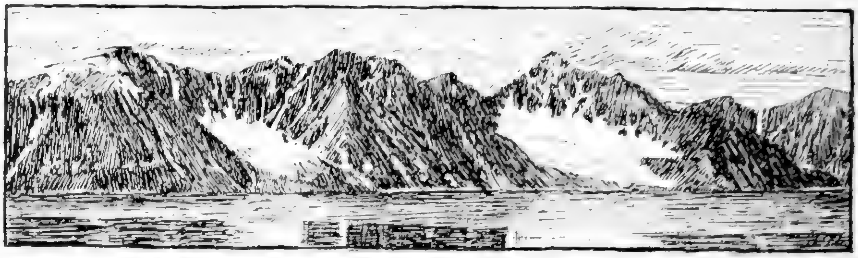


Fig. 6. Cirque-glaciers on the west coast of Cross Bay, Spitsbergen [from Nansen, 1920].

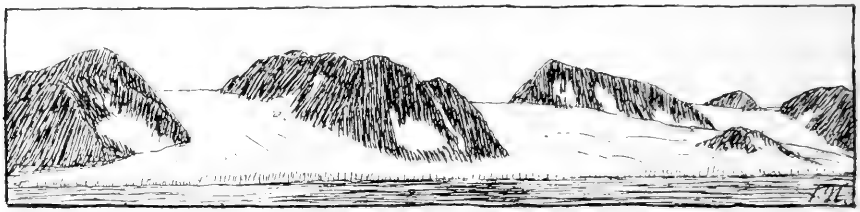


Fig. 7. Future picture of the coast in Fig. 6 [from Nansen, 1920].

would here move with consirably greater velocity along the fjords and sounds then over the islands between them, and it would go on deepening them at a very much greater rate than it could erode the surface of the islands. The velocity of its movement along these channels may have gone on increasing with increasing depth, and its erosive effect would increase very much more. How then would it be possible that the inland ice could have planed the surface of the islands and peninsulas to practically the same level, while it has excavated the sounds between them to very different depths?

The inevitable effect of the erosion of the inland ice in this region must be that, not considering its smoothing and rounding of the local rock surfaces into roches moutonés, it will make the whole land surface much more uneven than it was before.

For this reason, according to my view, and as has also so clearly been pointed out by Høgbom [1913, p. 57], it is impossible that the deep sounds and channels, traversing the strandflat and dissecting it into its many islands, can have been formed after this plane had been levelled. If the sounds were deepened, to some considerable degree, by the glaciers of the inland ice, this deepening process could not in that case have left the plane between the sounds as undisturbed as it actually has. A glacial erosion, to that degree selective, is not conceivable on a flat plain.

If the sounds and channels have been formed chiefly by atmospheric and fluvial erosion, then as Høgbom has pointed out, it becomes still more absurd to think that they could have been eroded without the intervening plain being dissected by deep valleys, sloping towards the floors of these sounds. But this is not the case.

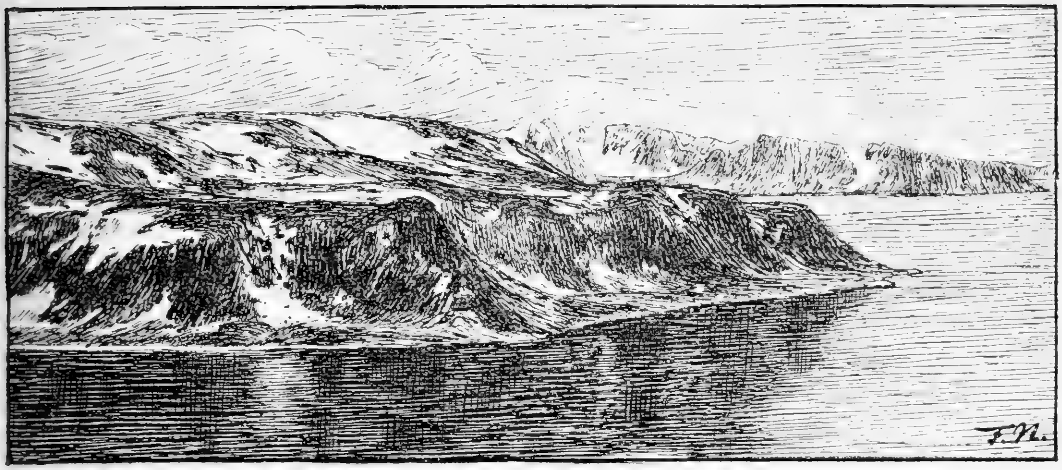


Fig. 8. Inner Norway Island, north coast of Spitsbergen [from Nansen, 1920].

Any profile of the Norwegian strandflat gives the impression that the land, rising between the sounds and submerged channels, has been truncated and planed after the latter had been formed, and that there have been relatively slight modifications of the relief after this happened.

The Erosion of Local Glaciers.

Another form of erosion is due to the activity of small "botten"-glaciers or cirque-glaciers, and of snow and ice accumulated in depressions and hollows of the rock surface, and remaining during the summer, or at least a greater part of it. Along the edges of these glaciers and snow-accumulations, the frost will have a strong disintegrating effect on the rocks during the season when the snow is melting, and when there are perpetual oscillations of temperature between frost and thaw. All joints and fissures in the rocks are here kept full of melting wtaer, ready to burst the rocks at each frost, that may even occur several times during the day and night. The rocks are therefore rapidly eaten away and thumbling down on to the glaciers or snow-heaps which carry them off.

This erosion is thus a combination of glacial erosion and atmospheric weathering (mainly by frost) which is especially powerful in glacial climates, and may be studied now at full work in Spitsbergen [cf. Nansen, 1920, 1921, Chap. VIII].

Fig. 6 represents cirque-glaciers now at work on the west coast of Cross Bay, Spitsbergen. Fig. 7 illustrates the probable future effect of this erosion when the cirque-glaciers have got time to cut through the mountain walls behind them.

As was already pointed out by Amund Helland and Lorange, there must also be a very active vertical erosion under the cirque-glaciers

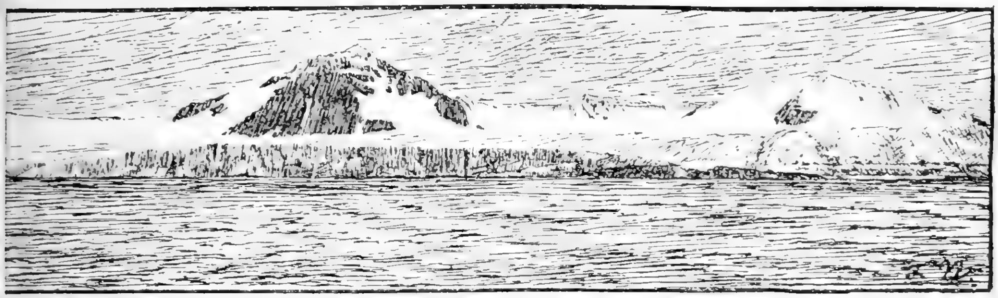
Figs. 9 & 10. The Buchanan and Murray Glaciers along the est

This may, to some great extent, be due to the alternating melting and freezing of the ice and water, at the under side of the glaciers, caused by sudden changes in pressure, as was mentioned on a preceding page. It may also be caused by melting water coming from above in the summer, and again freezing under the ice. As Werner Werenskiold has first pointed out to me, the pressure under water filling holes in the ice, will be greater than under the ice at the same level, owing to the considerably higher density of the liquid water. If the temperature is at melting point, the ice may thus melt under the water, and this may continue down to the bottom of the glacier, provided that the holes remain full of water. But as soon as the pressure is reduced, the water will again freeze under the glacier. Such holes, more or less filled with melting water, may often be formed along the edges of the glaciers, between the ice and the rock, and in this manner the disintegration of the rock may be increased.

At the bottom of crevasses often formed near the inner edge of the cirque-glaciers there may also be frequent changes of temperature above and below freezing point, causing rapid disintegration of the rocks [cf. W. D. Johnson, 1904].

It is, however, obvious that the cirque-glaciers also erode the ground by their movement. Although in most cases the movement of these small glaciers may not be considerable, we find that they have scoured and polished the rocks on the floor of their cirques, they have smoothed the edges and have plucked stones. Moreover their motion is of importance by carrying away débris and detritus formed by the erosion.

The whole process described above, may have a general denuding effect upon the land surface where it works, which is considerably greater than the average erosion of the inland ice. There is also this difference, that it will be mainly limited to the land surface which is above the sea. Given sufficient time, it might therefore be able to denude the coast land towards sea-level and might transform it into a fairly low, though uneven plain, provided that the climatic conditions allow the cirque-glaciers to descend to the sea. In Lofoten the cirques have actually been eroded to some depth below present sea-level [cf. Helland, Thorolf Vogt, 1912, Ahl-



coast of Prince Charles Foreland. Spitsbergen [from Nansen, 1920].

mann, 1919]. It is conceivable that, where the cirque-glaciers are sufficiently thick, they may be submerged to some extent, but, as a rule, they will not descend much below sea-level.

It is obvious that, in the manner described above, the local erosion of small cirque-glaciers and accumulations of snow on the mountain sides along the shores, may help to form low coastal borders, backed by oversteepened mountain walls, as demonstrated by Fig. 8.

I have observed in Spitsbergen that several cirque-glaciers, after having eroded themselves down nearly to sea-level, may be widened by horizontal erosion, until they meet and their glaciers unite and form one continuous, nearly horizontal ice-sheet, covering a fairly flat shore land in front, with a mountain wall ascending steeply behind. Figs. 9 and 10 illustrate some glaciers of this kind, covering the low shore land along the east coast of Prince Charles Foreland, Spitsbergen.

In the same manner as a cirque-glacier, the flat shore glaciers may have an ability to eat themselves backwards into the mountain side, by the frost erosion along their inner edge. The remaining ridges between the original cirques may thus gradually disappear, and few traces of them may be left. As the flat glacier, by the pressure of the snow, each year accumulating on its surface, will be moved slowly towards the sea, it may gradually carry away the débris.

In this manner we might imagine that a kind of strandflat, with an abruptly ascending, oversteepened mountain acclivity behind, can be formed. But the plain thus arising cannot be expected ever to become very broad, nor very level and regular, and there are in fact no indications that the strandflat of Norway, has to any appreciable extent been formed in this manner. In southern Norway there are very few traces of cirques having ever been formed near present sea-level; though this does not prove that it may not have been the case during the Great Ice Age.

Any how, it cannot be doubtful that, in regions with the necessary climatic conditions, as it now is in Spitsbergen, the above mentioned form of glacial erosion may have been of importance for the development of a low shore land, although it has not been able to form a typical strandflat.

V. MARINE DENUDATION. SHORE EROSION BY FROST.

There remains then no other process for the planing of the strandflat but the marine denudation. Most writers assume that this denudation is chiefly due to wave erosion. But if the wave erosion has been able to cut the plane of the broad and nearly horizontal strandflat along the coast of Norway, it must certainly have been able to cut similar planes, at least to some extent, along more southern coasts, exposed to the full fury of the ocean during sufficiently long periods, even though those coasts were less dissected. But, as a rule, no real strandflat occurs along the coasts of milder regions.

Considering the extremely slow progress of wave erosion alone on a coast built up of solid rock, it is conceivable that during the very long time which the wave erosion will need for cutting a fairly broad strandflat, the land will be so much denuded and dissected by the atmospheric weathering and fluvial erosion, and will be so much raised by the isostatic elevation thus caused, that the traces of the strandflat may be more or less obliterated.

The striking fact is that the typical strandflat is a characteristic feature of high northern and southern latitudes. It occurs preëminently in regions that have formerly been subjected to glacial conditions or have at least had very cold climates, like the coast of Siberia. It seems, therefore, to be a natural conclusion that the formation of typical strandflats have, as a rule, had some connection with low temperatures.

S. W. Cushing [1913] has described a remarkably smooth emerged plane of marine denudation along the east coast of India, which is like a strandflat. It is backed by "an ancient sea wall," rising steeply to an average height of over 650 metres above sea-level, in some regions even to 2300 metres in an almost vertical wall. Numerous remnants of quartzite rise in the shape of steep-sided ridges or stacks, often with flat summits, above this plane. Their bases are not unfrequently marked by sea caves, and there seems to be room for little doubt, but that this plane, in places about 75 kilometres broad, is actually formed by wave-erosion [cf. D. W. Johnson, 1919, p. 231]. The plane has been developed over meta morphic structures mainly, represented by numerous schists, gneisses, and quartzites. "Because of its low lying attitude and meager rainfall it has been little dissected."

Cushing does not give the height above sea-level of the inner margin of the plane, but it might be inferred that it cannot be much over 70 or 80 metres; and the plane dips gently seawards to the low, flat shore.

It is conceivable that, in a region with very meager rainfall, and consequent slow subaërial denudation, the wave erosion may, in the length of time, be able to develop sharply defined planes backed by oversteepened sea walls. But in regions with a more abundant rainfall, the subaërial denudation will work faster than the wave erosion. During the long time which the latter would require for the development of a broad plain of marine abrasion, the subaërial denudation would certainly denude the land surface much more, and it would wear down the sea wall (the cliff), and give it a gentle slope. If the plain of marine abrasion be elevated (by isostacy) above sea-level, its surface would gradually be more or less dissected by the subaërial denudation, and after some time there may be no very sharp boundary between the marine plain and the more undulating surface inland, especially as the whole land would gradually be elevated, by isostatic movement, at about the same rate as it was denudet, and nearly the same amount.

Hence, as a rule, we will find no typical and sharply defined strandflat in regions with an active subaërial denudation, unless there have been especially favourable conditions for its development, like those prevailing in regions exposed to severe climates.

After having had an opportunity of studying the process of marine denudation and its effects more closely, especially in Spitsbergen, I have modified somewhat my earlier views [1904, 1905] as to the manner in which the strandflat has been developed (mentioned on pp. 5 f.). I have been lead to the conclusion that the wave erosion has been of but little direct importance for the planing of the strandflat of northern regions, compared with the erosion effected by frost in and just above the shore-line, which process I have found to be even much more effective in an arctic climate, than I formerly believed (cf. above p. 5).

As the general expression 'marine denudation' is by most writers combined with wave erosion, I prefer to use the expression *shore erosion by frost* for this special form of marine denudation.

When sea-water freezes (at —1° to —1.9° C.) it does not expand so suddenly in the moment it is transformed into ice, as fresh-water does at 0° C. But at sinking temperature the ice of sea-water goes on expanding gradually [cf. O. Pettersson, 1883]. According to my observations, this continues as long as the sea-ice holds in its pores liquid brine which is gradually transformed into ice. New sea-water ice is also soft, porous,

Fig. 11. Shore at Cape Elisabeth, Bear Island (after a photograph by J. G. Andersson).

and flexible, and very different from the hard, solid, and brittle fresh-water ice.

For this reason the sea-water, when it penetrates into the fissures of the rocks and freezes there, has not as great a disintegrating power as the fresh-water, and there is a material difference in this respect even if the water contains comparatively little salt [cf. O. E. Schiotz, 1894].

One might, therefore, expect that the sea-water cannot by freezing produce a very powerful erosive effect on the shores, especially if it is not much diluted with fresh-water. It is an obvious difference in this respect between the shores of a lake and the shores of the sea.

It has, however, to be considered that in the fjords, and sounds, and enclosed parts of the sea, especially in the Arctic or glacial regions, the sea-surface is generally covered by layers that are very much diluted by river-water, and by the melting water of glacier-ice carried into the fjords, often producing nearly fresh surface-layers.

Moreover, nearly fresh surface-layers are quite commonly formed in Arctic seas by the melting during the summer of the ice, formed in the sea during the winter. If the sea is sheltered against waves by floating ice, or by islands, this fresh surface-layer may remain more or less unstirred during the summer and autumn, till it again freezes next winter.

In this manner, the disintegrating power of the sea, caused by freezing, will become more vigorous along sheltered coasts, either in fjords and sounds, or where the coast is sheltered by floating ice.

In a somewhat different manner the sea has, however, a much greater erosive effect along the shores in cold climates. As was mentioned before, glaciers or patches of snow may, by alternate thaw and frost, have a vigorous disintegrating effect upon the rocks along their edges.

Similar conditions prevail along coasts in an Arctic or glacial climate. Ice is formed on the beach or along the shore-line, just above high-tide

Fig. 12. Northwest shore of Reindeer Islands (Kjellman Islands), coast of Siberia. (August 20, 1893).

level, and is covered by snow-drifts during the winter. This ice and snow remain in greater or smaller patches on the beach, above high-tide level, during the summer, or at least during the greater part of it (cf. Figs. 11 and 12). Along their edges, especially on their inner side, a very effective erosion goes on during the melting season in the manner mentioned on p. 25. As the dark shore cliff absorbs the light heat-rays, the melting will begin very early at its base. All cracks, fissures, and pores in the rocks are kept full of melting water, ready to freeze at the slightest frost, and will split the rocks [cf. Nansen, 1920, 1921, Chap. VIII].

As the masses of melting snow and ice, as well as the cold sea surface, keep the air temperature near the freezing point of water, a slight fall of temperature may be sufficient to cause frost. Alternations of thaw and frost may therefore occur almost every day and night during a great part of the year.

Owing to its dark surface the rock will absorb the light heat-rays to a much greater extent than the snow and ice surface. Every time the rock is exposed to direct sun-shine it may, therefore, be heated to temperatures much above the freezing point of water, although the air-temperature in the shade is very low. The snow and ice, especially along the vertical always dark rock-walls, will then be melted, and the fissures and cracks of the rock kept full of liquid water. As soon as the direct sun-shine disappears from the rock surface, this water will freeze at once.

This process may be repeated several times during the twenty four hours, and may begin very early in winter or spring, as soon as the sun rises sufficiently high to have an appreciable effect. In not too northern latitudes it may even occur, more or less, during the whole winter. In polar regions I have observed drops of liquid water being formed on the surface of white ice cliffs in this manner when the air-temperature was below — 15° C.

In regions where the sea is covered by ice during the winter, it is also of importance in this respect that, during late winter and spring, the atmosphere is generally very clear, and there may be continual sun-shine

Fig. 13. 'Ice-foot' (shore-ice) formed above the upper fucus-limit, and above the average sea-level, at Holstensborg, Greenland. [K. J. V. Steenstrup, 1907.]

during a great deal of the time, till the sea is opened, and fogs become frequent.

The result is that the rocks are rapidly disintegrated and crumble to pieces.

The tide may also be of importance by alternately submerging some part of the shore twice every day and night, even during the cold winter. This may cause alternate melting and freezing of the water in the fissures and depressions of the rocks, wherever the shore is not covered by more permanent layers of ice. Thus an active disintegration of the shore rocks may be produced even by the sea-water.

During the time of the year when the sea is more or less open, the wave action will wash away from the shore the débris formed by the frost disintegration. This is of the greatest importance for the continued shore erosion by frost. The waves and the tide may also break loose the ice formed on the beach, and may carry it away with the débris, accumulated on its surface from the cliffs above.

The ice formed at low water, on small water pools left by the tide on the beach, may also be of some importance in this respect. Mineral particles and small stones enclosed in this ice, may be carried along with it when the tide rises [cf. O. E. Schiøtz, 1894]. The waves may help to break the ice loose, and thus the shore erosion may be increased.

The socalled 'ice foot', or thick layer of solid ice, formed along Arctic shores during the winter, may also carry along with it enclosed stones, or stones and débris fallen from the cliff on to its surface, where it is broken loose in the spring or summer [cf. Knutsen, 1889, p. 249]. But according to my observations, this transport by the 'ice foot' is less than might be expected, because on the one hand, a great deal of the 'ice foot' lies above the average high-tide level, and melts gradually *in situ*, without being carried away by the sea, and on the other hand, the ice on the lower

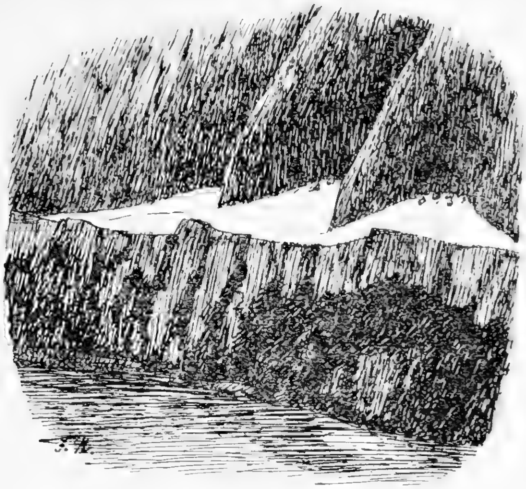


Fig. 14. Picture of the future, showing how the 'ice-foot' in Fig. 13 may erode a shore-ledge in the length of time.

beach may be so firmly frozen in between the stones, and boulders, and rocks, that it cannot be broken loose by the waves, but is gradually worn away or melted *in situ*. I have seen ice remaining during the summer in this manner between the stones on the sea bottom along submerged beaches.

In a different manner a transport of débris may be effected. The stones loosened by the disintegration of frost from the cliff and the steep mountain side, will fall down on the sloping snow surface of the 'ice foot' and thumble, or gradually glide, down this slope to the shore where they may reach the surface of the sea ice and be finally carried away by this ice. Or they are deposited in or near the water, and when they have been sufficiently disintegrated by frost and waves, are finally washed away. In this manner a terrace of loose stones and débris may often be formed along the shore outside the bench cut in solid rock.

The accumulations of ice and snow along the shore will year by year eat themselves landwards, making the shore-bench broader, and forming a higher and higher cliff, or mountain wall, of crumbling rocks inside. Thus the typical shore of Arctic lands is developed.

This may even occur along steep coasts where the mountain side falls abruptly into the sea, as is demonstrated by Figs. 13 and 14. Figs. 13 illustrates a small 'ice foot' formed above the upper sea-tang (fucus) limit and above the average high-tide level at Holstensborg in Greenland [K. J. V. Steenstrup, 1907].

Fig. 14 illustrates how a shore-bench might be formed in the length of time by the frost erosion of the accumulations of ice and snow at this level. The rate of the erosion will greatly depend on the resistance of the rock to the disintegrating effect of the frost and ice. In places where the rock is relatively less resistant, small cirques may be formed.

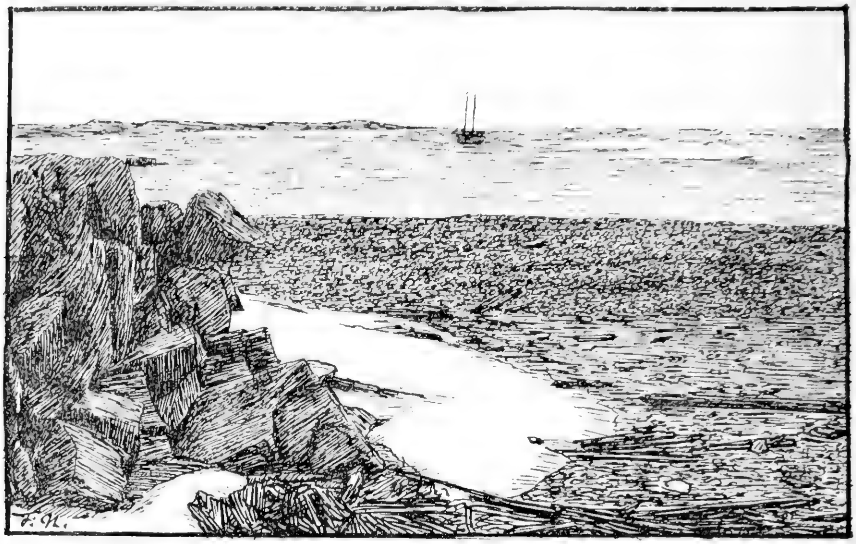


Fig. 15. An old shore cliff at the inner margin of a strandflat of low level, on Verleegen Hook, Spitsbergen [Nansen, 1920].

During storms with high-water, especially in late summer and autumn, the débris accumulated on the bench may be more or less washed away. The débris will also be moved outwards by the creeping motion in the accumulations of ice and snow themselves, and by the transport caused by the alternate melting and freezing of water along their inner margins.

It might be objected that the ice formed on the beach is sea-ice and will not therefore have much erosive power. But on the one hand, the sea in these regions is often covered by nearly fresh surface-layers, as mentioned above, and on the other hand, when the sea-ice grows old, especially during summer, the brine gradually sinks out of it, and its melting water becomes practically fresh, so that, for instance, it makes excellent drinking water. Moreover, the ice on the beach is generally covered by deep snow-drifts which remain during a great part of the summer.

This form of shore erosion may be studied at work in its different phases in Spitsbergen. We may there see how it is now forming ledges along the present shores, and we may see how it has been able to form broader benches or small strandflats as demonstrated by Fig. 15, where there is an old vertical shore cliff of disintegrated rock, with an eroding accumulation of snow at its base, on the inner side of a quite low strandflat.

After this chapter on the formation of the strandflat, had been written, my attention has been called to a paper by Thorolf Vogt [1917] which he has kindly sent me. It is of great interest for our subject as it describes recently formed shore-ledges, cut just above high-tide level in very steep rock walls along the coast of Kvænangen Fjord in northern Norway.

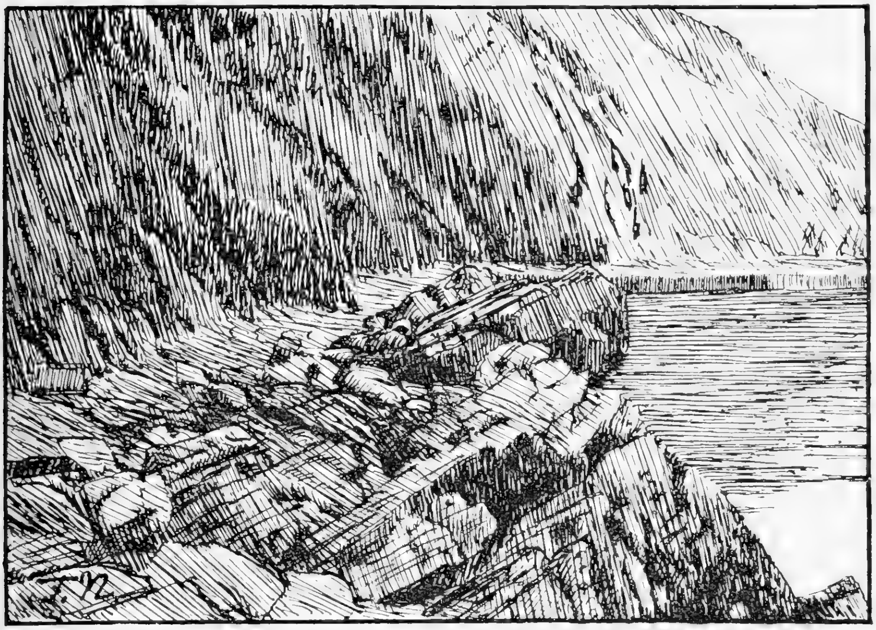


Fig. 16. Shore-ledge cut in gabbro with bands of syenite, at Simalanga, Kvænangen Fjord [after a photograph by T. Vogt].

A more convincing demonstration of the manner in which the shore-erosion by frost actually works, could hardly be found.

The ledges are 8 and 12 metres broad, the one is cut in gabbro with bands of syenite (Fig. 16), the other in dolomite. Their outer edges rise generally between half a metre and one metre, or a little more, above the level of their floor inside, which lies perhaps half a metre above the upper fucus limit, and slightly above average high-tide level. The floor of the ledges may probably be flooded at spring-tide.

As Vogt maintains, these ledges are obviously formed by frost disintegration in recent time and at present sea-level. He thinks that the eroding work has to a great extent been performed by accumulations of snow on the ledges, which have frequently been soaked with spray from the waves, and have afterwards been frozen. In this manner he finds an explanation of the height of the ledges above the average high-tide level. I think, however, that it is the alternate melting and freezing of the ice and snow accumulated on the ledges, which have had the chief erosive effect on the rock in the manner described on a preceding page. The ice has been formed on the ledges at spring-flood and at exceptional high water, as well as by water washed up by the waves in cold weather, and on top of this ice snow-drifts have been accumulated (cf. Fig. 14). Because of the salt contained in the sea-water the soaking of the snow by the spray from the waves may reduce somewhat the disintegrating effect of the melting and freezing snow.

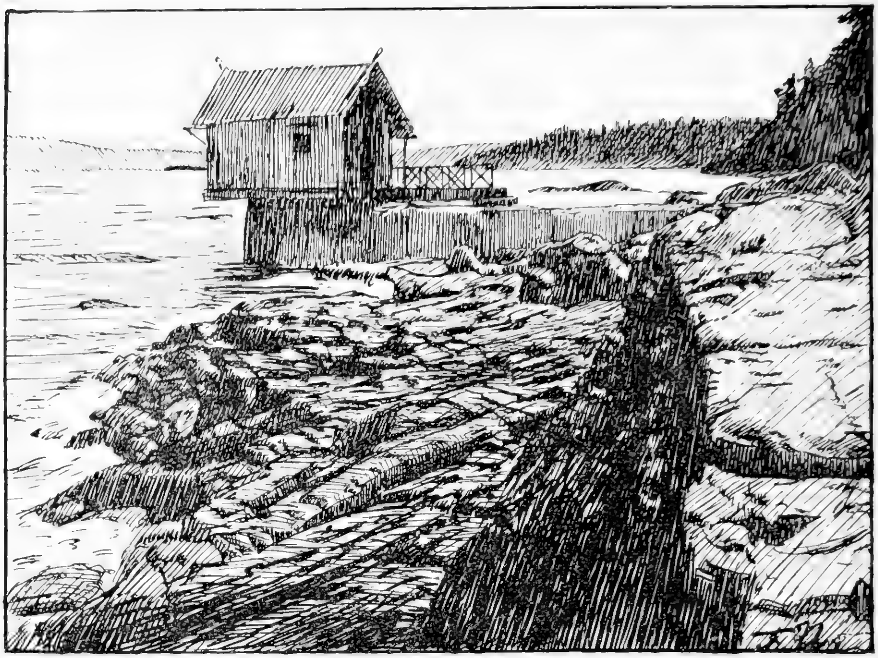


Fig. 17. Shore-ledge 8 metres broad cut in argilaceous shist on the Fornebo Peninsula.

The actual occurrence of such shore-ledges, recently eroded by frost in solid rock and at present sea-level along shores where a considerable wave action has been working simultaneously, as is the case in Kvænangen Fjord exposed to the stormy Loppen Sea, is a convincing evidence that, where the necessary conditions are present, the shore-erosion by frost is much more effective than the wave erosion, and it is able to cut shore-benches in solid rock in a much shorter time.

It might be objected that the mountain sides of Kvænangen Fjord, where Vogt's ledges have been cut, are so very steep with so deep water just outside (a depth of 22 metres only 4 metres outside the shore) that the wave erosion would, in any case, have very little effect on such a nearly vertical rock wall. But the fact is, as Vogt points out, that the loose stones as well as the projecting solid rocks on the rough surface of the ledges are angular, and show no appreciable traces of having been rounded by the waves. While the disintegrating effect of the frost has been able to cut these ledges 8 and 12 metres broad into the steep mountain wall, the wave erosion has not even been able to produce any appreciable effect upon the outer edge of these ledges. The wave action has, however, obviously been of importance by helping to carry away the débris.

Similar shore-ledges, formed by shore-erosion by frost, also occur in more southern latitudes. Along the shore outside my house on the Fornebo Peninsula (at Lysaker), in the inner end of Christiania Fjord, relatively

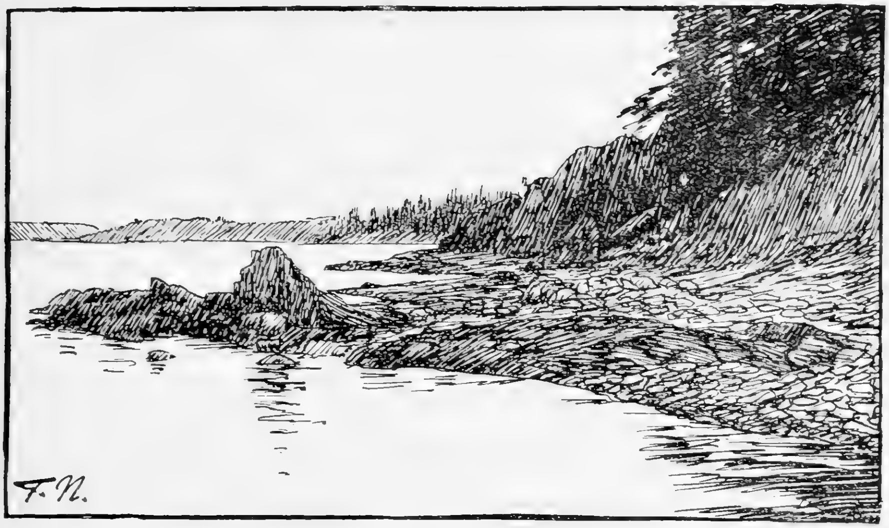


Fig. 18. Shore-ledge 18 metres broad, cut in argilaceous shist near Fornebo Harbour.

broad ledges have been formed in this manner, in recent time and at present sea-level. Figs. 17 and 18 represent some parts of these shore-ledges. They are cut in solid rock and are from 8 or 9 metres (Fig. 17) to 18 and 20 metres broad (Fig. 18). The rock consists chiefly of ordovician clay-slates, alternating with bands of lime-stone, occurring in series of lenticular nodules with intercalated shales [cf. Werenskiold, 1911]. This formation is intersected by numerous dykes of diabase.

The general floor of these ledges is perhaps half a metre above average sea-level. The tide is insignificant in the inner end of Christiania Fjord, and the sea does not often rise sufficiently to flood the ledges. In som places the outer part of the ledge, near its edge, may be somewhat higher than the floor inside. In Fig. 17 the outer edge of the ledge is about 0.6 to 0.8 metre above average sea-level, while the floor inside is 0.2 to 0.3 metre lower. In some places rocky nabs occur near the outer edge rising as much as 1 metre above the floor of the ledge (see Fig. 18). These projecting nabs and ridges near the edge of the ledges, are in some cases formed by dykes of diabase, which has been more resistant to the erosion than the argilaceous shists and lime-stone, but they may also, as in Figs. 17 and 18, consist of the same kind of rock as the inner part of the ledges. In the nab in Fig. 18, there is relatively much lime-stone.

These ledges have obviously been formed by shore erosion by frost, in a similar manner as that described on the preceding pages. When the fjord was covered by ice in the early winter, as it always used to be except in late years when the fjord is kept open by ice-breakers, the ledges were covered by thick layers of ice formed at high water. When this ice melted, all fissures and depressions of the rock surface would be kept filled with water, which would freeze and disintegrate the rock at each frost.

The argilaceous shists and shales are easily denuded in this manner. The nodules of lime-stone may be more resistant, and they therefore often project somewhat above the surface of the surrounding shales.

As Fig. 17 shows, the rock of the higher parts of the ledges has the very rough surface typical for rocks disintegrated by frost. In some places where the rock surface is extremely rough the relief of the many projecting ridges and blocks may amount to nearly one metre. The edges of the projecting rocks, on the outer part of the ledges as well as further in, are but slightly rounded by the wave action, which has obviously been of very little direct importance for the original formation of these ledges. The surf at high water has, however, been of great indirect importance by washing away the débris formed by the frost erosion.

Where the ledges are low, and slope gently seawards below average sea-level, as in some part of the shore represented in Fig. 18, the solid rock-surface is more or less covered by a layer of stones of different sizes. It is possible that the wave erosion may here have denuded somewhat the outer part of the ledges. The stones are rolled up and down the beach by storms from the south and south-east, which always cause high-water and may have great effect by a vigorous surf. The rock-surface of the lower levels show indications of wave erosion, though it has also to some extent been disintegrated by frost.

The stones have obviously been broken loose from the solid rock by frost disintegration. There are all stages from a great number of angular stones recently disintegrated, and consisting to a great extent of diabase, to rounded, wave-worn pebbles, which greatly consist of the more resistant parts of the argilaceous shist, especially the calcareous nodules.

These ledges have been developed in recent time after the land had been elevated very nearly to its present shore-level; and there has obviously been no appreciable elevation of the land after their formation. The surface of the ledges shows no traces of glacial erosion, but the surface of dykes of diabase in several places projecting in the shore-line at the outer edge of the ledge is rounded and striated by glacial erosion, and so is the upper surface of the dyke of diabase to the right in Fig. 17, forming the cliff backing the ledge. The low skerry seen in the background, behind the bath-house to the right, is also rounded and striated by glacial erosion.

In many other places along this shore one also finds rock-surfaces, chiefly of dykes of diabase, which are rounded and striated by glacial erosion. They are sometimes situated near sea-level outside the shore-ledge, and sometimes above it.

This shows that the rocks of the shore had been scoured and rounded by the glaciers of the last glacial period, before they were attacked by the shore-erosion, after the shore had been elevated to its present level. The argilaceous shists were then easily disintegrated by frost, and were cut back by the shore-erosion, while the dykes of diabase were much more resistant. The ledge illustrated in Fig. 17, was cut back till the erosion stopped against the nearly vertical wall of the dyke of diabase to the right in the picture. This wall rises about 1.7 metre above the floor of the ledge. The level upper surface of this dyke is about 2.2 metres above the sea, and seems to be part of a shore-ledge formed before the last glacial period. A little further inland there is a higher ledge at about 3.1 metres above the sea, which is 40 to 50 metres broad, and partly cut in solid rock, partly formed of loose material.

In the region of Fig. 18 there was no dyke of diabase to stop the shore erosion, and the shore-ledge has here been cut back about 18 metres to the foot of the cliff of argilaceous shist, which in some places is nearly vertical, 4 to 6 metres high and even 10 to 12 metres high.

In one place (at Godthåb) there is a broad dyke of syenite-porphyry along the shore, in which the shore-ledge has been cut, and it is to some extent backed by a cliff of argilaceous shist. This porphyry is traversed by numerous fissures and was easily disintegrated by frost.

The effect of the shore erosion differs much with the height above sea-level. At the lowest levels of the shore, where the rocks emerge only at low water, the recent shore erosion has been insignificant. One may even find rocks of argilaceous shist scoured by the glaciers, which have kept their rounded polished surface, where the glacial striation is still visible. The reason is obviously that the rocks at these low levels have been protected by the water against the disintegration by frost, while the wave-erosion has had no appreciable effect. They are a convincing demonstration how the former process has been essentially more effective than the latter one.

The disintegrating effect of alternate thaw and frost may be most vigorous just above average sea-level, where ice is formed at high-water, but where the freezing of the water during frost is not too frequently disturbed by submergence. The shore-ledges have therefore been developed at this level.

In some places the ledges are, however, as much as a metre, or even 1.3 metre, above average sea-level, and are rarely submerged. It is therefore a question whether the shore may not have been slightly elevated since their formation. If so it can, however, only be a fraction of a metre.

These ledges on the Fornebo Peninsula demonstrate on a small scale very clearly how the shore erosion by frost, assisted by the wave action, works, and how it is able, in relatively short time, to cut fairly broad shore-ledges. The planing effect of this erosion may differ much according to the resistance of the rocks and other circumstances. The result is an often very uneven rock surface, varying somewhat in height in different places. We cannot therefore expect that a plane of abrasion thus formed, will ever become quite level.

If W. C. Brøgger [1905] is right in assuming that the coasts of Christiania Fjord were still rising during the first part of the Bronce-age, but attained their present level towards the end of that age, we may assume that the ledges of the present shore of the Fornebo Peninsula have had about 2500 years for their formation.

The ridges along the outer edge of the shore-ledges, rising above their inner floor, which are so conspicuous on the ledges in Kvænangen Fjord (Fig. 16) and of which there are also traces on the ledges of the Fornebo Peninsula (Figs. 17 and 18), appear to be a common feature on shore-ledges formed by frost erosion. They occur frequently on the lateglacial and postglacial raised beaches of Norway, where especially O. E. Schiøtz [1894] has called attention to them. They are also mentioned by other

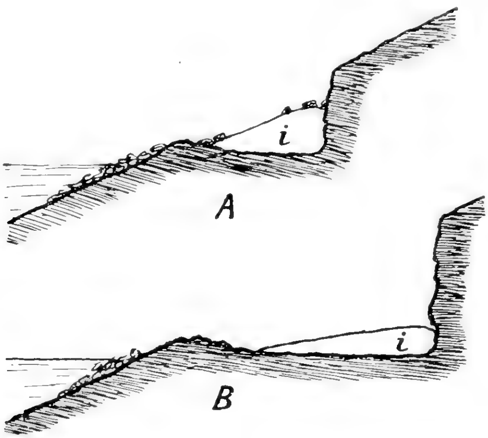


Fig. 19.

writers. J. H. L. Vogt and J. Rekstad [Vogt, 1900, p. 73] state that near the outer edge of the shore-ledges in Helgeland, 10 to 20 metres broad or more, rocky nabs frequently rise one or two metres above the general floor of the ledges (*e. g.* on Leka in Helgeland). They are obviously formed by the greater effect of the disintegration by frost on the inner part of the ledge, where the accumulation of ice and snow remains longer, while it is more easily washed away by the waves along the edge. On the inner part of the ledge the accumulation of ice and snow (Fig. 19, i) may thus erode the rock down to a lower level without being disturbed by the waves, as is demonstrated in Fig. 19, A and B.

The raised beaches of Norway have obviously, as a rule, been formed by shore erosion by frost, in a similar manner as the strandflat, but during relatively short periods.

Already Feilden and De Rance [1878] pointed out very clearly the great importance which the disintegration by frost and the ice-foot must have had for the formation of the many raised beaches or shore-ledges in Arctic regions.

Blytt [1881] considered the elevated shore-lines to have been formed by the freezing of the sea-water in regions with a great range of the tide.

H. Knutsen [1889, p. 249] thought that the shore-lines were chiefly formed by the transport of the ice-foot (see above), and J. H. L. Vogt joins this view [1900, pp. 75 f.; 1907, p. 25], he also thinks that the disintegration by frost in the shore is of great importance.

O. E. Schiøtz [1894] maintained that the raised shore-lines have been formed by the disintegrating effect of the frost, and also by the transport of mineral material by the ice formed on the shore-ledge. He pointed out that sea-ice must have less erosive effect than fresh-water ice, because the sea-water does not expand so suddenly when freezing as fresh-water.

P. Schei [1904, p. VIII] strongly maintained that the ice-foot, in Ellesmere Land up to 100 metres broad, was of the greatest importance for the formation of shore-lines.

Thoulet has mentioned the erosive effect of the freezing sea-water on the shore-line in Newfoundland.

J. Rekstad [1907, 1916] maintains that the elevated shore-lines have been formed by frost and the ice-foot, and by the transport of stones with this ice-foot when loosened.

He also points out that there are often small cirque-like depressions in the mountain slope, above the raised shore-lines, and the thinks they have been formed by small cirque glaciers [1916, p. 16].

Some writers have held the opinion that the raised beaches should have been formed chiefly by the erosion of drifting ice. Judging from my observations of the effect of the drifting ice on Arctic shores, I hold it for impossible that shore-ledges can be formed in this manner. The drifting ice has in fact an insignificant erosive effect. During ice pressures the ice-floes may be piled up against the shore, and may push up stones and gravel on to the beach, but will have very little effect upon the solid rock. The transporting effect of this drifting ice is also insignificant, except that it may transport detritus and gravel carried down on it by water or small snow-slips from the shores, or it may occasionally carry stones enclosed by freezing.

It has also been maintained that the raised beaches have been formed by wave erosion; but we have already seen that the waves work extremely slowly on the shore, compared with the frost. The wave action is, however, of much importance for the formation of the shore-ledges, by washing away the débris formed by the frost erosion. But in some places where the coast is open and the surface water of the sea is salt, the wave action may have been a hinderance to the development of the shore-ledges by washing away the ice and snow on them. This may especially have been the case in postglacial time when the climate was less severe.

On the other hand, the waves will have a greater erosive force on exposed coasts. But as the wave erosion will attack a vertically more extended surface of the shore cliff than does the shore erosion by frost, it will not cut a sharply marked incision in the mountain side, as has been pointed out by T. Vogt [1917].

Thus we may have an explanation why raised beaches are less conspicuous and seldom observed along the open coasts of Norway, while they are often very conspicuous in the fjords and sheltered sounds, especially in northern Norway, where the climatic conditions have been favourable for their formation. The lower salinity of the surface layers of the sea in the fjords and sounds may also have been of some importance in this respect.

A striking difference between the strandflat and the ledges of the raised beaches, besides the difference of extension and width, is that the latter are tilted, having always a dip seawards, while the plane of the strandflat is very nearly horizontal. It is obvious that the strandflat is a formation that has been developed during long periods when the shore-line was standing at a very nearly stable level, while the ledges of the raised beaches have been formed during relatively short periods when the shore-line had only temporary levels.

VI. THE DEVELOPMENT OF THE NORWEGIAN STRANDFLAT.

It seems to be probable that the shore-ledges have been formed by the same process as the strandflat, and that they are in a way embryonic strandflats, that might have developed into more mature ones, if they had been allowed the necessary time.

But how may these narrow ledges develop into the broad planes of the strandflat?

The wave action is obviously of much importance for this development. While the frost is disintegrating the rock by the alternate melting and freezing of ice and accumulated snow above the average high-tide level — widening the ledges into broader benches and at the same time lowering their floor — the waves attack the outer edge of the benches, assisted to some limited extent by the frost, and in the length of time they will manage to wear down this edge, even below low-tide level, and will thus get access to the inner floor of the benches. There may here be plenty of débris and loose stones for the surf to work with, rolling them forwards and backwards, and thus gradually wearing down the outer part of the benches, and make them slope gently into the water, in the manner which may be studied on a small scale on the shore-ledges of the Fornebo Peninsula (cf. Fig. 18).

In this manner the sea, headed by the sharp teeth of the frost of an Arctic climate, and following with the roaring surf, may eat itself landwards and create a gradually broadening low and flat shore-plane, sloping very gently seawards, and with its inner part emerged above high-tide level. Landwards this plane will be bounded by a more or less vertical cliff, continually retreating before the attack of the frost.

When the shore-plane attains a certain width, the waves may lose their force in the shallow water over the outer submerged part of this shore-plane, before they reach the emerged shore, and their kinetic energy will then to a great extent be expended in transporting the gravel on the flat sea-floor [cf. Nansen, 1904, p. 182]. But by so doing they will erode the sea-floor, and will continue to do so as long as the shallowness of the water prevents them from attacking the emerged shore with their full energy. Thus both processes, the horizontal shore erosion by frost and waves, and the vertical wave erosion on the submerged part of the shore-plane, will go on simultaneously, and will continue their gradual march landwards.

This is the probable genesis of the typical Arctic shore, which we find in many regions where the sea-level has remained fairly stable for a sufficiently long time. I may instance the north coasts of Russia and Siberia.

Wilhelm Ramsay describes [1900, pp. 59 f.] an illustrative example of such a flat shore formed at present sea-level on the northern coast of the Ribachi Peninsula (Fisher Peninsula, Murman Coast). This shore-plane (Fig. 20) is emerged at low-tide to a breadth of 50 metres, and is cut in black clay-slates, which is easily disintegrated by frost. This coast has a severe climate, but is at the same time exposed to the violent surf of the open and stormy northern ocean.

Although the frost is the chief causal agent for the formation of the shore-ledges, the aid of an effective wave erosion is thus necessary in order to develop these ledges into broader shore-planes, because on the one hand the waves must wash away the débris of the frost erosion, and on the other hand they must denude the outer part of the planes sufficiently to get access to their inner parts.

Though the shore-ledges may be easily formed in fjords and sheltered sounds, it is thus obvious that the best conditions for the development of extensive shore-planes must be along the open, outer coast, exposed to the full force of the wave action of the open sea, and where also the land generally is lowest and most dissected into islands, so that there is much less rock to be cut away.

The rate of the wave erosion increases very much with the storminess of the sea, it being proportional to something between the *third* and the *sixth* power of the velocity of the wind [cf. Nansen, 1904, pp. 181 f.] provided that the latter has a steady landward direction.

Thorolf Vogt, in his valuable paper on recent shore-ledges [1917, p. 121], has already given expression for a view of the formation of the strandflat which is similar to what has been here described. He says: "The forces developing shore-lines, work qualitatively very sharply limited without removing very much rock, while the surf combined with frost disintegration removes much greater quantities of rock without working so sharply limited as to level. Where there is a vigorous surf in connection with an intense disintegration by frost the necessary conditions prevail for an abrasion of great dimensions, and this may be the point of view from which one has to consider the development of the strandflat."

In the above discussion of the development of the strandflat by the joint action of frost disintegration and the breakers, the sea-level was supposed to remain stable. If, however, the coast be slowly submerged during this process, it is obvious that the frost disintegration as well as

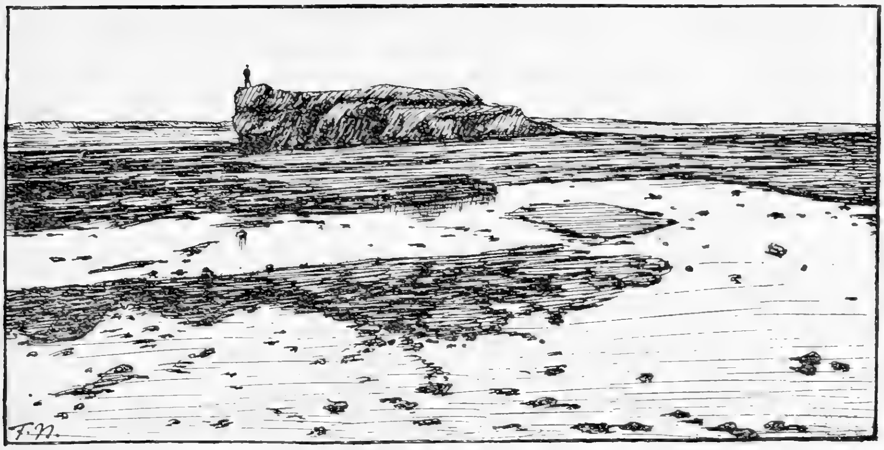


Fig. 20. Shore-plane formed at present sea-level, on Ribachi Peninsula. The picture is taken at low water [after W. Ramsay, 1900].

the wave erosion on the shore may be much increased horizontally. The sea will then get freer access to the shore-ledge. It will gradually raise the level of the disintegration by frost, and the breakers will reach the actual shore with greater force, less energy being expended in deepening the submerged part of the shore-plane. Hence the combined erosion of the frost and the breakers may advance landwards at a greater rate. The result will be a wider but more sloping shore-plane. The effect of the erosion will be extended more horizontally, but the vertical erosion will be less.

If the coast be slowly emerging during the process, the result will be the opposite. The effect of the combined erosion will be extended less horizontally, and more vertically. It will lower the seaward part of the shore-plane, and the result will also in this case be a more sloping plane, but narrower, standing on the whole at a lower level.

During those periods when, according to my view, the Norwegian strandflat was mainly developed, the sea-level was for a long time fairly stable, or the coast was being quite slowly submerged, owing to the weight of the accumulating ice-caps (cf. infra). During the periods of emergence of the coast, after the ice-caps had been removed, the land was much submerged. Then the raised beaches were formed, while the strandflat was lying below sea-level. The climatic conditions may then, to a great extent, have been less severe and less favourable for the shore erosion by frost.

The ability of the shore erosion, described above, to develop a strandflat along a coast, will depend on the relative length of the shore-line and on the heigth of the land (*i. e.* the quantity of rock to be removed), not considering the power of resistance of the different kinds of rock.

Along a relatively undissected and high coast the effect of the shore erosion in this respect, will be very little, and unless the rocks be very weak, it would hardly be able to form a strandflat of much width, even though it could work during the longest geological time we might possibly imagine.

Along a much dissected coast, like the west and north-west coast of Norway, the conditions are, however, entirely different. The length of the shore-line has been enormously increased, the islands and peninsulas will be attacked by the shore erosion from all sides, and its effect will be increased accordingly.

Moreover, along this dissected coast the greater part of the denudation towards sea-level has already been accomplished beforehand by the subaërial denudation and the glacial erosion, which have worn away enormous quantities of rock, and there is comparatively little work left for the shore erosion, in order to plane off the small and low islands and peninsulas more or less to sea-level, and thus form the strandflat; especially as during the cold periods, when this plane was in my opinion mainly given its present flat surface, the atmospheric weathering and the local glacial erosion by frost denuded the surface of the dissected coast land vigorously.

On the greater and higher islands, or where the rocks were more resistant, it would take longer time for the shore erosion, assisted by the atmospheric weathering and the local glacial erosion by frost, to denude the land to sea-level. In such places mountains or smaller knolls and ridges may still be left, surmounting the level of the strandflat, often as isolated stacks or 'monadnocks'.

The result of the whole process, gradually developing the planes of the strandflat by the erosion of the shores of the islands, will be that a quite common shape of many islands and even of small skerries, is more or less similar to that of a hat swimming on the sea with the brim near sea-level and a rounded crown forming the central part.

When was the Norwegian Strandflat developed.

The conclusions arrived at on the preceding pages regarding the mode of formation of the strandflat, make it probable that the Norwegian strandflat has been developed to its present form chiefly before and during the quaternary glacial periods.

We do not know what the climatic conditions may have been along the coast of Norway in late tertiary time, and whether they may have been favourable for an active shore erosion by frost, so essential for the formation of a strandflat. This is, however, hardly probable, as the climate may have been too mild.

Towards the beginning of the first quaternary ice age, the temperature sank, and a more effective shore erosion began when frosts became more frequent. As time went on the climatic conditions grew more favourable for the shore erosion by frost, and at the same time the subaërial denudation became more effective, as the disintegration of the rocks by frost increased. Provided that the level of the shore-line was then approximately the same as during later interglacial periods, a more active formation of the strandflat may have begun.

But as the coast had not yet, at that time, been dissected by the glacial erosion, it is hardly probable that the development of the strandflat could make much progress.

After the valleys of the coast had been deepened by the erosion of the Great Ice Age, and the coast land had been dissected by the numerous deep fjords and channels, intersecting the coast and splitting it up into the many islands and peninsulas the conditions were essentially changed, as has been pointed out on a preceding page. It therefore seems probable that the Norwegian strandflat has chiefly been developed to its present shape after that time.

It is possible that in interglacial times there may have been periods with climates sufficiently severe for shore erosion by frost so essential for the formation of the strandflat; but the climatic conditions preceding, accompanying, and succeeding each glacial period were especially favourable for this erosion. At the same time the subaërial denudation of the outer coast land was also very effective.

For the development of the strandflat it was, however, also essential that the shore-line was stable during long time and standing at or near the level of the strandflat. This was probably the case during a great part of the interglacial times and at the beginning of the glacial periods, while during the glacial periods the land was gradually depressed by the weight of the growing ice-caps, as was pointed out above. The strandflat cannot therefore have been developed during the late part of the glacial periods or during the time of submergence after these periods, even though the ice had retreated from the outer coast. The development of the strandflat could not begin until the land had again been elevated nearly to its normal level. But at that time the climatic conditions would not, as a rule, be favourable for the shore erosion by frost.

We are thus lead to the conclusion that the strandflat has been developed chiefly during interglacial periods with cold climates, and especially during the very cold time preceding each glacial period, and during its first part, before the outer coast was covered by the inland ice, and as long as the level of the shore-line still remained nearly stable.

This may have lasted some time, because the level of the ocean was lowered by the accumulation of water in the ice-caps on land. The gradual sinking of the land caused by the growing load of the ice-cap, may thus for a long time have been more or less counterbalanced by the sinking of the shore-line. It should also be considered that the depression of the land began in its interior parts where the ice masses first accumulated, and did not extend to the outer coast before after some time. During the last glacial period some part of the outer coast was probably never depressed, as will be mentioned later.

We do not know how many quaternary ice ages there have been in Norway. But if there have been only two, as is generally assumed, we are lead to the conclusion that the present plane of the strandflat has been developed chiefly during the cold time preceding the last glacial period, while its formation may already have begun during the time preceding the first, great Ice Age. There are, however, indications which, according to my view, make it probable that there have been several glacial periods in Norway, and that the strandflat has been developed during several different periods, as will be mentioned later. We must then assume that during each interglacial time the ice-caps of Norway have almost entirely disappeared, so that the coast has been able to rise to its normal level at which the strandflat has been developed. Oxaal [1914, pp. 42 f.] has maintained that there were three glacial periods in Norway, and that the upper level of the Norwegian strandflat, in about 40 to 50 metres above sea-level, has been planed by marine abrasion during the first interglacial period, while the planes of the lower levels of the strandflat, in about 10 metres or even less above the sea, have been developed during the second interglacial time. My investigations have lead to similar conclusions, which will be mentioned later, after the observations and measurements of the strandflat in various regions have been described.

Some writers have maintained that the strandflat must have been formed before the fjords, because there are no traces of a strandflat along the coasts of the latter. The answer is: *Firstly*, that there are actually strandflats in the fjords, not only in their outer parts where there are often beautifully developed planes, *e. g.* in the mouth of the Hardanger Fjord; but there are small strandflats also in their inner parts, as will be described later.

Secondly, the shore erosion will need a relatively very long time for the development of a strandflat in most fjords, especially in their inner parts, because the fjord sides are as a rule very steep and high, and consist of resistant rocks.

Thirdly, the fjords have been much excavated and deepened by the glaciers during each glacial period, and the strandflat along their sides would then be more or less obliterated by this erosion, especially in the inner parts of the fjords.

Fourthly, if the strandflat was to some extent developed during the first part of each glacial period, before the land was too much submerged — the inner parts of the fjords were then soon filled with glaciers, while the planing of the strandflat may still have continued along the outer coast.

The fact that nevertheless small strandflats do occur along the inner coasts of the fjords, is a convincing evidence that the fjords had been formed before the strandflat was developed.

The Height of the Norwegian Strandflat.

Several writers, like J. H. L. Vogt, Thorolf Vogt, and A. G. Høgbom, make the height of the inner margin of the Norwegian strandflat, at the foot of the steep mountains, especially in Helgeland and Lofoten, to be near 40 metres above sea-level, Oxaal says between 40 and 50 metres, perhaps nearest the former height, while H. Reusch and Andr. M. Hansen put it at 100 or even 120 metres. The reason why the latter writers have got such great heights is obviously that they have taken the benches of raised beaches as belonging to the strandflat.

As was pointed out on p. 42, there is, however, this striking difference between the strandflat and the raised beaches, that the planes of the former are very nearly horizontal and have obviously been developed during times with a more or less stable sea-level, while the raised beaches are tilted and have been formed during periods of submergence of the land, when the shore-line was staying at temporary levels for relatively short periods. It ought therefore to be sharply distinguished between the two kinds of formation, although they are formed more or less by the same process of erosion; and may often lie nearly at the same levels.

But even if we stick to the planes of the real strandflat it may be difficult to determine the exact height of their upper limit because, on the one hand, this limit between the strandflat and the steep mountain side is not often very sharply marked, as the upper planes of the strandflat are old formations, which have been much modified and dissected by later glacial erosion, and on the other hand, the level of the shore-line has not remained quite stable during the development of the strandflat, and its planes are obviously formed at somewhat different levels. Amongst other things it may then to some extent depend on the resistance of the rocks which plane has become most conspicuous.

Nevertheless there is a fair agreement between the estimations of most writers of the height of the upper limit of the strandflat, but at the same time distinct lower planes of the emerged strandflat have also been described. We shall return to this subject after our investigations of the strandflat have been described. We will then also have to consider another question: Why it is that these nearly horizontal levels of the strandflat are now raised above present sea-level?

The partial Absence of a Strandflat along some Parts of the Norwegian Coast.

A difficult question of much interest is: Why there are so great differences in the development of the strandflat along the various parts of the Norwegian coast?

While the high and steep west coast of Norway has a well developed and broad strandflat, in some places nearly 40 kilometres broad, there are, for instance, only slight indications of such a formation along its southern and south-eastern coast, although the land is there very much lower, sloping gently towards the coast, and there would consequently have been much less rock to denude in order to form a strandflat.

As far as I can see, one main reason may have been that during the cold interglacial periods, when the strandflat was to a great extent developed, the climatic conditions were much less favourable for the shore erosion by frost along the south and south-east coast of Norway than they were further north, and therefore the strandflat could not be developed to any considerable extent in those southern regions. It is the same reason why in postglacial time, shore-ledges, cut in solid rock by shore erosion by frost, have been so well developed in northern Norway while they have not been formed along its southern coasts.

In the inner part of Christiania Fjord, where there was more of an inland climate with colder winters, a strandflat has been developed, as will be described later.

During the glacial periods the climatic conditions may have been favourable for the shore erosion also in southern Norway, but then the south and south-east coast was relatively soon submerged, while the outer west coast was only slightly submerged, if at all. As Andr. M. Hansen [1895] has already pointed out, the south and south-east coast was also soon covered by ice, and during most part of the glacial periods there was no border of bare land similar to that existing outside the fjords of the west coast.

There is still the possibility that the big glacier that filled the submerged Norwegian Channel round along the coast, and excavated it to depths of 500 and even 700 metres below present sea-level, may also have eroded the outer part of the coast, and may more or less have cut away parts of any strandflat that had been developed, provided that there have been several ice ages, when the Norwegian Channel was filled by a big glacier.

It is, however, much more difficult to account for the absence of a strandflat, near present sea-level, along the coast of Finmarken. In this region the strandflat suddenly ends, just with the extension of the igneous and possibly Archæan rocks outside Ringvadsøi, Rebbenesøi, Grotøi, and northern Kvaløi. These islands consist of igneous and so-called Archæan rocks, extending north-eastwards along the coast from Vesterålen and Senjen. Outside these islands as far as north of Kvaløi, there is a submerged strandflat with a great many skerries, sunken rocks, and shoals. But north-east of Kvaløi this strandflat suddenly ends. Vannøi, east of Kvaløi consists partly of sedimentary rocks (schists) and partly of 'Archæan' rocks. Fugløi, east of Vannøi consists entirely of schists. North of these two islands there are some scattered submarine platforms with sunken rocks and shoals (in 70° 36′ N. Lat.), which may be considered as belonging to the strandflat, and which are probably built up of harder 'Archæan' rocks [cf. Nansen, 1904, pp. 42, 117 ff.].

East of this region, which coincides with the western boundary of Finmarken, the typical strandflat, near present sea-level, entirely disappears. The outer coast is here chiefly built up of sedimentary rocks and crystalline schists, less resistant to shore erosion than the igneous and so-called Archæan rocks to the west and south-west. The coast suddenly changes character at this boundary line between the geological formations. There is no typical 'skjærgård' along the Finmarken coast; only in some few places, round Ingoi and outside the north-west corner of Mageroi, where more resistant 'Archæan' rocks occur, are there indications of a 'skjærgård' and a strandflat at sea-level.

The only explanation I can find of the absence of a strandflat, near present sea-level, along the coast of Finmarken, and of the remarkably close relation of this absence to the change in the geological structure of the coast, is that the sedimentary rocks and schists of Finmarken have offered relatively little ristance to the vigorous shore erosion of this northern region and to glacial erosion. During periods with a low shore-line, the rocks of the outer coast have therefore been denuded to deeper levels. They have also been cut away by glacial erosion.

The outer coast of Finmarken is to a great extent very steep and precipitous, forming high shore cliffs, with much oversteepened, sometimes almost vertical mountain walls, often some hundred metres high. This is especially the case in East-Finmarken where the coast consists chiefly of series of dolomite-bearing sandstones and shales of great thickness [cf. O. Holtedahl, 1918]. This coast has obviously got its typical configuration by a vigorous and very effective shore erosion. If in this region the formation corresponding to the strandflat along the Norwegian coast to the south-west occurs, it may therefore be looked for at lower levels, below the sea-surface, where submerged platforms actually occur at depths of between 40 and 90 metres [cf. Nansen, 1904, pp. 117 ff.]. It may, however, be difficult to distinguish between these platforms and the inner part of the continental shelf.

It is obviously a general feature that coasts built up of relatively weak rocks, offering little resistance to shore erosion, never have a typical 'skjærgård', while this formation always occurs along coasts consisting of harder Archæan or igneous rocks, and formerly exposed to glacial erosion.

As examples of coasts without a 'skjærgård' besides Finmarken, I may mention the coasts of Bear Island, Spitsbergen, and Iceland. These coasts are mostly built up of rocks which offer relatively less resistance to shore erosion, such as sandstones, shales, dolomite, limestones, basalts, etc. But wherever harder igneous rocks occur, there are generally indications of a 'skjærgård', *e. g.* outside the north-west corner of Mageroi, at the northwest corner of Spitsbergen, in the region of North Cape on North-east Land and the Seven Islands, at the south-west corner of Barents Island, &c.

It might be objected that Franz Joseph Land, the Faroes as well as Shetland are not built up of very resistant rocks, but are none the less dissected into a great number of islands. The fact is, however, that they are not surrounded by a typical 'skjærgård', with numerous low islands, skerries, sunken rocks, and shoals, like those along the coast of Norway and Greenland.

The above mentioned coasts, consisting of relatively weak rocks, *e. g.* on Bear Island, Iceland, and the Faroes, have as a rule high precipitous shore cliffs, showing that the coasts have been exposed to a vigorous shore erosion.

By our above discussion we are led to the conclusion that the absence of a strandflat near present sea-level along the outer coast of Finmarken in northern Norway is chiefly due to a too vigorous erosion on a shore of relatively weak rocks, while the insignificant development of the strandflat along the south and south-east coast of Norway, has partly an opposite reason, a too ineffective shore erosion in regions where the climatic conditions as a rule were too mild.

Summary.

Summarizing the results of the above discussion we may describe the cycle of the formation of the Norwegian strandflat as follows:

During preglacial, probably postmiocene (or possibly still longer) time the coasts of Norway, as well as its land-surface on the whole, were much denuded by subaërial weathering and fluvial erosion. The land-surface and the coasts were to some extent dissected by fluvial valleys which may even have descended below present sea-level, on to the now submerged continental shelf the plain of which they have probably traversed [cf. Nansen, 1904, pp. 54 ff., 58, 151 f., Ahlmann, 1919, pp. 209 f.]. When these submerged valleys were formed is difficult to decide.

During a great part of this very long preglacial time the marine denudation was not by far so effective as during the quaternary glacial and interglacial periods, because probably milder climates did not favour the shore erosion by frost, at least not along the greater part of the Norwegian coast, and the marine denudation was therefore chiefly limited to wave erosion.

When the time of the first quaternary ice age approached, the climate became colder, and more favourable conditions for shore erosion by frost as well as for a more active subaërial denudation (greatly increased by frost) extended southwards along the coast of Norway. A more active development of a narrow low foreland along this coast may have begun.

An essential condition for the formation of the present strandflat of Norway did, however, not exist before the coast had been eroded and dissected by the glaciers of the Great Ice Age. The preglacial fluvial valleys were then much deepened, the coast was dissected by numerous deep fjords and channels, and was split up into thousands of peninsulas and islands, the length of the shore-line, *i. e.* the line of attack of the shore erosion, was enormously increased. The waste on the land was swept away, and bare rock-surfaces were exposed to the attack of the erosion, especially the disintegration by frost.

During interglacial times there may have been cold periods favouring erosion by frost, at least along some parts of the Norwegian coast. But especially the climatic conditions preceding and accompanying each glacial period, greatly increased the subaërial denudation as well as the shore erosion, in all regions not covered by the inland ice, *i. e.* especially the outer coastal border along western and north-western Norway. During these periods, as long as the level of the shore-line remained fairly stable, before the land was too much submerged by the weight of the inland ice, the strandflat was chiefly developed, along the much dissected coast, by the joint action of subaërial denudation, particularly by frost, and local glacial erosion on the peninsulas and islands outside the inland ice, and finally by the shore erosion by frost and wave action.

The two first mentioned processes were of main importance for the denudation of the land towards sea-level; because they attacked the whole land-surface, while the shore erosion gave the thus denuded uneven islands and peninsulas their nearly horizontal plane. By the repeated advances of the margin of the inland ice and its glaciers all waste was swept away seawards from the land, and bare rock-surfaces were exposed to fresh attacks of the erosion when the glaciers retreated.

But as the shore-line was not quite stable, at least not during some part of the time, when the final planes of the strandflat were developed — because, for instance, the sea-level was gradually lowered by the accumulation of water in the ice-caps on land — the strandflat was not finally planed at a perfectly fixed level of the shore-line. Besides this, it is also probable that when the land had again attained its level of isostatic equilibrium, after each glacial period, the shore-line may have stood at a level somewhat lower than that of the preceding interglacial time, owing to the removal of a great deal of rock material and waste by the erosion during each glacial period, as will be mentioned later.

It is not, therefore, to be expected that the strandflat as we now see it, should form one definite and sharply marked plane. The level of its surface may vary somewhat according to circumstances.

Then it has also to be considered that during each glacial period the strandflat has been largely exposed to a vigorous glacial erosion which may have modified its surface more or less, and made it more uneven.

The degree of maturity to which the strandflat may have been developed in the various regions, will naturally depend upon the time during which these various processes of denudation, especially the shore erosion, have had to work, and also upon the initial height of the land and the power of resistance of the rocks. Some islands may have been entirely levelled, others more or less, leaving higher hills and mountains in their interior parts, etc. We may therefore expect to find all different stages, from almost perfectly flat and level planes of low islands and peninsulas, to regions with more varying and undulating heights, and only some islands and peninsulas here and there have been nearly planed, or have planed borders round their shores.

As the strandflat has been eroded by glaciers, at least during one, and probably during two glacial periods, we cannot expect to find very sharp lines of demarkation between the planes of the strandflat and the shore cliffs of the surmounting ridges and stacks, as these have been rounded off by the glaciers. On Værøi and Rost in Lofoten, and probably also on Træna, the strandflat was not eroded by glaciers during the last glacial period. Hence the emerged strandflat on some of these islands is very level, but hardly more so than we may also find in other regions.

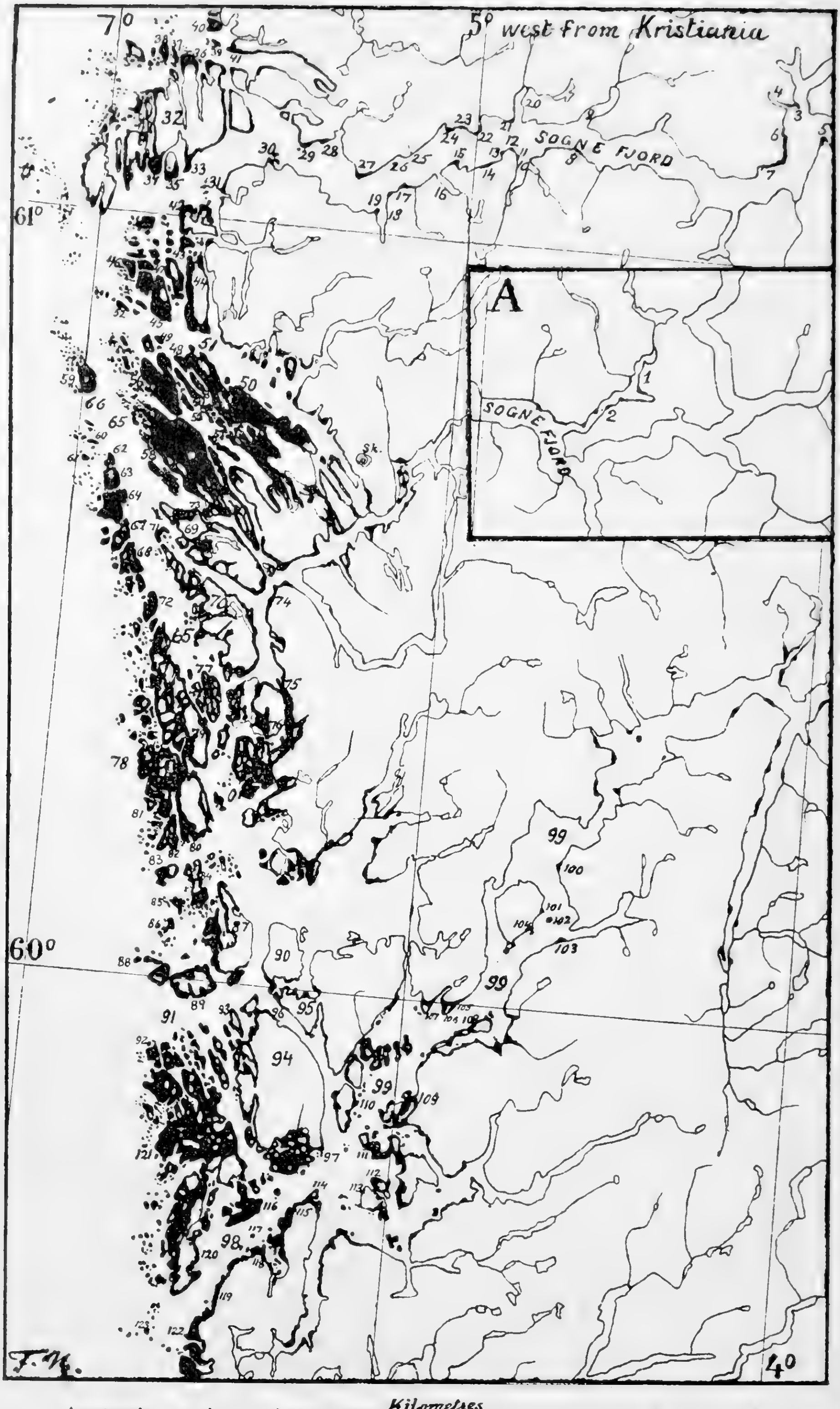
VII. THE STRANDFLAT OF THE NORWEGIAN WEST COAST FROM THE REGION OF SOGNE FJORD TO THE REGION OF HARDANGER FJORD.

The heights of the strandflat given in the following descriptions were determined by levelling. In the summer of 1911, in the Sogne Fjord, along the Norwegian coast, and on the Shetland Islands, a small levelling telescope and a levelling rod (4 metres long) were used. In the following summer, on Spitsbergen, the same rod was used, but the levelling instrument simply consisted of a U-shaped glass tube containing coloured water. Where there was an opportunity, the level was also determined by the horizon of the sea. This is not a very accurate method, but as the distances within which the measurements were made were never considerable, the final error of a levelling thus performed hardly ever exceeded a metre. If the distances are greater the use of a telescope would greatly increase the accuracy of the measurement.

The accuracy with which the heights of the strandflat may be determined, does not, however, as a rule depend on the levelling method employed. The real difficulty is in most cases to decide where the actual level of the strandflat is. Seen at a distance this level may look at if it were quite sharply defined; but coming near one often finds the surface of the strandflat to be uneven, with depressions and elevated ridges, causing doubt as to what actually indicates the general level, and whether it should be put perhaps one metre higher or lower, and sometimes even more.

As the strandflat has been denuded by glacial erosion after its final formation, it may be preferable in most cases to be guided more or less by the elevated ridges, if their summits are lying approximately at equal heights. But on the other hand, the surface of the strandflat may originally have been fairly rough, and the ridges may have been higher than the general level. It will, therefore, often be a question of personal judgement what the correct height should be estimated to be.

Another difficulty is the determination of the present shore-line on which the levelling is based. Most observers have used the upper fucus limit in the shore as a base, which may have great advantages. But this



7°
5° west from Kristiania
SOGNE FJORD
A
SOGNE FJORD
61°
60°
4°
Sk.
Kilometres
0
50
100

Fig. 21.

Fig. 21. Map of Norwegian west coast between Sogne Fjord and Bommel Fjord. The Strandflat is marked black where the author has investigated it. A is the inner continuation of Sogne Fjord. Scale 1 : 1 000 000. 1 mm. equal to 1 kilometre.

1 Sogndal Fjord. 2 Norum Fjord. 3 Tjugum. 4 Ese Fjord. 5 Vangsnes. 6 Balestrand. 7 Kvamsoi. 8 Tangen. 6 Hoiang Fjord. 10 Fuglset Fjord. 11 Ardal. 12 Holmen. 13 Akre. 14 Sorevik. 15 Matsnes. 16 Eike Fjord. 17 Oppedal. 18 Risne Fjord. 19 Brekke. 20 Vadheim Fjord. 21 Afsnes. 22 Mjelleli. 23 Torven. 24 Rå. 25 Ringereide. 26 Lavik. 27 Brendingsdal. 28 Bo. 29 Næsje. 30 Rutletangene. 31 Dingenes. 32 Inner Sulen island. 33 and 34 Two southern peninsulas of the latter. 35 Næs Island. 36 Northern peninsulas of Inner Sulen island. 37 Buskoi. 38 Færoi. 39 Sakrisoi. 40 Luten Island. 41 Skivenes. 42 Hisoi. 43 Store Vatsoi. 44 Sandoi. 45 Bjortnes Island. 46 Kversoi. 47 Grimen Island. 48 Vardetangen, northwestern extremity of Lindås Peninsula, 49 Store Tangen. 50 Lindås Peninsula. 51 Fens Fjord. 52 Rautingen. 53 Kjelgaulen. 54 Bakoi. 55 Njotoi. 56 Fosen Island. 57 Lygre Island in Lygre Fjord. 58 Radoi. 59 Feie Island. 60 Henoi. 61 Lyngoi. 62 Forhjelmen. 63 Sæloi or Hjelmen. 64 Alvoi. 65 Hjelte Fjord. 66 Fedjeosen or Fedje Fjord. 67 Bredviksoi. 68 Blomsoi. 69 Holsenoi. 70 Askoi. 71 Herloi. 72 Toftoi. 73 Gjernes on Holsenoi. 74 Salhus. 75 Bergen. 76 Nordåsvand. 77 Lille Sotra. 78 Store Sotra. 79 Litårnet. 80 Håkensund. 81 Glesvær. 82 Toftoi. 83 Kors Fjord. 84 Hundevågoi. 85 Horge Island. 86 Mogster and Akre Islands. 87 Hufteroi. 88 Fugloi. 89 Selbjorn Island. 90 Reksteren Island. 91 Selbjorn Fjord. 92 Slotteroi Lighthouse. 93 Fondoi. 94 Stord Island. 95 Tysnes Island. 96 Langenuen Sound. 97 Lervirk. 98 Bommel Fjord. 99 Hardanger Fjord. 100 Hamaren. 101 Haukanes. 102 Silden Island. 103 Ænes. 104 Akrehavn and Akreholm. 105 Ulvanes. 106 Steinane. 107 Ölve. 108 Snilstveitoi. 109 Husnes. 110 Huglo Island. 111 Hålsnoi. 112 Fjelbergoi. 113 Borgundoi. 114 Tittelsnes. 115 Valestrand. 116 Moster Island. 117 Hjartholm. 118 Ekelandsnes. 119 Nesheim and Nordbo. 120 Southern peninsula of Bomlo Island. 121 Bomlo Island. 122 Ryvarden Lighthouse. 123 Lyngsoi.

line is not always easy to determine, especially not in the fjords. The upper limit of high tide has also been used, but that is still more uncertain, as the marks of high water may be much influenced by the waves and by storms. I have, therefore, started from what I estimated to be the mean level of the shore-line, as marked by the colour of the rock-surface and by the organic life in the shore, balanes, snails, &c., and also the sea-weed. I admit, however, that this way of estimating may be more or less arbitrary, and I consider the upper fucus limit to be preferable as a base wherever it is fairly distinct.

The Strandflat of Sogne Fjord.

Along both sides of Sogndal Fjord and Norum Fjord, in the inner region of Sogne Fjord (see Figs. 21 and 22), there are very conspicuous low, flat points (promontories) and benches, being obviously parts of a strandflat, cut in solid rock at the base of the steep mountain sides. They have an equal altitude of about 10 metres above sea-level. The rocks in this region are partly crystalline schists overlying phyllite, partly gabbro.

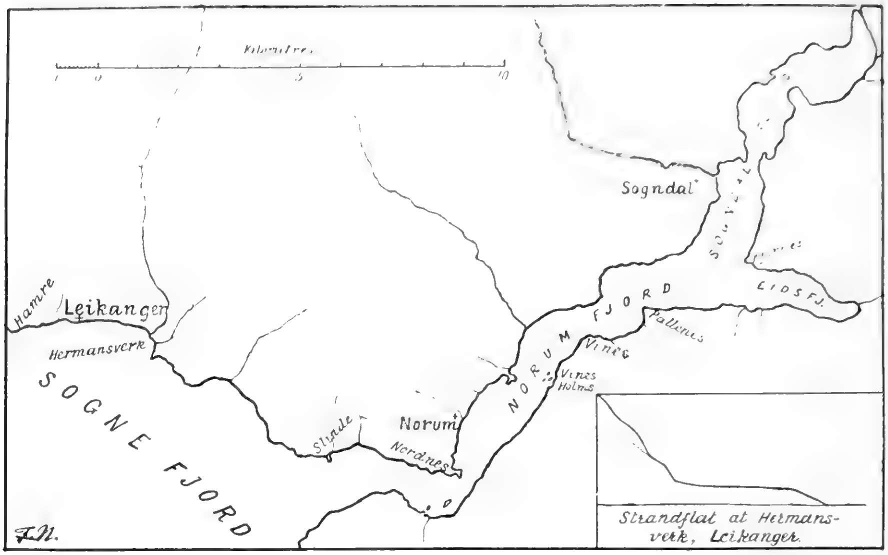


Fig. 22. Sogndal Fjord and Norum Fjord, in the inner part of Sogne Fjord.

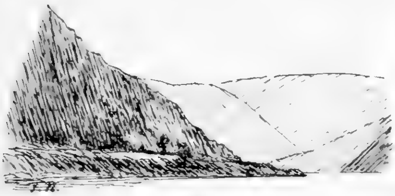
At *Kjørnes*, the flat, rocky point (crystalline schist) between Sogndal Fjord and Eids Fjord, there is a very level plane cut in solid rock, and forming a distinctly marked incision in the mountain slope (see Fig. 23). The level of its flat surface is 9.84 metres above the sea.

At *Pallenes*, in Norum Fjord (Fig. 24), a distinct horizontal ledge lies at about 10 metres above sea-level, and is the same formation as the plane observed at Kjornes. The rock is here gabbro.

At *Vines* (gabbro), farther out in Norum Fjord, a distinct plane is cut in solid rock forming an incision in the mountain slope at about the same level as at Pallenes and at Kjørnes. The small islets, the Vines Holms, outside the shore, form a continuation of this plane (see Fig. 25).

The small peninsula, on the other side of the fjord, just opposite the Vines Holms, forms a very distinct strandflat at an average level of some-

Fig. 23. Kjørnes Point, between Sogndal Fjord and Eids Fjord. Strandflat 9.8 metres above sea-level. (July 29, 1911).



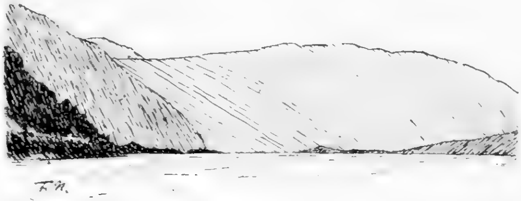


Fig. 24. Fig. 25.

Fig. 24. Pallenes in Norum Fjord. Strandflat about 10 metres above sea-level. After photograph. (July 29, 1911).

Fig. 25. Vines and the Vines Holms in Norum Fjord. In the background to the right the low peninsula at Nordnes. After photograph. (July 30, 1911).

what less than 10 metres above the sea, but the highest ridge of this peninsula approaches 10 metres.

The low peninsula (crystalline schist) at *Nordnes* (see Fig. 25) further out in the Norum Fjord, shows no distinct horizontal level, but the outermost portion which has obviously formed a round islet, has on its outer side indications of the same level nearly at 10 metres above the sea.

At *Övre Slinde* (crystalline schists), near the mouth of Norum Fjord, the level of the strandflat is 12.4 metres above the sea. Along its inner margin it forms a distinct incision in the mountain slope, indicating that its plane has been developed by shore erosion (Fig. 26).

At *Hermansverk*, in Leikanger, there is a very distinct strandflat at a level somewhat lower than 10 metres above the sea (see Fig. 22, lower right corner).

The rocky point at *Hamre* (phyllite), west of Hermansverk, shows the same distinct strandflat at nearly 10 metres above sea-level.

This strandflat at about the same level is observed on most points and headlands in this region more or less irrespective of their geological structure. Both sides of the outer part of Sogne Fjord, outside Leikanger, consist entirely of Archæan rocks.

Fig. 26. Fig. 27.

Fig. 26. Strandflat at Övre Slinde in Sogne Fjord, near mouth of Norum Fjord. After photograph. (July 30, 1911).

Fig. 27. Vegarnes in Tjugum, seen from Ekedal. After photograph. (Aug. 10, 1911).

Fig. 23. Ekedal with the tower of the church in Tjugum and the Ese Fjord behind, seen from Vegarnes. (Aug. 10, 1911).

In *Tjugum*, Balestrand, on the north side of Sogne Fjord, the strandflat is represented by the peninsula *Vegarnes* (Fig. 27) and by the flat narrow foreland (Fig. 28) on which the church of Tjugum is situated, under the steep mountain slope. In the outer part of Vegarnes there is a wide plain or level rock-surface about 11 or 12 metres above sea-level. The ridge of the peninsula reaches 25.05 metres above the sea.

The platform at Tjugum church (Fig. 28) has a level surface at about 12 metres above sea-level, but the rock rises gently higher and has its highest level near the foot of the mountain slope, at 20 metres above the sea. A projecting rock-knoll rises 3.8 metres higher, giving a total height of 23.8 metres.

The islet at *Kvamso*, between Målsnes and Kvamme, shows a distinct strandflat at between 12 and 20 metres above sea-level. The same plane is continued along the coast inwards along Balestrand, and the houses and farms are lying on this plain.

Vangsnes (Framnes), on the other side of Sogne Fjord, rises to a flat rocky plain at 25.82 metres above sea-level. But the top of the peninsula is 32.15 metres higher, at a level of 57.97 metres above the sea.

At *Tangen*, on the south side of Sogne Fjord, opposite Hoiang Fjord, there is a well-marked strandflat (Fig. 29) on which the houses are situated. The level of this plane at the houses of Tangen, was measured to be 17.2 metres above the sea. Farther to the west the plane is a couple of metres lower, whilst to the eastward there is a well developed plane 1 or 2 metres higher.

Along the coast westwards from Tangen, platforms of a strandflat occur at many places, forming often sharply marked incisions in the steep

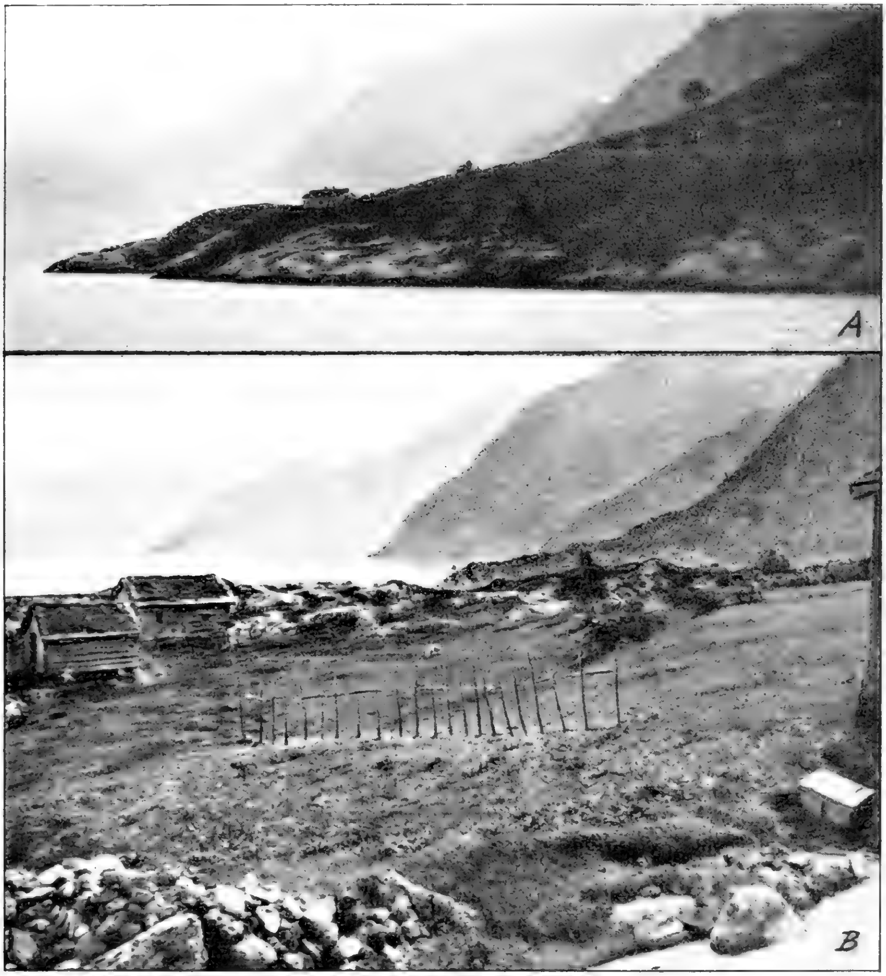


Fig. 29. Tangen on south side of Sogne Fjord. A. Seen from the sea. B. The platform of the strandflat at Tangen, 17.2 metres above sea-level. (Aug. 11, 1911).

Fig. 30. The ness at Årdal, west side of entrance to Fuglset Fjord. (Aug. 11, 1911).

Fig. 31. Strandflat at Holmen west of Fuglset Fjord. A. Eastern side. B. Western side. (Aug. 11, 1911).

mountain slope, and the strandflat is perhaps still better developed on the opposite side of Sogne Fjord, westwards from Hoiang Fjord. The farms are lying on this plane on both sides of the fjord.

Illustrations are here given of the ness or rocky point at *Årdal,* on the west side of the entrance to Fuglset Fjord (Fig. 30), of the point with sharply marked strandflat at *Holmen,* west of Fuglset Fjord (Fig. 31), and of the strandflat at *Åkre* (Fig. 32). The height of the level of the strandflat is at all these places very nearly the same as at Tangen.

Further west there were similar platforms on each ness and point, and also at some places along the shore between the points, *e. g.* at *Sørevik.*

At *Matsnes,* east of Eike Fjord on the south side of Sogne Fjord, there is a well developed strandflat, forming a sharp incision in the

Fig. 32. Strandflat at Åkre. (After photograph. Aug. 11, 1911).

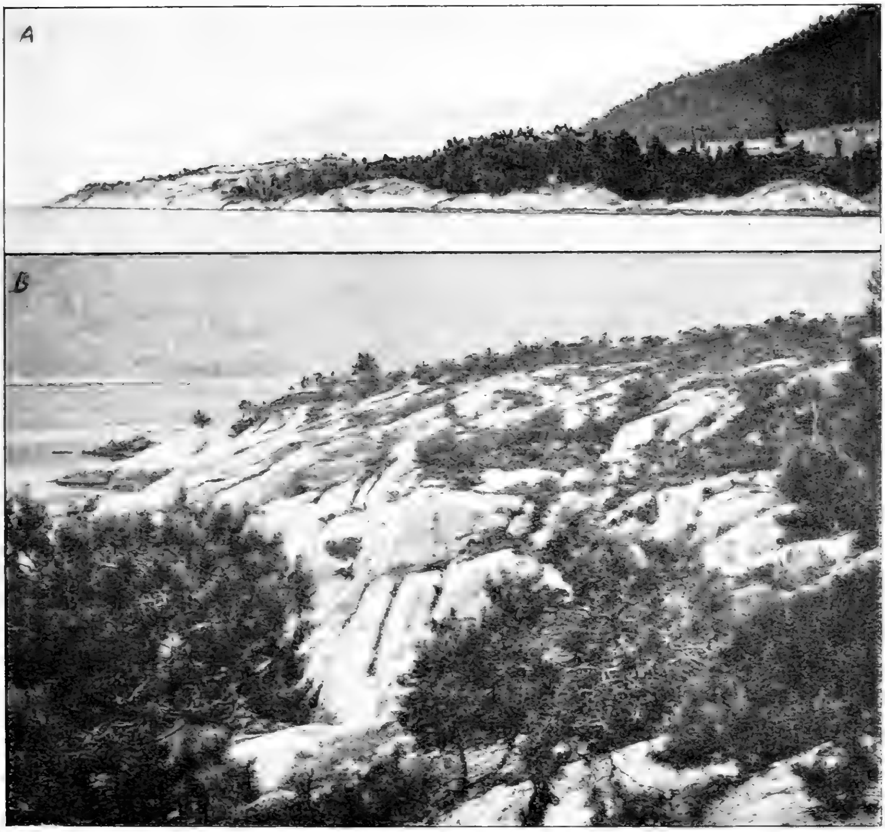


Fig. 33. Strandflat at Matsnes, east of Eike Fjord on southern side of Sogne Fjord. A. The point seen from the west. B. Surface of strandflat, looking southeastward. (Aug. 11, 1911).

mountain slope (Fig. 33). There are three low points with ridges parallel to one another. The two ridges have exactly the same level, measured to be 17.1 metres above the sea. At this height there is a distinct plane cut in the solid rock-surface. This plane lies a little lower on the westernmost point. But here a ridge rises to about 25.5 metres above sea-level. A similar ridge rises to the same level on the middle point.

The strandflat at Matsnes is relatively broad and extends a considerable distance westwards along the coast of the fjord. Its surface is scoured by glacial erosion (see Fig. 33 B). The projecting edges of the rocks are rounded on the thrust-side or eastern side, and are more angular on the lee side or western side (Fig. 33 B). But the surface has on the whole the appearance of having been originally formed by shore erosion by frost, and not by glacial erosion.

Further west at *Brekke*, west side of Risne Fjord, there is a very conspicuous strandflat forming a distinct incision in the mountain side (Fig. 34).

Fig. 34.

Fig. 34. Risne Fjord with well marked strandflat at Brekke on west side (right hand side) of entrance to the fjord. (Sketch July 27, 1911).

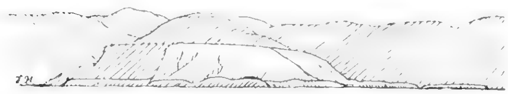


Fig. 35.

Fig. 35. Strandflat along the north side of Sogne Fjord from Vikholm and Mjelleli (to the right) and westwards past Torven towards Rå. (Sketch Aug. 10, 1911).

Fig. 36.

Fig. 36. Strandflat at Brendingsdal and Bekken, where Sogne Fjord bends northeastwards towards Lavik. (After photograph. July 27, 1911).

Fig. 37.

Fig. 37. Næsje Peninsula and Næs Holm, in Bø, on the north side of Sogne Fjord. (After photograph. July 27, 1911).

Fig. 38.

Fig. 38. Rutletangene seen from the east. (After photograh. July 27, 1911).

At *Oppedal*, between Eike Fjord and Risne Fjord, fluvial terraces have been deposited on the strandflat.

On the north side of Sogne Fjord we find equally well developed coast platforms all along the shore, *e. g.* at *Afsnes* on the west side of Vadheim Fjord, at *Torven* (Fig. 35) where there are conspicuous platforms in many places along the shore from Vikholmen and Mjelleli westwards to Vareleite, Rå and farther west at Lavik and Brendingsdal (Fig. 36). The average height of these platforms seems to be the same (about 17 metres above sea-level) as at Matsnes and Åkre on the opposite side of Sogne Fjord.

At Torven there is a conspicuous plateau, the height of which I estimated to be something like 200 metres above sea-level (see Fig. 35). At

Ringereide further west, near Lavik, there is a hanging valley at about the same height, and a mountain ridge slightly higher.

This plateau and hanging valley may possibly indicate the approximate height of an initial Palæic valley of this region, which had been developed to great maturity before the excavation of the present Sogne Fjord began.

Near the mouth of Sogne Fjord the platforms of the strandflat on both sides of the fjord become conspicuously wider and more developed than further in the fjord.

The whole peninsula at *Næsje* in Bø, with the Næs Holm outside on the north side of Sogne Fjord, is low and flat, and belongs to the strandflat (Fig. 37).

At *Rutletangene* opposite this place, on the south side of the fjord, there is an exceptionally well developed and level strandflat, on the peninsula as well as on the islets outside (see Figs. 38 and 39), and this plane is very distinctly marked as a formation different from the mountain slope inside. Fig. 39 illustrates well the evenness of the plane.

The surface of this strandflat is seen in the panorama Fig. 39 taken from a hill (28 metres above the sea) surmounting the plane. The surface is somewhat undulating with small hills or knolls. The tops of most of them are at the same level, measured to be 16 metres above the sea. Two hills farthest out reach an altitude of 20 metres. Another level at which the tops of some ridges are lying, is a little lower than the hill from which the panorama was taken; they are about 25 or 26 metres above sea-level. Only one ridge on the westernmost point reached an altitude of 32.5 metres. By far the greater part of this wide plane is, however, lying between 15 and 16 metres above sea-level. The whole surface of the strandflat at Rutletangene is well rounded by the erosion of the ice.

At *Dingenes* south of the entrance to Sogne Fjord there is a well developed and unusually level strandflat (Fig. 41). Its average altitude was measured (on Aug. 12th, 1911) to be 11.28 metres above sea-level. A round knoll rises 3.38 metres above this plain to an altitude of 14.66 metres. The surface of the strandflat is scoured and rounded by glacial erosion as seen in Fig. 42.

On the northern side of the entrance to Sogne Fjord indications of a strandflat, forming incisions in the steep mountain sides of sandstone, were observed in the sound between Inner Sulen island and Losneoi (Fig. 42 A), and well marked planes of the strandflat were observed on the two southern peninsulas of Inner Sulen and on the greater part of Næs Island (Fig. 21, no. 35) between them. A hill is rising above the level of the strandflat in the northern part of the latter island. The rock is sandstone on these islands, with a border of phyllite along the south-eastern side of Inner Sulen and the southern side of Losneoi.

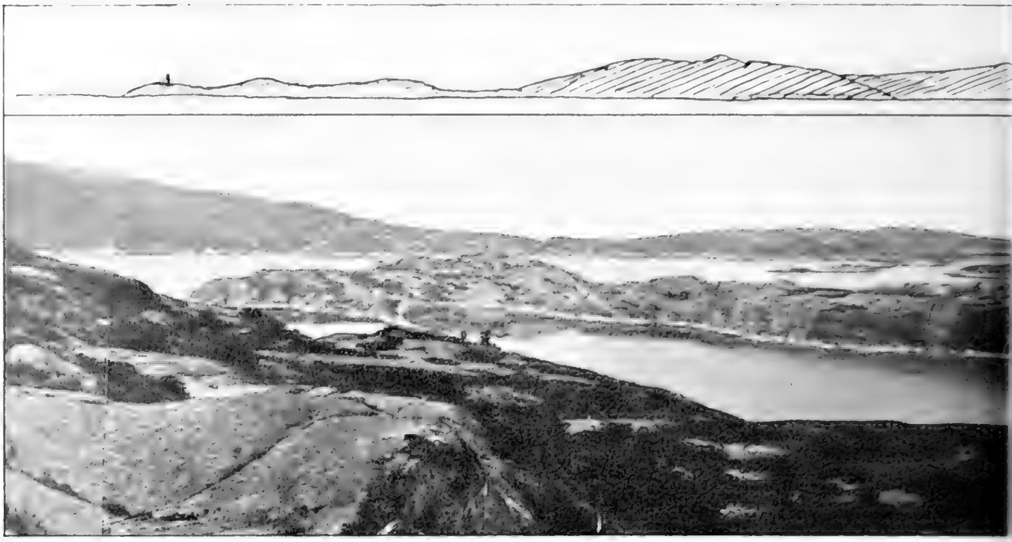


Fig. 39. Rutletangene. A. Seen from the west (Sketch Aug. 12, 19

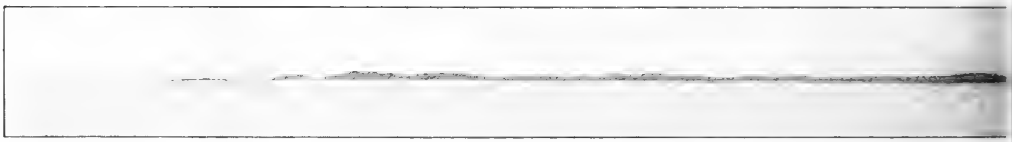


Fig. 40. The islands on the southern side of the Sogne Sea or entrance to Sogne Fjord. View t

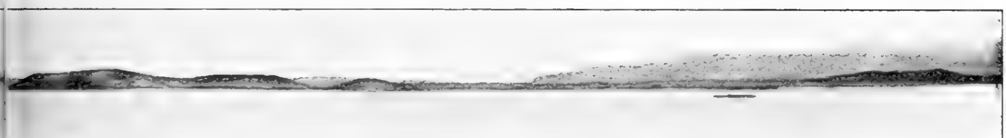
The Genetic Origin of the Strandflat in Sogne Fjord.

Along the Norwegian west coast, north and south of the mouth of Sogne Fjord, numerous formations of the strandflat were observed, perfectly similar to those which have been described above along the shores of the fjord. All these formations must obviously have had the same genetic origin, and before proceeding further in our description, let us examine what this origin might have been.

Dr. Hans Reusch has described similar low rocky benches in front of the mountain slopes along the shores of Hardanger Fjord, especially in its inner part [1901, p. 189]; but strange to say he has not observed similar features in Sogne Fjord. He states that the height of these benches is often about 20 to 30 metres. I have not investigated these formations in the inner part of Hardanger Fjord, but in the outer part of the fjord I found their height to be about 19 metres above sea-level and even more (see later). They seem accordingly to be perhaps slightly higher there than in Sogne Fjord, although I have also observed a lower level there only some few metres above the sea.

Reusch thinks that these rocky benches are remnants of the floor of the initial "Hardanger valley system" in which the deeper channel of the

hotographic view of Rutletangene and islands outside. (Aug. 11. 1911).



the sea west of the coast between Rautingen and Kversoi, see Figs. 21, 52, & 46. (July 27, 1911).

fjord has been excavated later. These benches should consequently be of preglacial origin. Reusch also points out that the strandflat along the coast outside the fjord may perhaps have been formed at the same time as this valley system.

Reusch's explanation of the origin of these benches seems to me improbable for several reasons. *Firstly* it is hardly credible that these benches and flat rocky points on the sides of the fjord could possibly have survived the violent glacial erosion by which the fjord was excavated to its present depths, 600 or 800 metres deeper.

Secondly if the strandflat along the coast outside the fjord was formed simultanuously with the initial Hardanger valley system, the floor in the inner part of that valley — in the inner part of the present fjord region, in Sorfjord — must certainly have been considerably higher than the sea-level indicated by the strandflat along the coast outside. But the level of the benches and rocky points along the sides of the inner Hardanger Fjord is no higher than the strandflat of the outer coast, and the floor of the initial valley must obviously have been lower along its middle than now indicated by these benches along its sides. In Sogne Fjord we found that the flat rocky points had even a somewhat lower height

Fig. 41. Dingenes. (After photograph Aug. 12, 1911).

than the strandflat along the outer coast. If these points and benches were remnants of an initial valley floor, formed at the same time as the strandflat of the outer coast, we would therefore have to assume that the land in the inner part of the fjord is now standing comparatively a good deal lower than the land along the outer coast.

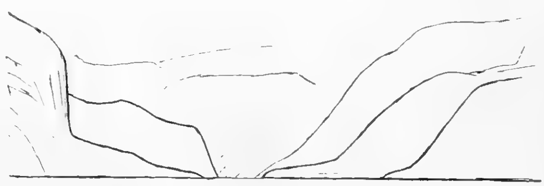
Thirdly the flat platforms of these rocky points and benches often form very distinct incisions in the steep mountain slopes on the sides of

Fig. 42. View landwards from top of Dingenes. Surface of strandflat, rounded by glacial erosion. (Aug. 12, 1911).

the fjords, indicating that these platforms and benches have been formed after the mountain slopes and not simultaneously with them. The comparatively level surface of the platforms also prove that, after their final formation, they cannot have been exposed to any very effective glacial excavation like that which gave the fjords and their sides their present main features.

There is no possibility that these low and flat points along the sides of Sogne Fjord can have been formed by glacial erosion, transforming

Fig. 42 A. Southern entrance to the sound between Inner Sulen (to the left) and Losneoi. (Sketch Aug. 12, 1911).



the projecting spurs on the sides of a valley in a manner similar to that suggested by Ahlmann [1919, p. 73, Fig. 35]. The very nearly uniform height of the points must have been determined by the sea-level at the time of their formation, while the erosion of the glaciers that filled the Sogne Fjord could not be determined by the level of the sea to any similar extent.

Without considering whether spurs may be eroded by glaciers in the manner suggested by Ahlmann, the distinct incisions frequently formed in the mountain slopes by the flat platforms of the rocky points along the sides of Sogne Fjord also prove that they cannot have been originated in such a manner.

There seems to me to be no other feasible explanation of the genetic origin of these flat rocky points and benches along the sides of Sogne Fjord, as well as Hardanger Fjord, but that they have been formed by shore erosion, chiefly by frost, and that they are formations identical with the strandflat of the outer coast. The fact that this strandflat in the fjords chiefly occurs on the rocky points and headlands, and much less along the shores between the points, is what might be expected, considering that the shore erosion by frost has a much greater surface for attack along the sides of a headland, than along the straight coast.

Summary. We may summarize our researches in Sogne Fjord as follows: numerous indications of a strandflat occur along both sides of Sogne Fjord and in its side branches, chiefly on most of the points and promontories. The altitude above the sea of the horizontal level of this strandflat varies somewhat in the different regions of the fjord, it being about 10 metres in the inner part in Sogndal Fjord, Norum Fjord, and Leikanger, about 12 metres in Tjugum and Balestrand, and about 16 or 17 metres in the outer part of Sogne Fjord from Tangen and Høiang Fjord to its mouth at Rutletangene.

A higher level of the strandflat, about 25 metres above the sea, was observed in Tjugum (on Vegarnes and at Tjugum church), in Balestrand, on Vangsnes, at Matsnes, and perhaps on Rutletangene. This is the approximate height of the inner boundary line of the strandflat at Matsnes, where it forms a distinct incision in the mountain slope.

The Strandflat north and south of the Mouth of Sogne Fjord.

North of the mouth of Sogne Fjord a strandflat was observed on the northern peninsula of *Inner Sulen*, and especially well developed on the islands Buskøi, Færøi, and Drevøi to the west. The strandflat is very conspicuous on Sakrisøi and Luten Island to the northeast of Inner Sulen, and also on the mainland at Skivenes, east of Sakrisøi (see Fig. 21). The rock is chiefly phyllitic schists in the whole of this region.

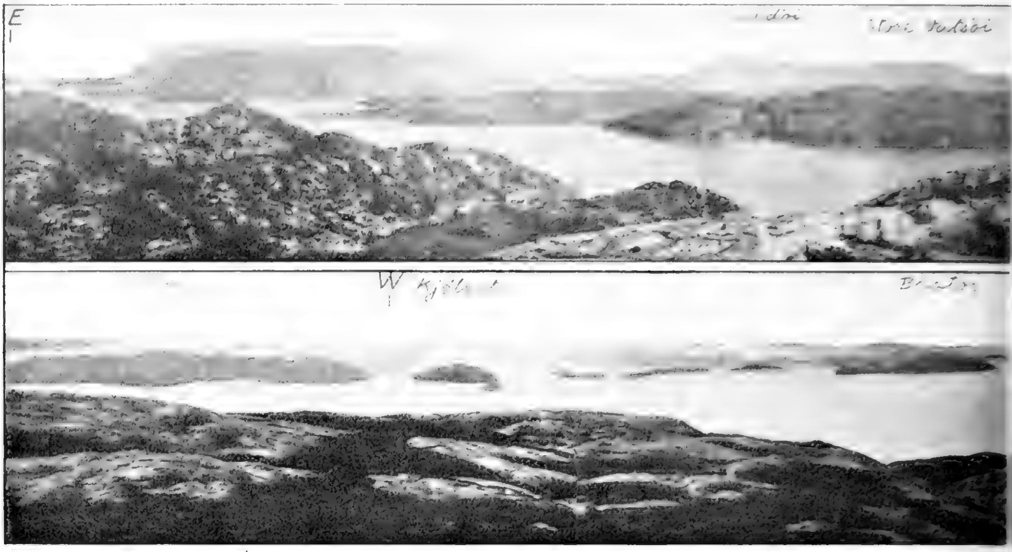


Fig. 43. Panoramic view of the islands seen between E, S, W to N from a hill, 42 metres above sea-level
upper ones a

On all the islands to the south of the entrance to Sogne Fjord the strandflat is well developed and its horizontal plane is very conspicuous.

A well developed strandflat extends along the western side of *Hisøi* (His Island, Fig. 21, no. 42) continuing southwards on *Store Vatsøi* (Fig. 21, no. 43) and other small islands, and along the western side of *Sandøi* (Fig. 21, no. 44). The rocks are here Archæan.

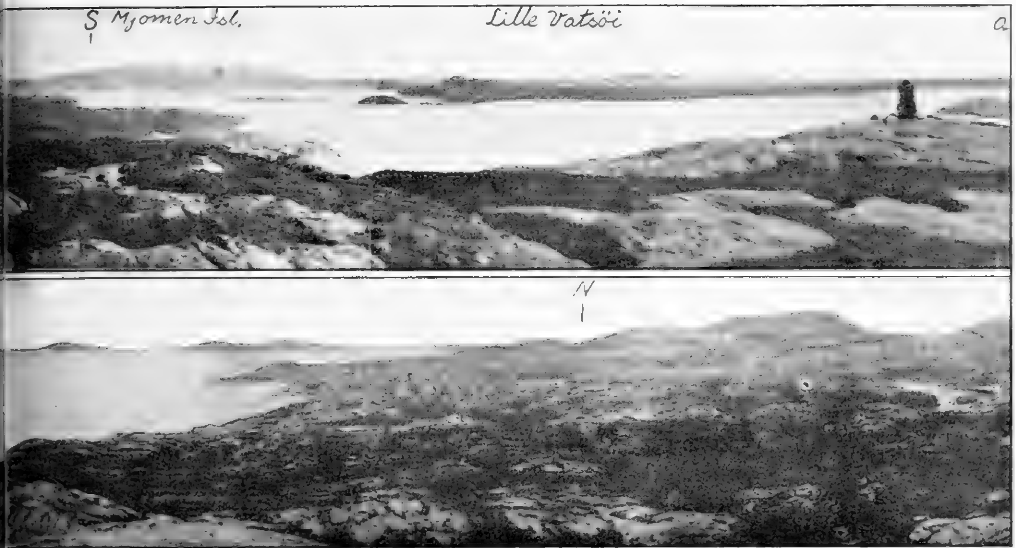
A photographic panorama of the strandflat extending over the islands in this region, was taken from a small hill surmounting the plain on *Pigenes*, on the southwestern corner of His Island. The altitude of the hill was measured to be 42.05 metres above sea-level (Fig. 43).

The altitude of the ridges of a good many islets seawards is somewhat less than 28.0 metres above sea-level, while a great deal of the other ridges approach a level of about 36 metres. Many of the highest tops of the islands rise to nearly 42 metres above the sea, the altitude from which the panorama was taken.

The strandflat cut in Archæan rocks along the western side of *Sandøi* (Fig. 44) forms a very conspicuous flat platform on which the farms are situated. I estimated its height to be about the same as that measured at Pigenes, *i. e.* between 28 and 36 metres above sea-level, perhaps chiefly about 30 metres. The steep slope of the mountain inside ascends abruptly from the nearly horizontal platform.

A great number of erratic blocks, partly very big, are scattered about on the surface of the strandflat on this island and on the other islands in this region.

All the islands west of Hisøi and Sandøi form a very conspicuous strandflat, which is a continuation of the plane extending along the



...nes, Hisoi. E, S, W, N are East, South, West, and North. Lower pictures are a direct continuation of the ...g. 12, 1911).

western sides of those two islands, and over Store Vatsoi and the other islets between them. Fig. 40 gives an impression of the flatnes of the strandflat in this region west of Hisoi and Sandoi. All the islands are very flat and low, and here are few higher hills. They consist of Archæan rocks. On *Mjomen Island* (the island between Sandoi and Bjortnes Isl., Fig. 21, no. 44 and 45) there is a mountain in its northern part, while the southern part is quite flat. On the east side of *Bjortnes Island* (Fig. 21, no. 45) a mountainous hill rises above the strandflat, which is otherwise extended over the whole island.

The whole of *Kversoi* and *Grimen Island* (Fig. 21, no. 46 and 47) form parts of the level strandflat, and so do the two *Vats Islands*, Store Hille Island, &c. north and northeast of Grimen Island and Kversoi.

The Region of Lindås Peninsula.

The strandflat continues over the many islands to the south, and is especially well developed and level on the southern side of Fens Fjord, where the rocks are chiefly crystalline schists (Ulriken gneiss) and a band of gabbro or labradorite rocks along the northeastern side of the Lindås Peninsula. On the northern side of the Lindås Peninsula the plain is extremely flat as seen from the sea (Fig. 46) with all the farms lying on it, very nearly at the same level between 16 and 18 metres above the sea.

A panorama was taken from an isolated hill on Vardetangen, the northwestern end of Lindås Peninsula, 27.25 metres above sea-level. The first part of the panorama (Fig. 45 A) begins in the north-east, looking towards the flat Håvarden Island (of labradorite rocks) in Fens Fjord

Fig. 44. Strandflat along the western side of Sandoi. A. In northern part of island, seen from Undelandssund south of Skjergehavn. B. Middle part of island. C. View northward from Fens Fjord through sound along west coast of Sandoi. (Aug. 12, 1911).

and the southern end of Sandoi in the background on the northern side of the fjord. It goes southwards with the sun to east, south-east, &c., over land consisting of Ulriken gneiss, with labradorite rocks in the far distance. The second part of the panorama (Fig. 45 B) extends over islands (of Ulriken gneiss) from south-southeast and ends in north-northwest looking towards Store Stangen in Fens Fjord. Årsoi and Bortnes Island are seen in the far distance.

This panoramic view shows that the strandflat has a remarkably uniform height in this region, which was measured to be on the average about 17 or 18 metres. The farms are lying at this altitude.

The pictures prove that the hill, 27.25 metres high, from which the photographs were taken, is higher than the plane of the strandflat on Lindås Peninsula as well as on the islands to the west.

Further south, on the Lindås Peninsula and on the islands along its western side (Bakoi, Njotoi, &c.), the strandflat has very nearly the same height of about 18 metres. The rocks are Ulriken gneiss. At *Kjelgaulen* (Fig. 21, no. 53), on the southern end of the island between Bakoi (Fig. 21, no. 54) and the northern part of Lindås Peninsula, the height of the plain was measured to be between 17 and 22 metres above sea-level. Many of the ridges were lying at a level of 28 metres, but at this height one was above the general level of the strandflat on the islands to the south. But many ridges on the islands towards the west or seawards, on Bakøi, Njotoi, and Fosenoi (Fig. 21, no. 54—56), rise to altitudes about 42 m. The ridges on the islands towards the south are on the average lower. and I looked down upon them from the height of 42 metres (see Fig. 47).

A level and well developed strandflat extends along the eastern side of Lygre Fjord over the many islands, Risoi, Lauoi, Dragøi, Bragøi. Spjotoi, &c. and along the whole of the Lindås Peninsula (Fig. 48). The rock is Ulriken gneiss in this region.

There is also a well developed strandflat on the land on the western side of Lygre Fjord, on the Lygre Islands (Fig. 21, no. 57), and on the peninsula to the south of them (Fig. 49). The level plane is sharply defined against the steeply ascending hills on the southern portion of Radoi behind.

The general height of the extremely level strandflat in the whole of this region, on both sides of Lygre Fjord and northwards towards Kjelgaulen, seems to be between 20 and 25 metres above the sea, but possibly rises slightly westwards towards the sea.

The Region of Radøi.

The conspicuously level strandflat of the northern Lindås peninsula is continued westwards over the islands Bakoi and Fosenoi (Fig. 21, no. 53—56), and southwestwards over Radoi (Fig. 21, no. 58) which is on the whole very flat, especially in its northwestern part. Fig. 50 is a view of the northwestern end of Radoi with the many small islets outside and Fosenoi to the north, taken from the sea southeast of Feie Island (Fig. 21, no. 59). The height of this outer, very flat land I estimate to be about 17 metres above the sea, or very much the same as that of northwestern Lindås Peninsula. Small hills rise here and there above the plane of the strandflat, but this is much more frequent in the southeastern part of Radøi.

Seawards outside Hjelte Fjord and Fedje Fjord (Fig. 21, no. 65, 66) there is a series of low islands: Feie, Sulen, Staksoi, Hennoi, Lyngoi, Forhjelmen, Sæloi, Alvoi, &c., forming the so-called Öigaren. Seen at a distance the surface of this series of islands exhibits an almost uniform horizontal level or strandflat at about the same height as that of the land inside.

The lighthouse of Helliso, at the southwestern end of Feie, is situated on a rock-surface 17 metres above the sea, which is very nearly level with the general surface of that island, to judge from what I saw from the sea. Here and there more or less isolated hills rise above the plane of this strandflat, *e. g.* Hesten and Feiebjornen on Feie, Sælstakken (59 metres), and Åsdolen (49 metres) on Sæloi. On the islands Bredviksoi and Blomøi to the south there are also a few hills rising to 51 and 52 metres above the sea, and one hill on Blomøi even to 70 metres.

It is noteworthy that these outer series of islands have such a very sharply defined strandflat in very nearly the same level as Radøi inside of Fedje Fjord and Hjelte Fjord although they are built up of Archæan

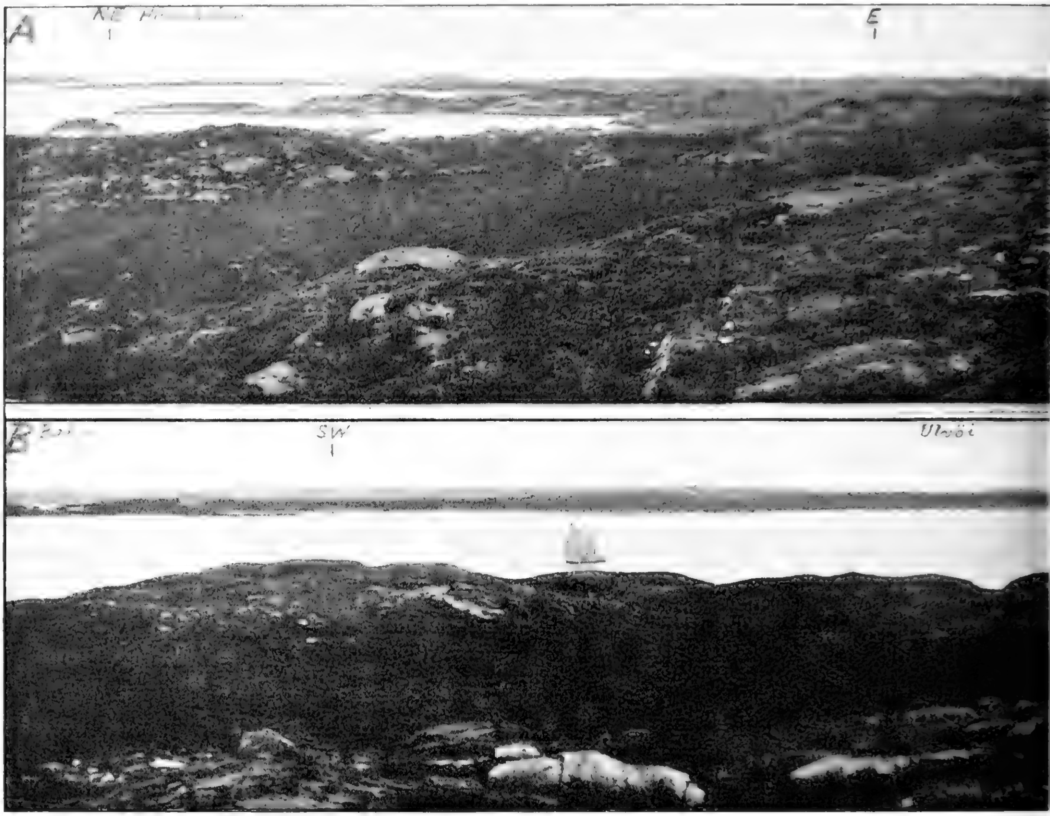
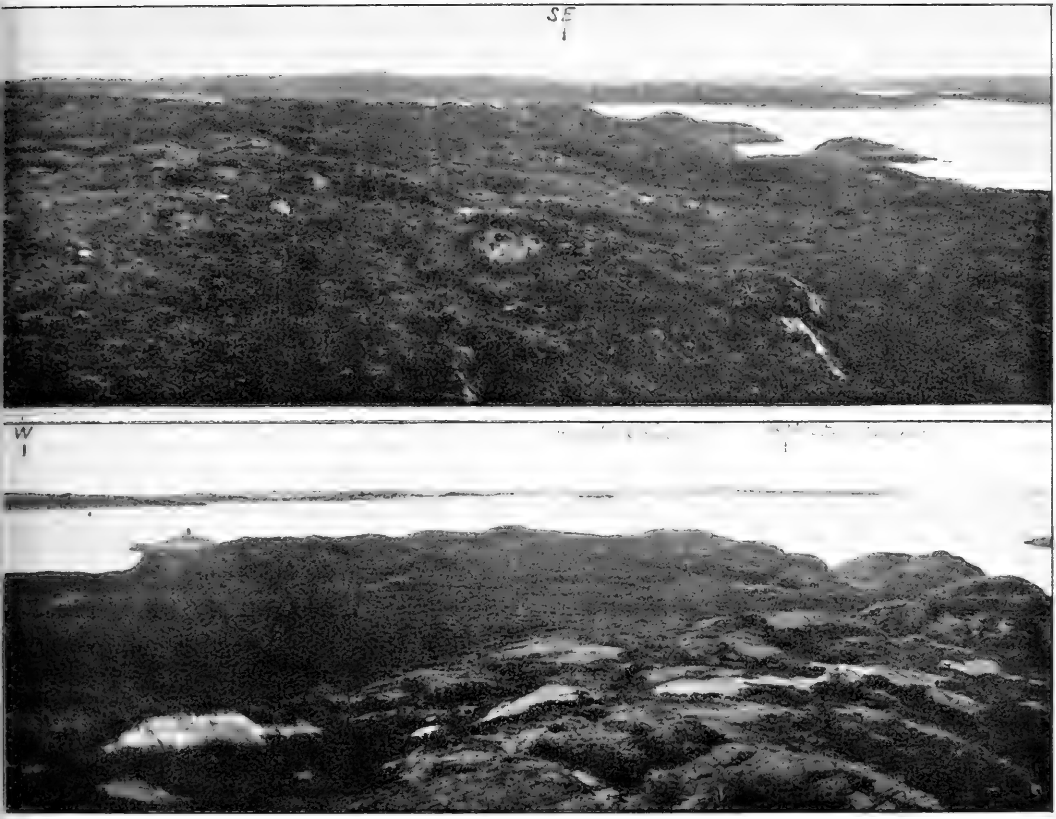


Fig. 45. Panoramic views taken from Vardetuva, on Vardetangen, the north-western end of Lindås Peninsula and north-northwest

rocks, while Radoi chiefly consists of younger crystalline schists (Ulriken gneiss) and in some parts of labradorite rocks.

Ahlmann has visited Sæloi or Hjelmen, and says [1919, p. 102] that there is a general level between 20 and 25 metres above the sea. "In certain places along the western side we can also distinguish a lower level of denudation at 10—14 m."

In the Manger district, in the middle portion of Radoi, Ahlmann distinguishes "two levels: one at 12—16 m. above sea-level, and the other at 33—40 m. above sea-level. The first-named is considerably smaller in extent than the latter, but seems to be somewhat more level. It extends quite near the shore as an open plain, but also stretches in as bays into the higher level. Perhaps we may include in this level also the narrow ledges which in certain places occur along the valleys and hollows at the height of about 12 m. above sea-level" [1919, p. 99]. I know the Radøi and the Manger district very well, but have not been ashore there for many years, and not with the purpose of studying the strandflat. Ahlmann's description agrees, however, exactly with my recollection of it,



\. View eastwards between north-east, Havarden Island, and south-southeast. B. Between south-southwest Aug. 12, 1911).

and I think that these are just the characteristic features one might expect to find along a coast where the shores have been cut back by frost erosion, forming broad benches or narrower ledges backed by steep cliffs, or shore-walls, along the outer coast as well as in the bays. The débris formed by this erosion has been carried away to some extent by the wave action, but much more by the glaciers which have afterwards moved across the land. The steep sides of these bays and small valley channels on Radoi, which Ahlmann considers to have been formed by glacial erosion, and of which he has given a very good picture [1919, p. 101, Fig. 47], have just the characteristic features of shore-cliffs formed by frost erosion, and have not, as far as I can see, the typical surface of rock-walls originally formed by glaciers, although they are to some small extent scoured by the glaciers of the last glacial period.

Ahlmann says that his higher level of between 33 and 40 metres, comprises the greater part of the Manger district, and he thinks that in the southern part of the island, at Sæbø, this same level may possibly be 45—50 metres above the sea, and he draws the conclusion that this "upper

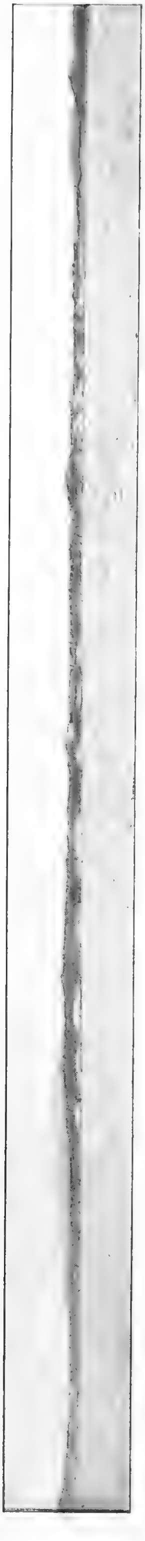


Fig. 46. Northern end of the Lindås Peninsula seen from Fens Fjord. (Aug. 12, 1911).

Fig. 47. View southwards towards Lygre Fjord and westwards towards Bakoi, Njotoi and Fosenoi, from a hill west of Kjellgaulen, 42 metres above the sea. (Aug. 13, 1911).

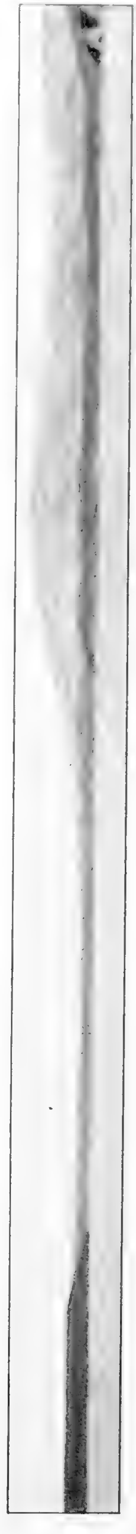


Fig. 48. Strandflat on islands and mainland along eastern side of Lygre Fjord, seen from the sea near Kalvehovve, north of Lygre Island. (Aug. 13, 1911).

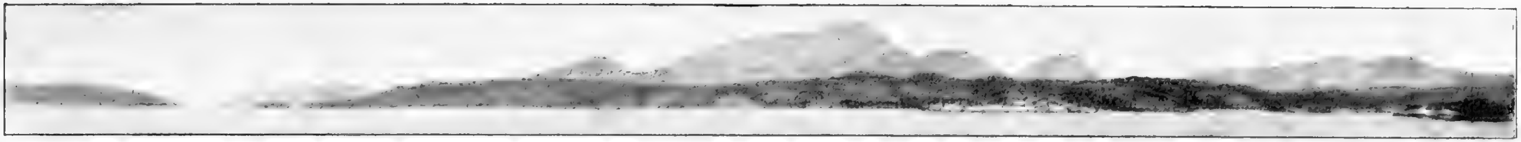


Fig. 49. View southwards from the sea near the skerry Biskopskallen, in the sound between Eastern and Western Lygre Islands. (Aug. 13, 1911).

Fig. 50. The northwestern end of Radøi and Fosenøi with the islets outside, view from the sea near Sandholmflu. (July 27, 1911).

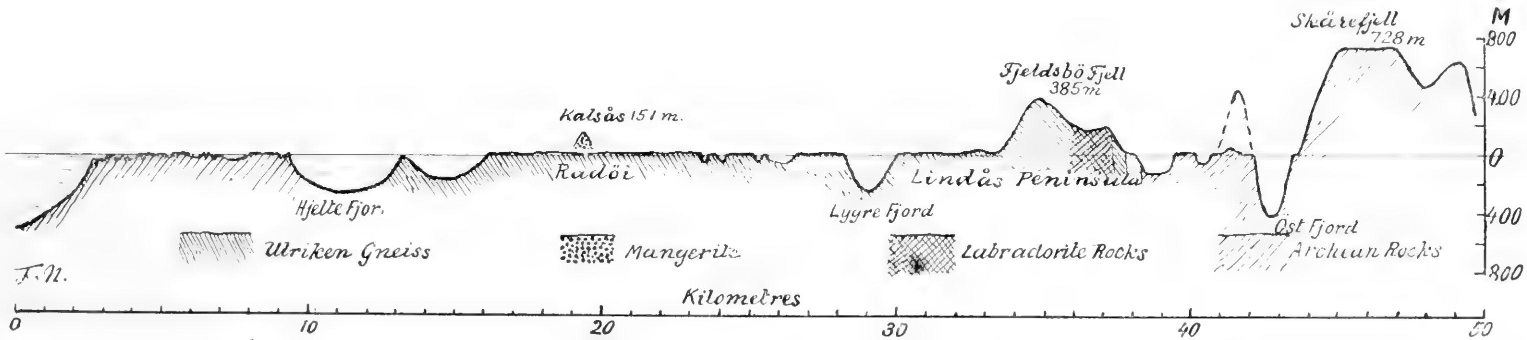


Fig. 51. Profile across Radøi and Lindås Peninsula, from Lyngøi (Fig. 21, 61) to Skäre Fjell (Fig. 21, Sk.) on the mainland.

Fig. 52. Strandflat at Salhus north of Bergen. (Aug. 14, 1911).

denudation altitude slopes gently towards NW, or from 45—50 m. at Sæbofjell to 25—30 m." in the north-western part of the island.

He furthermore considers it indisputable that the denudation surface at 20—25 m. above sea-level on Hjelmen (or Sæloi, Fig. 21, no. 63) in Öigaren outside Radoi "corresponds to the upper level on Manger. The slope which this level proves to have at Manger thus continues as far out as Öigaren".

Although this denudation surface may have a slight slope, especially on extensive islands, I do not believe that this slope can be as great as assumed by Ahlmann. The reason why he finds the heights greater in the region of Sæbo is obviously because the labradorite rocks of this region are more resistant to the erosion than the gneiss in the other parts of the island. The strandflat has not therefore been developed to such a degree of maturity, and more hills and ridges rise to higher altitudes.

On Holsenoi, at Gjernes (Fig. 21, no. 73), just opposite the Sæbo region, he says himself that inside a hill quite near the shore "there extends a well-marked denudation plain at 25—30 m. above sea-level". Hence, according to his own measurements, the height of this surface is no higher here than in the Manger region, on the contrary it seems to be 8 or 10 metres lower, or very much the same as the average altitude he found in his most north-western profile across Radoi, in the Bo region where it was between 24 and 30 metres above sea-level.

On the other hand it may be noticed that, according to my observations, the general level of Feie, Fosenoi, and the north-western end of Radoi is probably somewhat less than 20 metres, or about 17 metres,

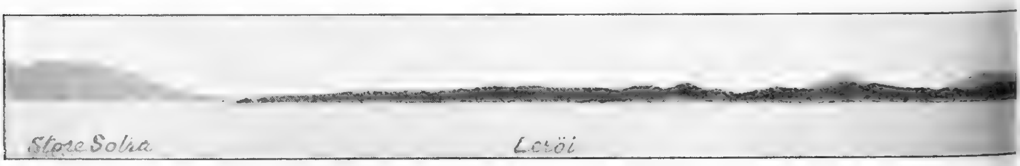


Fig. 53. Strandflat on the southwestern end of Fane Peninsula and the island

and is obviously very nearly the same as that which I found in the north-western part of the Lindås Peninsula. But this surface may correspond to Ahlmann's lower level which he found both at Manger and on Sæløi (Hjelmen), where it was, however, 10—14 metres above the sea, and which he thinks, "does not show any inclination in any definite direction".

Fig. 51 is a profile across Radøi and the Lindås Peninsula from Lyngøi and Forhjelmen (Fig. 21, no. 61 and 62) in Öigaren (in 60° 40′ N. Lat.) to Skårefjell on the mainland (in 60° 42′ N. Lat.) east of Öst-fjord. This profile demonstrates the remarkably level plane of the very broad strandflat, above which the mountain sides rise abruptly. It also shows how the plane of the strandflat extends uninterupted and without any marked change in height across regions of different geological structure. Some of the hills surmounting the plane of the strandflat are built up of comparatively resistant rocks, *e. g.* Kalsås consisting of mangerite.

Region of Bergen.

In the region round Bergen the land is more mountainous than along the coast farther north, and the strandflat is much less developed, and has not such great extent as in the region of Radøi and Lindås. But it is quite conspicuous along the sides of the sounds and fjords in some places.

At *Salhus*, in the Salhus Fjord, north of Bergen, the strandflat forms, for instance, a well marked incision in the mountain slope (Fig. 52).

Bergen is to some extent situated on a narrow strandflat, which extends more or less southwards through the valley to Fjosanger and Nordåsvand.

On the *Fane* Peninsula, between Nordåsvand and Fane Fjord, south of Bergen, the strandflat has a wide extension west of the steeply ascending mountains. Seen from the sea to the west (Fig. 53), it appears very flat and conspicuous. A great many of the islands to the west of Fane are also low and form parts of the strandflat.

In the region of Os at the southern extremity of the whole peninsula between the Bergen By Fjord and Samnanger Fjord, the strandflat is well developed and sharply defined in the region of Rotingen (Fig. 54).

side. The low island right in front and to the left is Lerøi. (July 26, 1911).

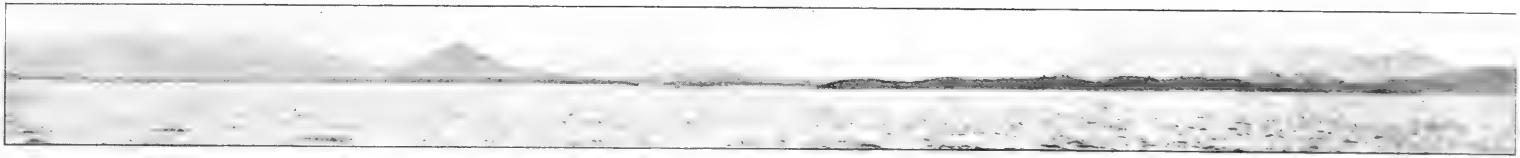


Fig. 54. Strandflat on the northern side of Bjørnefjord, at Røtingen (Aug. 27, 1911).

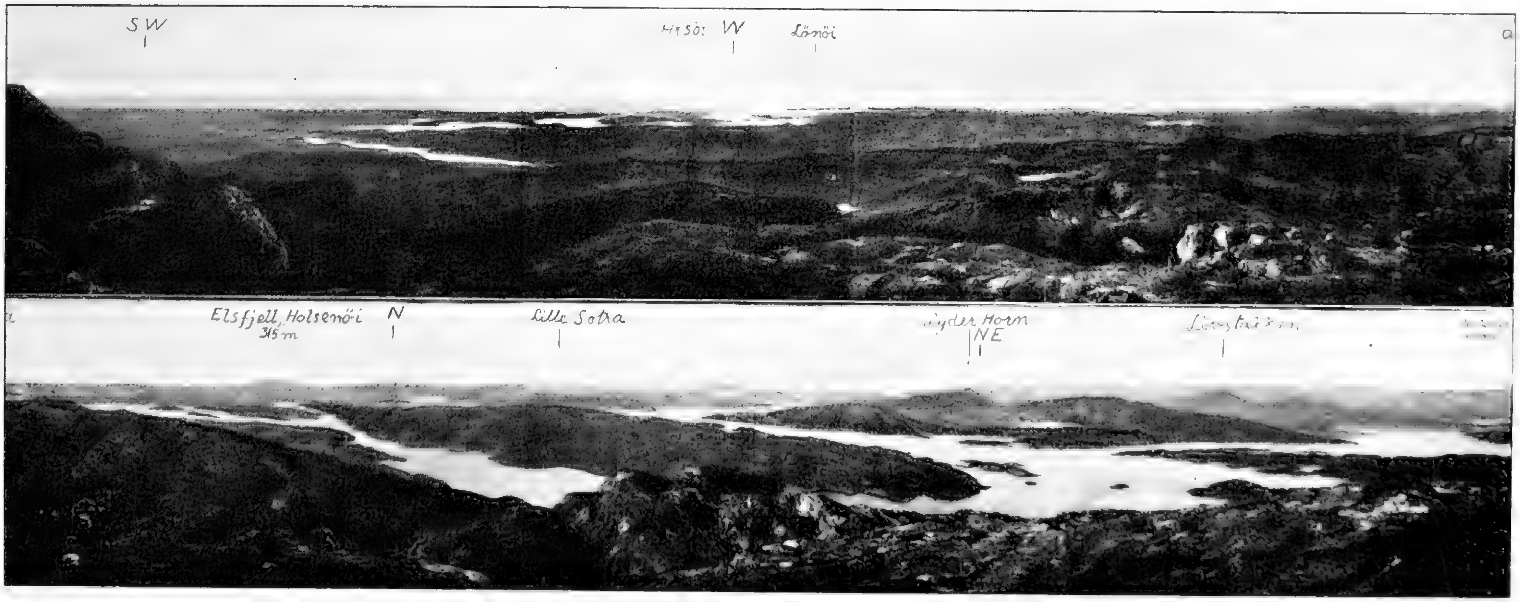


Fig. 55. Panorama of the many islands: Store Sotra, Lille Sotra, etc. and the mainland, west of Bergen, taken from the top of Litårnet at about 335 metres above the sea. (Aug. 20, 1911). The lower picture is a direct continuation of the upper one at *a*.

Fig. 56. Northward view from the summit (71 metres above the sea) of the peninsula at Ekerhovde on Store Sotra. (Aug. 21, 1911.)

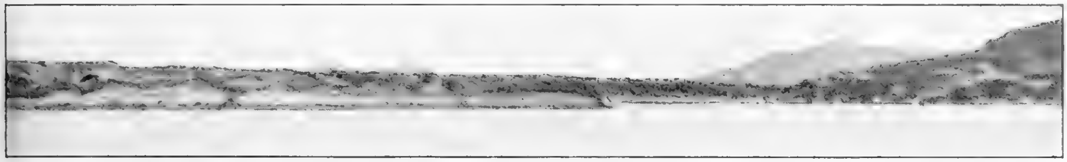


Fig. 57. Strandflat at Håkensund, southern end of Store Sotra. (Aug. 21, 1911.)

Fig. 58. The strandflat seen northwards from the hill (42 metres above the sea) north of Glesvær. (Aug. 21, 1911.)

Region of Sotra.

The strandflat has a wide extension on the big island *Store Sotra* and also on *Lille Sotra* (Fig. 21, no. 78 and 77) to the west of Bergen. But it is comparatively uneven on these islands with many ridges and hills rising above the general level of the strandflat, to heights more than 60 metres. The strandflat comprises the greater part of Lille Sotra, and the whole western and northwestern part of Store Sotra with the exception of the many above-mentioned ridges and hills rising above its general level. In the eastern and south-eastern part of Store Sotra the land is more mountainous, rising to heights of 341 metres at Litårnet (see Fig. 21, no. 79). Fig. 55 gives a panoramic view of the land towards

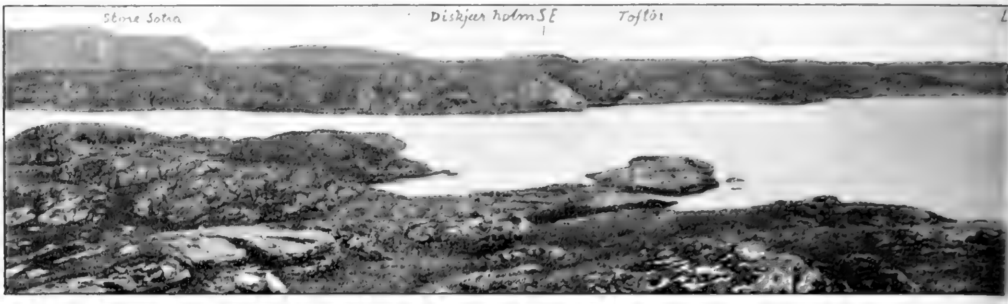


Fig. 59. Panoramic view between east and west-south

the west, north, and east, taken from the top of this mountain. We here look down upon the extensive strandflat, which is especially flat and conspicuous towards the southwest and west. A part of the above-mentioned strandflat in the region south of Nordåsvand i also seen towards the east, to the right.

At *Ekerhovde*, on the east coast of Store Sotra, just west of the southern end of Lille Sotra, and under Litårnet, the height of the general level of the strandflat was found by levelling to be about 30 or 32 metres above the sea. At a height of 52 metres one was decidedly above the general level of the strandflat.

The summit of the small peninsula at Ekerhovde, west of the southern extremity of Lille Sotra, was 71 metres above sea-level. Many ridges and hills on Lille Sotra and the islands northwards, rise approximately to this altitude (cf. Fig. 56), and the highest hill on Lille Sotra even higher. But the average height of these ridges is somewhat lower, perhaps about 50 and 60 metres above the sea.

At *Håkensund*, at the southern end of Store Sotra, the strandflat has an unusually level surface at about 30 metres above the sea, and distinguishes itself sharply from the ascending mountain slopes to the north (Fig. 57).

In the region of Glesvær, at the southwestern extremity of Store Sotra, the strandflat is well developed (Figs. 58 and 59). Its altitude was found by levelling to be 29.9 metres above the sea. In some places on the peninsula to the north of Glesvær (Kausland) it may be a little higher, but it does not reach 40 metres. The altitude of the highest hill just north of Glesvær is 42.5 metres above sea-level, but this hill rises decidedly above the general level of the strandflat, as is shown by the view northward, taken from this hill, see Fig. 58). This picture gives an idea of the levelness of the strandflat in this region. In the background to the right is seen the mountain Litårnet from which the panorama Fig. 55 was taken. The altitude of the general level of the strandflat may be assumed to be between 30 and 33 metres above the sea in this region.

…n the hill above Glesvær harbour. (Aug. 21, 1901.)

It is interesting to note that the strandflat in this region just north of Glesvær and across the land westwards is cut in dioritic rocks, while the land both north and south, on Store Sotra and the other islands, is built up of Archæan gneiss and partly of granite [Reusch, 1901, p. 106]. This makes apparantly no difference in the height of the level strandflat.

Islands between Kors Fjord and Hardanger Fjord.

South of Kors Fjord (Fig. 21, no. 83) I observed a distinct strandflat extending over the southern parts of Hundevågoi (granites), and over Horge Island (granites) along the eastern side of Hufteroi (granites), and on the small islands to the west of the latter: Mogster Island (schists and other rocks), the Åker Islands (where it is very conspicuous), Fugloi (gabbro), and the many surrounding islets.

On the southern side of Hufteroi the strandflat is sharply incised in the mountain slope consisting of gabbro.

Along the southern side of Selbjørn Fjord a well developed strandflat, about 30 metres above sea-level, extends from Slotteroi Lighthouse over all the islands eastwards as far as the western side of Fondoi. These islands consist of granites, while the eastern part of Fondøi consists of gabbro.

On both sides of Langenuen Sound a strandflat is well marked, on the northern end of Stord Island (gabbro) as well as along the southwestern side of Reksteren Island (granites) and along the west side of Tysnes Island (gabbro), see Fig. 60.

Along the western side of Stord Island the strandflat is distinctly defined, but at an altitude perhaps somewhat higher than the usual level of the strandflat. The rocks are here granites, and in the southern part chlorite schists or similar schists, and also some conglomerate.

Along the eastern side of Stord Island there is a fairly distinct, but relatively high strandflat on many points, especially in the southern part near Leirvik (Fig. 61). The rocks are phyllite and in the northern part

Fig. 60. Strandflat in front of the high mountains on Reksteren Island and Tysnes Island (to the right). (Aug. 27, 1911).

gabbro. There are indications of a kind of shore ledge at altitudes of between 45 and 55 metres above sea-level. A well developed shore-line was observed at about 60 metres (measured with the aneroid barometer), which is more or less continuous with the highest level of a fairly extensive plane. There is, however, also a very low level of less than 20 m. above the sea, which is distinctly marked on the point north of Leirvik harbour (Fig. 62) and on the islands outside. The rock is here phyllite. A strandflat with about the same height is also found further eastwards in Hardanger Fjord.

Hardanger Fjord and Bømmel Fjord.

In Hardanger Fjord the strandflat is developed in the same way as in Sogne Fjord, though at a perhaps slightly higher level. It is conspicuous at the points of the promontories and peninsulas along both sides

Fig. 61. East coast of Stord Island, north of Leirvik. (Aug. 28, 1911.)

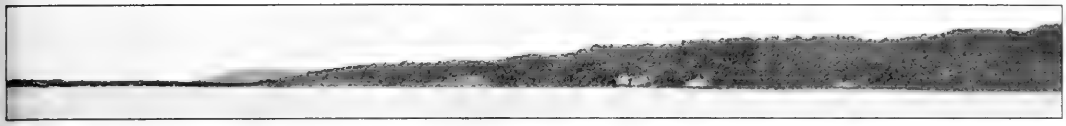


Fig. 62. View along the east coast of Stord Island towards Leirvik. Two levels are seen: the general higher level at 50 to 60 metres above the sea, and a lower one at less than 20 metres. (Aug. 28, 1911).

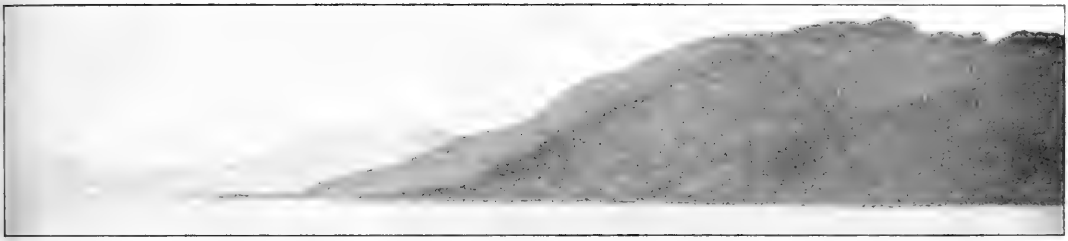


Fig. 63. Hamaren in Hardanger Fjord. (Aug. 30, 1911).

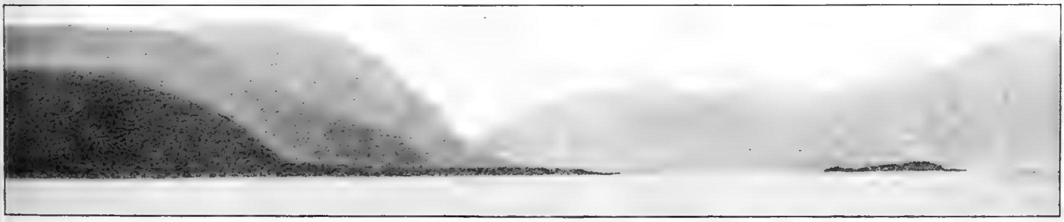


Fig. 64. East side of Varaldsøi, near Haukanes, with the Sild Island (to the right), Hardanger Fjord. (Aug. 30, 1911).

Fig. 65. Point and small islet at Akrehavn on Varaldsøi. Sild Island to the left. (Aug. 30, 1911).

Fig. 65. Southern end of Varaldsoi. (Aug. 30, 1911).

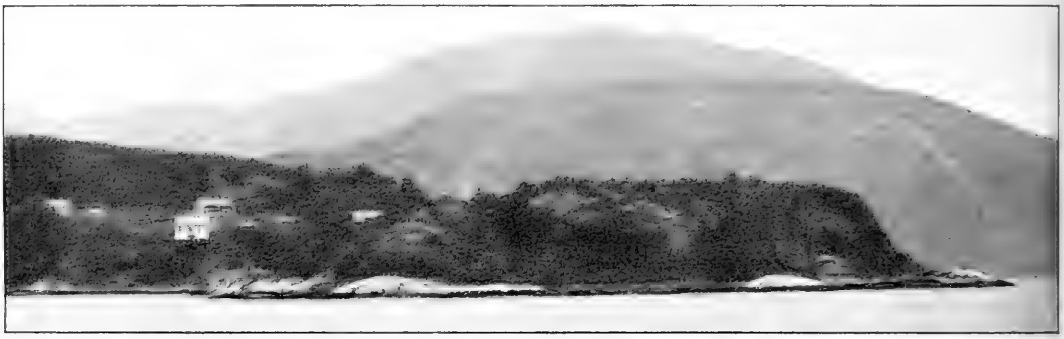


Fig. 67. Ænes in Hardanger Fjord, at the entrance to Mauranger Fjord. (Aug. 29, 1911).

of the fjord, *e. g.* at Hamaren (Fig. 63), on Varaldsoi (Figs. 64, 65, 66), Ænes (Fig. 67), and Ulvanes (Fig. 68). But it also occurs along the shores between the promontories. It is everywhere cut in solid rock, and forms often very conspicuous and sharply marked incisions in the mountain slopes (cf. Figs. 63, 64, 65, and 66).

The altitude of this strandflat was measured by levelling at *Åkrehavn* on Varaldsoi. The rock is here phyllite. The ridge of the point (Fig. 65) is 19 metres above sea-level. The level of the strandflat was also observed on Sild Island and on other islets along the shore, though the latter are as a rule somewhat lower.

The summit of the point at *Ænes*, opposite Varaldsoi, was found by levelling to be 33 metres above the sea, and belongs obviously to a higher level than that on Varaldsoi and Hamaren. The rock is here Archæan.

On *Snilstveitøi*, Kvinherred, there is also a well-developed strandflat in Archæan rocks.

I have not had an opportunity of investigating the occurrence of the strandflat in Hardanger Fjord inside Hamaren (Fig. 21, no. 100), but as mentioned on p. 66, Dr. Reusch has pointed out the occurrence of what he calls a "mountain-foot" or a low rocky platform along the sides of the inner parts of Hardanger Fjord, and in the map Fig. 21 I have

Fig. 68. Ulvanes, Hardanger Fjord. (Aug. 30, 1911).

Fig. 69. Southward view along the eastern side of Hardanger Fjord, towards Husnes, where the strandflat begins to extend and the high mountains withdraw. (Aug. 30, 1911).

marked the places with strandflat according to his map of the inner Hardanger Fjord [1901, p. 189]. Reusch states the heights of his platforms to be about 20 to 30 metres. I expect they are chiefly about 20 metres, which agrees with my measurements in the outer part of the fjord at Varaldsøi.

As in Sogne Fjord so also in Hardanger Fjord the strandflat is conspicuously wider and better developed along both sides of the fjord in its outer part, and in Bømmel Fjord, than in the inner fjord. It is especially outside the region of Husnes and Huglo Island (Fig. 21, no. 109 and 110) that the strandflat begins to extend more widely over the islands as well as on the mainland, and the mountains retire from the shores of the fjord, leaving the strandflat as a wide level foreland (cf. Fig. 69)

A distinctly developed strandflat extends along the northwestern side of Bømmel Fjord cut in rocks varying much in their power of resistance. It extends over the southern end of Stord Island (Fig. 70) consisting of phyllite and chloritic schists, over Moster Island (Figs. 70 and 72) consisting of chloritic schists and gabbro, along the eastern side of the southern peninsula of Bømlo Island, and over Espevær (Fig. 75) consisting of schists and gabbro.

Along the southeastern side of the outer Hardanger Fjord and Bømmel Fjord, the strandflat is well developed along the whole coast from Husnes (Archæan rocks, Fig. 69), on Hålsnøi, and Fjelbergøi (Archæan rocks and phyllite on both islands), along Valestrand from Tittelsnes (phyllite, Fig. 71), and southwestwards along the coast, consisting of Archæan rocks, towards Ryvarden Lighthouse and Haugesund (Figs. 73,

Fig. 70. Strandflat on southern end of St

Fig. 71. South-eastern side of Bommel Fjord, from Tittel-

Fig. 72. Panoramic view extending from Moster Island to the northwest across

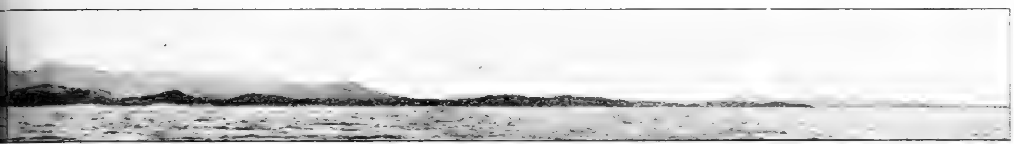
74 and 77), and further southwards along Karmsund, where the rocks are chlorite schists or similar schists.

I did not get an opportunity of measuring the height of the strandflat in this region of the fjord outside Stord Island. But on the whole it gave the impression of being higher than in the region further in the fjord, being as a rule perhaps about 30 metres above sea-level, and sometimes even higher.

As mentioned above I found a fairly well developed plane at between 45 and 55 metres along the eastern and southeastern side of Stord Island and especially at Leirvik. The distinct plane extending over the southernmost part of Stord Island (Fig. 62) has an average height approaching this level, or perhaps more correctly between 40 and 50 metres.

On Moster Island the average level of the strandflat is between 30 and 35 metres, but some few hills rise to 45 and 51 metres, and a hill in its northern part even to 55 metres. Whether the rocks are gabbro or weaker chloritic schists or similar schists makes no appreciable difference in the heights of the hills or the strandflat. The latter is lowest in the southeastern part of the island, near Mosterhavn, where it is less than 30 metres high. It is somewhat higher further west.

d and on Moster Island. (August, 1904).



-westwards along the coast of Valestrand. (Aug. 30, 1911).

anger Fjord to Valestrand and the coast towards the east. (Aug. 30, 1911).

On the opposite, southeastern, side of Bommel Fjord the strandflat seemed to have a similar height of between 30 and 40 metres, or in some places perhaps slightly higher. The rocks are here Archæan, only at Tittelsnes they are phyllite. The islands out in the sea to the west, at Lyngsoi (Fig. 21, no. 123), also seem to have a fairly considerable height approaching this higher level.

On Bomlo Island the strandflat has a wide extension along its western and over its whole northern part and on the islands outside. The height of the strandflat is on the average between 30 and 40 metres, perhaps nearer 30 metres, but many hills and ridges rise above its general level even to altitudes of more than 100 metres.

The Bomlo Island shows great variations in its geological structure. The whole northern part consists of granites, the middle portion of gabbro, while the southern peninsula is built up of schists, with spots of gabbro and also quartz porphyry.

On the whole the strandflat in the region of Hardanger Fjord seems perhaps to have a similar tendency towards rising slightly seawards from the inner regions as we found in Sogne Fjord. But it has to be noted that there are obviously at least two different levels: a lower level less

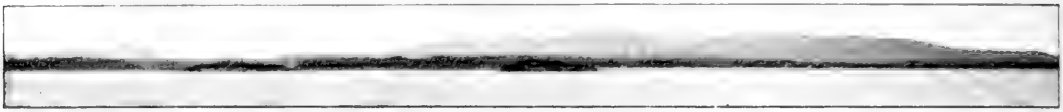


Fig. 73. Strandflat along south-eastern side of Bømmel Fjord, south-westwards from Ekelandsnes, in continuation from right end of Fig. 71. (Aug. 30, 1911).

Fig. 74. Strandflat along sonth-eastern side of Bømmel Fjord, near Nesheim and Norbø. Aug. 30, 1911).

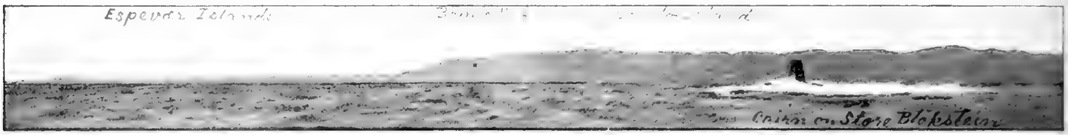


Fig. 75. Northward view towards the fairly high southern peninsula of Bømlo Island, and the low islands of Espevær to the left, taken from the sea north of Ryvarden Light house. (Aug. 30, 1911).

than 20 metres high observed at Leirvik, Varaldsoi, Hamaren, &c., and a higher level of about 30 metres, or between 30 and 40 metres.

The strandflat of the Hardanger and Bomlo region seems on the whole to have very nearly the same average height as in the Bergen region and the Sogne Fjord region, perhaps slightly higher in some places. On Stord Island the strandflat seems to be especially high.

VIII. THE STRANDFLAT OF THE SOUTHWESTERN AND SOUTHERN COAST OF NORWAY.

The Region of Karmøi.

On Karmoi there is a well developed strandflat extending over nearly the whole island. But here and there hills rise above the level of its plane (cf. Figs. 77 B and 78), and this is especially the case in the middle and southern part of the island, mostly on its eastern side.

The northern part of the island consists of chlorite schists, the middle and southeastern part of gabbro, and the southwestern part of granites or gneisses. The strandflat extends equally over these different formations without any appreciable difference in height. But the highest hills occur chiefly in the gabbro region. The coast of the mainland along the eastern side of Karmsund consists of chlorite schists.

According to levelling made north of the bay at Angvaldsnes, the general level of this strandflat is about 29 metres above the sea. But a great part of the plain, on which many farms are situated, is between 16 and 20 metres, and this is also the general level of the strandflat on the mainland along the eastern side of Karmsund. The town of Haugesund is situated on this plane at the same height about 17 metres above sea-level. The heights were measured by levelling with a theodolite from a hill at 30.5 metres above sea-level, north of Angvaldsnes Bay.

Fig. 78 gives a panoramic view taken from this hill. By careful levelling with the theodolite it was ascertained that the ridges of the undulating plain of Karmoi were very nearly at the same level as this hill, or a metre or two lower. *E. g.* the height of the platform on which the Angvaldsnes church is lying, was found to be 29.5 metres above sea-level. The bases of several houses in Haugesund were measured to be at about 16 metres above sea-level.

To the north Bjorjene Hills on Karmoi are seen rising above the plane of the strandflat. On the mainland hills are also seen rising above this plane, but *e. g.* east of Haugesund they distinguish themselves sharply from the level of the strandflat.

A sharply defined and widely developed strandflat extends southwards along Karmsund on the mainland (Fig. 80) as well as on Karmoi

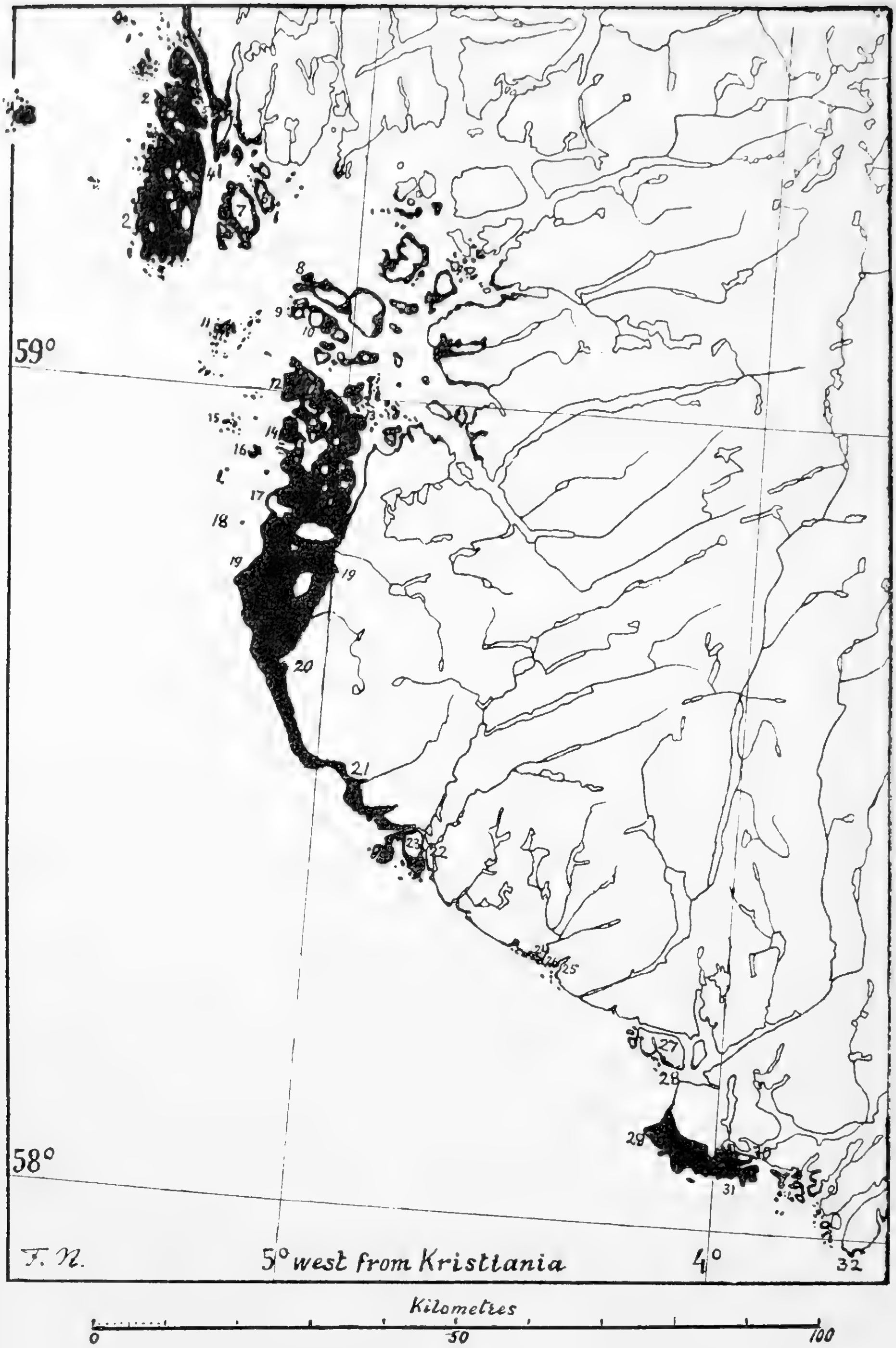


Fig. 76. Map of the Norwegian coast between Haugesund and The Naze (Lindesnes).

1 Haugesund. 2 Karmoi. 3 Angvaldsnes Bay. 4 Karmsund. 5 Hoie Varde. 6 Eastern Bokken. 7 Western Bokken. 8 Rennesoi. 9 Fjoloi. 10 Mosteroi. 11. Kvitingsoi. 12. Stavanger Peninsula. 13 Stavanger. 14 Tananger. 15 Håstein. 16 Roth Islands. 17 Hellesto (Håland). 18 Feisten Lighthouse. 19-19 Region of Klep. 20 Region of Nærbø. 21 Ogne. 22 Egersund. 23 Egeroi. 24 Presteskjær Lighthouse. 25 Josing Fjord. 26 Sogndal. 27 Hitteroi. 28 Lister Fjord. 29 Lister. 30 Farsund. 31 Southeastern part of Lister. 32 The Naze (Lindesnes).

Fig. 77. Strandflat north of Haugesund. (Aug. 30, 1911).

(Fig. 79) but, as mentioned above, a good many hills rise more or less abruptly above its plane. The geological structure differs much on the two sides of the sound, the rocks being gabbro on Karmoi and chlorite schists on the mainland; but there is no appreciable difference in the appearance or height of the strandflat.

A well marked strandflat, with a height approaching 30 metres, and forming a sharply defined incision in the mountain slope extends along the western and southern side of *Eastern Bokn island* consisting partly of phyllite partly of Archæan rocks (Figs. 81 and 82).

On the southern side of the island another level was noticed at about double that height or a little more (Fig. 82).

On the southern part of *Western Bokn island* (chiefly Archæan rocks and some phyllite), there is also a distinct strandflat.

The Stavanger Region.

The northwestern end of Rennesoi, north of Stavanger, forms a very flat and low strandflat (cut in granite), with a height of less than 20 metres (Fig. 83).

Ahlmann in his attempt to prove that the strandflat has not been formed by marine denudation, points out that the occurrence of the strandflat or rocky bench with a steep cliff behind it, on the southern side of Rennesoi, coincides with the tectonic difference in the geological structure of the island where igneous rocks, forming the cliff, rest on a base of weaker sedimentary rock (phyllite), forming the strandflat. He thinks that in such a case the formation of the bench "can be well explained as a result of subaërial and glacial erosion, but not by marine abrasion". But what is the explanation in the many thousands of other cases of similar shore-benches or strandflat formations where there is no such tectonic difference? And why have the horizontal strandflat and the shore-benches so very similar heights, or to a great extent practically identical heights, in the different regions so widely separated, although the rocks may differ much in their power of resistance to erosion? It seems that Ahlmann, in his anxiety not to admit the effect of the marine abrasion, has been compelled to seek for different explanations of the same formations in the different cases.

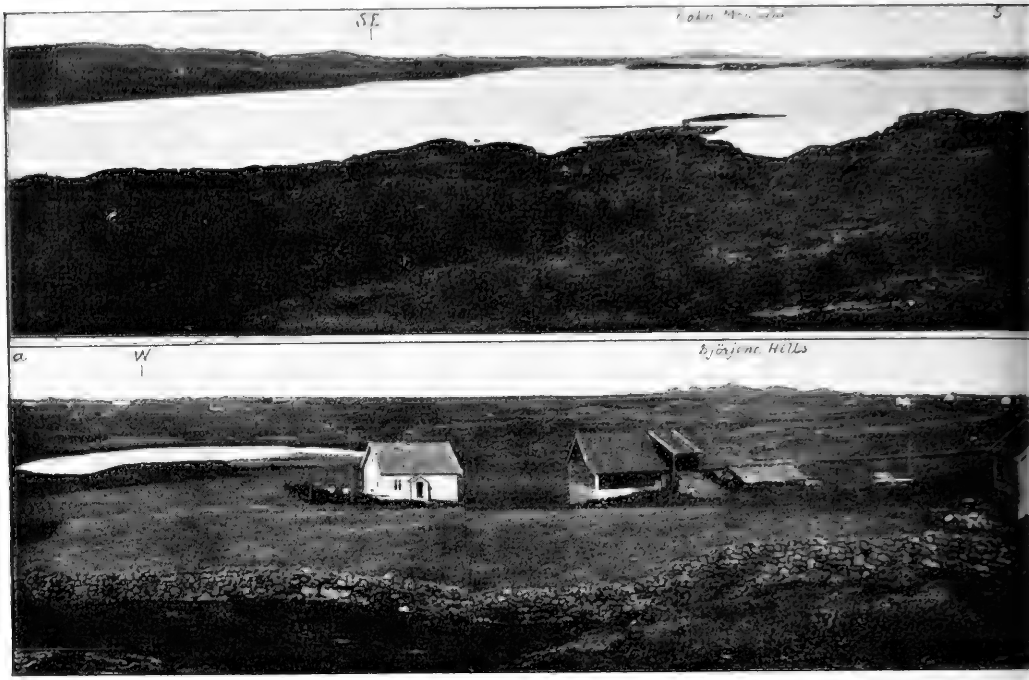


Fig. 78. Panoramic view of Karmøi and the mainland, taken from a hill north of the bay at Angvaldsr
of the u

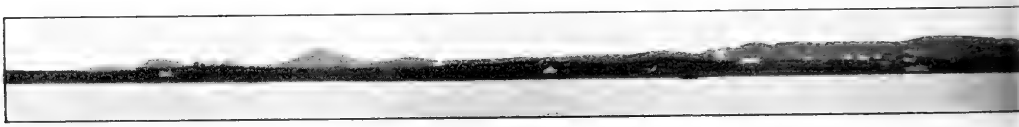
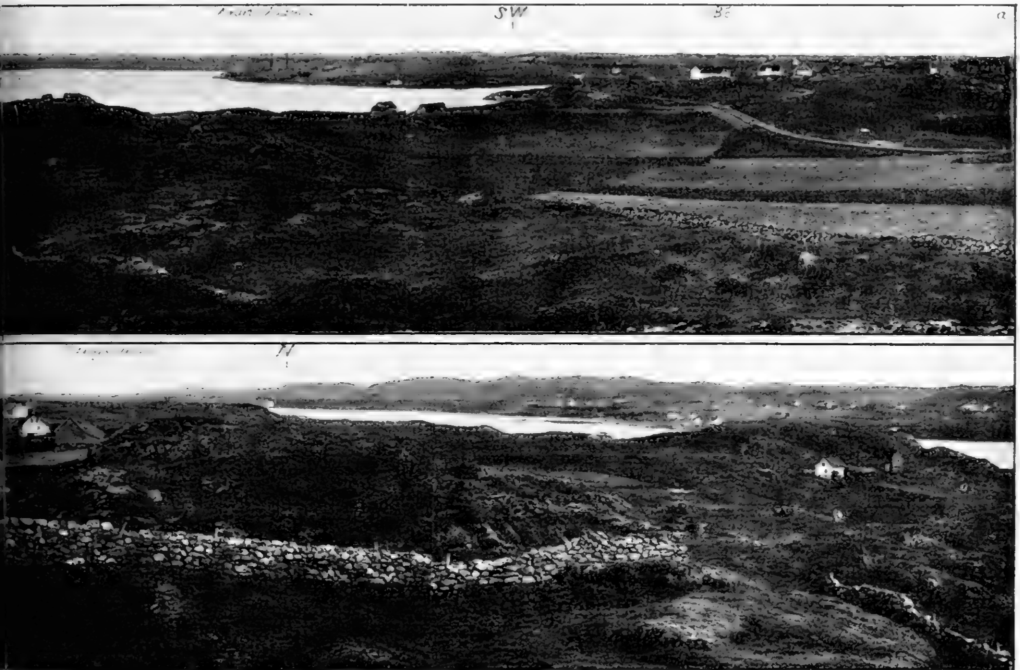


Fig. 79. Karmøi south of Høge Varde lighthouse, with hills rising above the plane of the standfla
(Aug. 31, 1911)

On the islands south of Rennesøi (Ulfstein Island and Fjolløi), there is a well-developed strandflat. The sketch Fig. 84 demonstrates how the almost horizontal plane of the strandflat extends to the foot of the mountains Byrefjell and Kneberg, which rise abruptly above this plane. The rock is granite on both islands.

The strandflat has a wide extent over most islands in this region north of Stavanger and out in the sea to the west where all islands are low and very flat.

Kvitingsøi with its hundreds of surrounding islets and skerries has a very conspicuous low flat level cut in chlorite schists (Fig. 85). In the eastern part of these islands where the view Fig. 86 was taken, the average height of the plane was measured by levelling to be about 9.5 metres above the sea. But the level at which the farms are lying farther westwards (see



ht of camera 32 metres above sea-sevel. (Aug. 31, 2911.) The lower pictures are a direct continuation
at *a*.

Fig. 80. The mainland along the eastern side of Karm-sund, seen from the sea south of Hoge Varde lighthouse.

Fig. 86 right side) is higher. I estimated it to be about 20 metres or perhaps a little more.[1]

The general level of the very flat Rott Islands further south, west of Tananger on the Stavanger Peninsula (see Fig. 89), was found by levelling to be about 17.7 metres above the sea, or perhaps between 16 and 18 metres, but the western and southern part of the islands is somewhat lower. They consist of phyllite.

The many islets between Kvitingsoi and Rott are mostly low and flat, marking a low plane (largely less than 10 metres high) above which

[1] After this was written I learn from kind information I have received from the Superintendant of Lighthouses, that the base of the lighthouse of Kvitingsoi is 22 metres above sea-level, which agrees well with my estimate, as this base is level with the plane mentioned above.

Fig. 81. Points at Övrebø on north-western side of Eastern Bokn island. (Sept. 1, 1911).

Håsteinen (phyllite) rises abruptly to a height of 45 metres (according to "Topografisk Kart Blad 6 D, Stavanger"). The island Storkjør, south-west of Rott, has a height of 18 metres.

The land on the *Stavanger Peninsula* forms on the whole an unusually level and well-developed strandflat, cut in solid rock, mostly phyllite, but in some places, at Tananger and round Hafs Fjord, also granite. The difference in the rocks causes, however, no appreciable difference in the plane or the height of the strandflat, though a difference in the roughness of the surface is easily perceptible. Hills, like Randeberg (Fig. 87) rise more or less abruptly to heights of 79 metres above this almost perfectly horizontal plane, extending to the foot of the hills.

North of Stavanger, at Finnestad near Dusevik, I found by levelling the height of the plane to be 29.5 metres above the sea. This plain is to a great extent covered by moraine material, but the solid rock (phyllite) protrudes at the surface of the plain in many places.

On the northwestern side of the peninsula, south of Tungenes Lighthouse, the strandflat is conspicuously level and low, less than 10 metres above the sea (Fig. 87), and is cut in solid rock (phyllite) forming the shore. The base of Tungenes Lighthouse is about 8 metres above sea-level.

At Tananger the general level of the very even plane of the strandflat, extending landwards and cut in granite, was found by levelling to be about 14 metres above the sea. Near the shore it was somewhat lower. The hill with a cairn, north of Tananger harbour, rises to about 22 metres above sea-level. The panoramic view Fig. 89 was taken from this hill. It shows that the level of the plane is much below that height. The height of the small Tananger Lighthouse seen in the middle of the picture is 15 metres above the sea, and that of its base about 11 metres. The height of Fladholm

Fig. 82. Eastern Bokn island, seen from the south, with strandflat extending along the whole coast from the point to the north-west, which is the same as in Fig. 81. (Sept. 1, 1911).

Fig. 83. The flat north-western end of Rennesoi, in front of the higher hills (Hestvarden 150 metres) in its middle part. (Sept. 1, 1911).

Fig. 84. Fjolloi and the island of Utstein Kloster with Byrefjell and Kneberg, seen from the sea at Vardesveina. (Sketch Aug. 1, 1901).

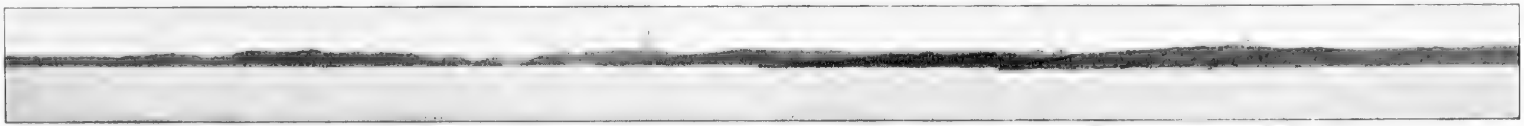


Fig. 85. Kvitingsoi with the lighthouse, seen from the east. (Sept. 1, 1911).

Fig. 86. Panoramic view of Kvitingsoi, towards south and west from a small hill on Krogoi, on the north-eastern side of the group of islands. Height of camera 11 metres above the sea. (Sept. 1, 1911.)

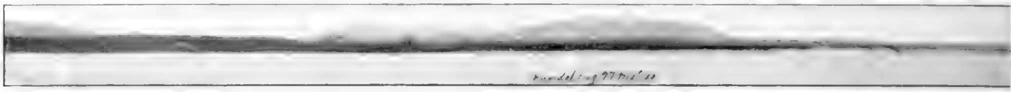


Fig. 87. The low strandflat cut in solid rock (phyllite) southwards from Tungenes Lighthouse, northern of Stavanger Peninsula. The Randeberg rising abruptly above the level strandflat. (Sept. 1, 1911).

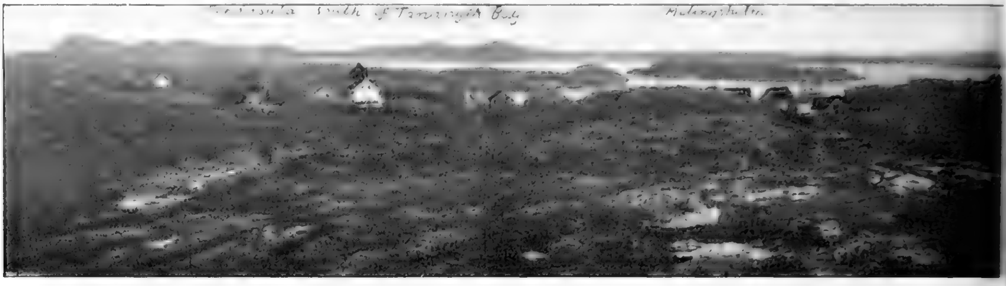


Fig. 89. Panoramic view of Tananger Bay and the islands outside, taken

Lighthouse is 15 metres above the sea, and its base about 8 metres. The picture demonstrates the remarkable flatness of all the islands outside the coast. These islands consist of phyllite. The picture also shows the roughness of the granite surface of this strandflat north of Tananger.

The ridge on the peninsula south of Tananger Bay (to the left in the picture) has a fairly rough contour, although it is built up of phyllite.

Further south, at Hellesto (Håland) at the northern end of Jæderen, we find the same strandflat cut in solid rock at the foot of steep mountain slopes, rising to heights of 90 metres above sea-level (Fig. 90). According to Reusch's geological map [1913] the rocks in this region are argilaceous schists (phyllite).

The height of the rock of Feisten, in the sea southwest of this place, is about 12 metres above sea-level.

Relation between the Geological Structure of the Coast and the Occurrence of the Strandflat.

In the preceding description of the strandflat along the Norwegian west coast, occasional remarks have been made on the geological structure of the coast and its relation to the occurrence and extension of the strandflat. The geological dates are taken from the geological maps of the coast and from Reusch's description with map of the geology of Søndhordland and Ryfylke [1913].

As has been pointed out on several occasions, it is striking how the strandflat often extends equally over regions with very heterogeneous geological structure, without showing any appreciable differences in its altitude or in its whole appearance. The plane of the strandflat is, for in-

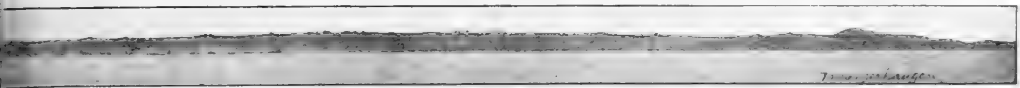
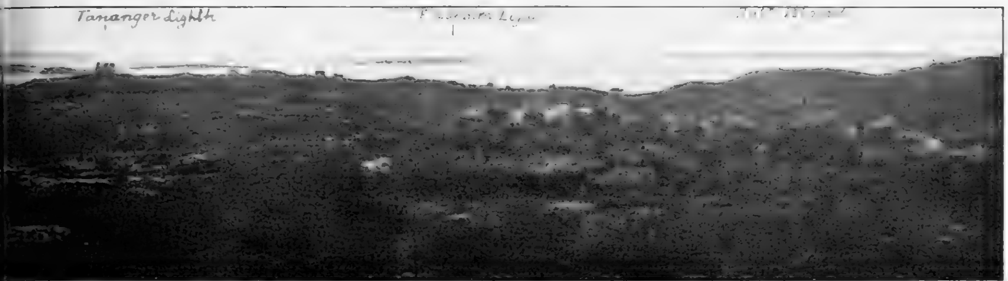


Fig. 88. The strandflat cut in granite north of Tananger. (Sept. 1, 1911).



.ll (22 metres above sea-level) north of Tananger harbour. (Sept. 1, 1911).

stance, very often continued horizontally without a break from regions built up of very resistant rocks, like granites and gabbro, into regions with weak schists (chlorite schists, phyllite, &c.). This is the case in the regions of Bømlo Island, Karmøi, and Stavanger Peninsula. A difference may be that in the regions of the more resistant rocks there are often more and higher hills and mountains surmounting the plane of the strandflat, and the latter may not have as wide an extension there as in the regions of weaker rocks. But even this is not always the case, *e. g.* on Bømlo Island, and the height of the real plane of the strandflat does not as a rule differ.

The only simple explanation of this striking feature seems to me to be that although the principal processes for the lowering and sculpturing of this coast have been the subaërial denudation and the glacial erosion, the final levelling of the plane of the strandflat has been accomplished by the marine denudation, *i. e.* chiefly shore erosion by frost. After this plane had been thus formed, there cannot have been any great amount of subaërial denudation nor glacial erosion within the outer regions of the strandflat, for otherwise greater differences in the heights of the plane of the strandflat would necessarily have been created, especially where the power of resistance of the rocks differ much. On the other hand the strandflat has been exposed to some glacial erosion, which has to some extent broken the level surface of the strandflat and made it less even than it was originally. The effect of this glacial erosion has naturally differed somewhat with the structure of the rocks and their power of resistance.

It has, however, to be considered that the power of resistance to shore erosion and also to glacial erosion depends less on the hardness of the rocks, than on their tendency to be split by the frost or to form a rough surface to be attacked by the moving ice. It is for instance striking that the granites have in some regions been quite as much eroded as the much softer schists, probably because they have as a rule a rougher surface.

Jæderen.

Jæderen or Jæren is the low land extending along the coast between the Stavanger Peninsula to the north and the Egersund region to the south. It is 11 to 13 kilometres broad and bounded along its eastern side by a mountainous land (of Archæan rocks) rising more or less abruptly above the plain, with comparatively steep mountain slopes, to altitudes of 100 to 200 or even 250 metres.

The plain of Jæderen is formed to a great extent by quaternary, chiefly glacial, accumulations which have filled up the depressions and hollows of the rocky ground, often to great thickness. In numerous spots here and there the bare rock appears, however, in the surface of the plain, and in the northern and southern part of the plain this is even the case near the outer coast line [cf. the map by Grimnes, 1910].

The plane indicated by these exposures of bare rock has a height above the sea of about 15 to 25 metres, near the coast, in the region of Sele and Byberg and eastwards to Hegre in the northern part of Jæderen, south and southeast of Hellesto (Håland). According to Bjørlykke [1913, p. 16] the protruding rocks southeast of Sele are hornblende- and mica-schists. According to Grimnes's map the protruding rocks rise to higher levels, above 50 metres, in the region further inland towards east-south-east, at Svensvoll, Lea, and Skjæveland, where the rocks consist of a grey gneiss [Bjørlykke, 1913].

Further east towards the foot of the mountains forming the eastern boundary of the plain, the level of the rocks is again lower, about 25 metres or even less, and at Åse, north of Høiland railway-station, Bjørlykke observed hornblende-schists and layers of brown granular limestone (marble).

Further south, between Bore and Klep, there are rocks of mica-schists and gneiss rising to 50 and even 75 metres above the sea, at a distance of only 3 to 6 kilometres from the coast.

Rocks of hornblende-schist, gneiss, and amphibolite rise to similar heights of between 50 and 75 metres in the region south of Klep towards Tu, where the hill Tua or Tinghaug (hornblende-schist and amphibolite) is even higher.

An almost continuous region with numerous exposures of Archæan rocks, chiefly gneiss, and hornblende-schists [Bjørlykke, 1913, p. 15], extends from Nærbø towards east-northeast. The rocks (gneiss) in the western part of this region, at Bjårland north of Nærbø, 4 kilometres from

Fig. 90. Rocky coast with strandflat at Hellesto at the northern end of Jæderen. (Sept. 2, 1911).

the coast, have heights of less than 20 metres, or about 17 metres above sea-level. But further east the heights rise towards 50 metres and more.

Further east and northeast, in the region of Tuneim, Mossige, Lende, Folland, and Hoiland near the foot of the high eastern mountains, the protruding rocks, observed by Bjorlykke, consist of phyllite, and their heights rise to 75 and 100 metres above sea-level.

In the southern part of Jæderen, north of Ogne, the level of the distinct plane of the low protruding rocks, of granite and labradorite, in front of the higher hills and mountains (of labradorite rocks) is between 15 and 25 metres.

It is of course impossible to study in detail the topography of the rocky ground where it is covered to such an extent by quaternary accumulations as is the case on Jæderen. It seems, however, probable that if these accumulations were removed, we would have a low somewhat uneven rocky surface to some extent perhaps broken up into peninsulas and islands separated by shallow fjords and sounds. But this rocky surface would probably to a considerable extent have low heights of about 10 or 15 to 25 metres above sea-level, as indicated by the rocks especially in the northern and southern parts of the plain.

I see no reason why this low rocky foreland should not be a strandflat of the same kind as the strandflat on the Stavanger Peninsula (forming its direct, northern continuation) and along the coast further north.

The striking topographical difference between the plain of Jæderen and the higher mountainous land to the east may to some extent be due to the difference in geological structure, the rocks of Jæderen being largely crystalline schists and partly phyllite which may have been more easily eroded to low levels than the Archæan and igneous rocks of the higher land to the east and south, although we have seen that fairly resistant Archæan rocks (gneiss, amphibolite, &c.) also occur on the low land of Jæderen.

But howsoever this may be, it seems to me obvious that the low and nearly horizontal level, or perhaps levels, marked by the rocks protruding in the surface of the plain of Jæderen, cannot have been formed solely by subaërial denudation, and still less by glacial erosion. The simplest explanation is here as elsewhere, that these low horizontal levels of the coast-land have been finally created by shore-erosion levelling the hills

Fig. 91. The land north-westward along the coast, seen from a hill (135 metres) on the peninsula north of Presteskjær Lighthouse. (Sept. 3, 1911).

of the low coast, which had already beforehand been much lowered towards sea-level by the other agencies. It is also a striking feature here on Jæderen, that the plane of the strandflat extends with almost uniform heights along the coast over regions with rocks differing very much in their power of resistance, a feature which is characteristic of the result of the shore-erosion.

Ahlmann suggests that the erosion of the inland-ice in a previously flat region, like Jæderen and the Stavanger Peninsula, would result "in soft and still more levelled forms than before" [1919, p. 48]. Although the glacial erosion may grind the forms rounder and softer, I do not consider it possible that it can make any extensive rocky ground more level than it was before. On the contrary I think it will always make it less level, and it is, in my opinion, probable that it is just the glacial erosion to which Jæderen has been exposed after its strandflat was finally levelled, that has made its rocky ground so uneven in height as it now seems to be.

There is no reason why the inland-ice should have had any special tendency to form such nearly horizontal planes just above sea-level. As pointed out before, the erosion of the inland-ice and the big glaciers is not limited in any way by the sea-level, but goes on equally well at all levels down to the depths below the sea reached by the moving ice. Why then are these planes always limited to the coasts? Why has not the inland-ice formed similar levels and horizontal rocky plains under the water, and also far inland, away from the coasts?

The high, steep Coast between Jæderen and Lister.

Everybody travelling southwards along the coast of Jæderen must be struck by the sudden change in the whole character of the coastland in the region of Ogne, about 17 kilometres north of Egersund, where the mountainous land suddenly approaches the coast, leaving only a com-

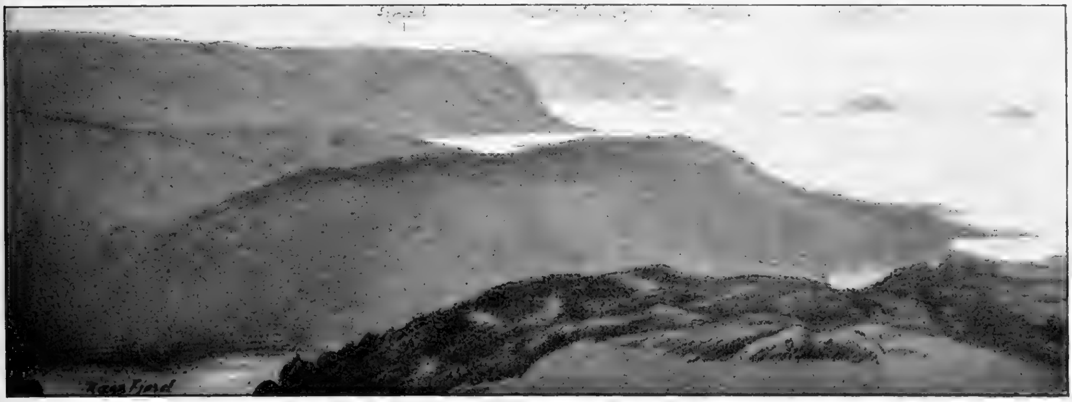


Fig. 92. View south-westwards towards Sogndal and the mouth of Jøsing Fjord, from a hill (135 metres) on the peninsula north of Presteskjær Lighthouse. (Sept. 30, 1911).

paratively narrow, but low and well marked strandflat, cut in solid rock, between the shore and the fairly steeply rising hills. This strandflat may be a couple of kilometres broad, with a level perhaps about 20 metres or less above the sea. It extends along the coast southeastwards as far as Egerøi, on the western peninsula of which it is fairly well developed. But further southeastwards from this island the coast becomes high and often precipitous as far as Lister, and there are only few indications of a very narrow strandflat in front of the steep mountain slope along this coast.

The sudden change in the character of the coast is obviously due to the difference in geological structure, the coast in this region being built up of resistant igneous rocks, the so-called Egersund labradorite rocks [Kolderup, 1914]. This high coastland is dissected by narrow valleys, but its general surface is fairly level or undulating, rising gently inland from a fairly equal height of about 130 to 150 metres, above the sea, near the coast. It is probably the same kind of formation as the fairly level coastland of southern Norway, about 100 metres high or somewhat more, which Ahlmann calls the base-levelled plain of southern Norway. I think it represents more or less the Palæic mountain surface of this region which has not been substantially lowered by glacial erosion because the inland-ice has had very slow movements over these mountain plateaus, although the rocks have everywhere been rounded by the moving ice (see Fig. 91).

In the region northwest of Presteskjær Lighthouse I found, by barometric reading, the fairly level mountain surface (Fig. 91) to be between 140 and 180 metres above the sea, and to the southeast, in the region of Sogndal and Jøsing Fjord (Fig. 92), it was perhaps about 170 to 200 metres high, with a steep declivity down to the shore, where in several places, under the headlands and elsewhere, there are ledges cut in the

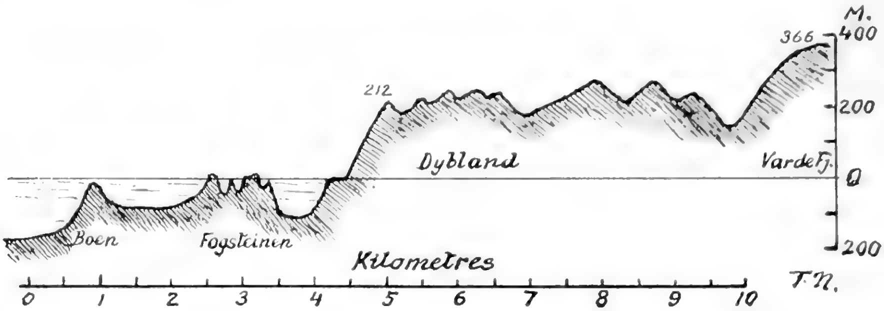


Fig. 93. Profile of the coast and the islets outside, at Dybland and Trætodden, the promontory south of Josing Fjord (see Fig. 16, 25).

solid rock (see Figs. 91 and 92). Along the coast northwest of Presteskjær, as well as outside Sogndal, Josing Fjord, and some other places, there are a number of low rocky islets and skerries (Fig. 92) consisting of the same kind of rock (labradorite) as the mainland. In connection with the ledges along the shores inside, they form a low and distinctly marked strandflat in front of this high and steep coast (see the profile Fig. 93).

The many islets and skerries along the steep coast west and southwest of Hitteroi, west of Lister Fjord, form a similar strandflat.

It can hardly be doubted that these shore-ledges and the low islands outside, have been cut by marine denudation (shore-erosion). They are in appearance perfectly identical with those we have found in Sogne Fjord and Hardanger Fjord. Here along this outer coast I suppose all ideas have to be given up that these formations could be due to base-levelling by subaërial denudation, or that they might be remnants of the floors of some preglacial valley-generation.

From Lister to the Naze (Lindesnes).

Like Jæderen the low plain of Lister is to a great extent formed by quaternary (glacial) accumulations, but especially in its southeastern part much rock rises to the surface of the plain, indicating a low and fairly horizontal level, or probably two levels, the lower one being also marked by the many low rocky islands and skerries outside the coast in this region south of Farsund (Fig. 94).

The rocks of the low land and the islands outside are chiefly Archæan gneiss and granite, partly also diorite and gabbro [Reusch, 1901, p. 92]. The higher mountains behind the low foreland consist chiefly of Archæan gabbro or labradorite rocks further inland.

Though there is a marked difference between the low foreland, and the higher land behind, the mountain-slopes do not on the whole rise so abruptly from the plain as for instance in some regions of Jæderen, but

Fig. 94. South-eastern part of the Lister Land, from Einarsnes north-westwards towards the valley of Framwaren, inside Helvig Fjord. View taken from the sea near Asegrund west of Svaneflu. (July 25, 1911).

nevertheless I see no reason why the low rocky levels should not be parts of a strandflat of the same nature as the one we have found extending all along the coast to the northwest and north.

The mountainous land inside the low land of Lister has a fairly level surface at about 200 metres or more above the sea, rising in Ravneheien to 350 and 366 metres (see Fig. 94).

Between Lister and The Naze (Lindesnes) and along the coast further eastwards where the rocks are partly gabbro or labradorite (between Farsund and The Naze) and partly Archæan, there are a great many low rocky islands and skerries indicating distinctly the lower level of a strandflat, and to some extent perhaps two levels.

The promontory of the Naze itself (consisting of Archæan rocks) belongs to the strandflat and exhibits two marked levels, a general higher level at about 16 to 18 metres above the sea, and another very low level at the outer point, only a few metres above the sea (Fig. 95). The level of about 16 to 20 metres was also observed further east, *e. g.* at Kjeholmen and Kalvehaue on Imsa Island at Spangereid (Fig. 96).

The Southern and South-eastern Coast of Norway.

Along the southern coast of Norway, between Mandal and Christiania Fjord, there is a border of numerous islets, skerries, and rocks, but there are comparatively few perfectly certain indications of a strandflat. Ahlmann goes, however, decidedly too far when he asserts [1919, p. 36] that "there is no sign whatever of marine abrasion or the presence of any marine coastal plain".

Where the general land surface is low and slopes gradually towards the coast, as it does in this region, it is very often difficult to decide where there is a coastal plain or strandflat cut by shore-erosion, and where it is only the general low level of the land surface that slopes gently into the sea. It seems to me, however, that a plane so nearly perfectly horizontal as is exhibited by many series of islands along this coast (see for instance Fig. 97 and especially Fig. 98) cannot have been formed solely by subaërial denudation and glacial erosion, but it must have been finally levelled by shore-erosion, in the manner I have previously described. Sometimes one may observe a distinct break between the horizontal level of this narrow strandflat and the slope of the higher land inside. The

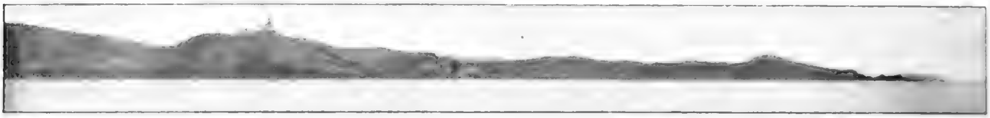


Fig. 95. The Naze (Lindesnes). The light of the lighthouse is 50.1 metres above sea-level. (July 25, 1911).

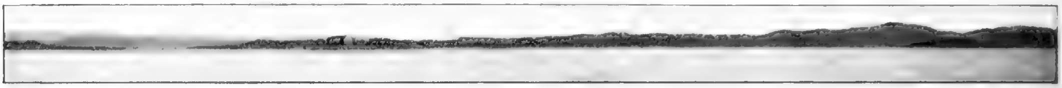


Fig. 97. Land northward from Ulvøisund, east of Christiansand. (Sept. 4, 1911).

islets and skerries in some places show indications of two levels of shore-erosion.

Some observations in the region of Langesund may be of interest to prove the existance of the strandflat along this coast.

The low islands in the mouth of Langesund Fjord, when seen from the sea (Fig. 99), exhibit a low level distinctly different from the much higher surface of the mainland on both sides of the fjord. The Langesund Peninsula shows a higher level.

Fig. 100 represents the southern point of the peninsula on which Langesund is situated. There can be no doubt that the flat points and ledges, a few metres above present sea-level, with the steep cliffs behind, have been cut by shore-erosion. They have obviously the same level as the islets outside, seen in the picture. It is hardly probable that these ledges and islets have been formed in postglacial time. We may be convinced of this by looking at the coast on the western side of the peninsula, a view of which is given in Fig. 101. The level of these low flat islands with rounded, ice-worn surfaces is approximately the same as that of the flat points and islets of Fig. 100, and it is also the same as the low, flat points forming distinct horizontal incisions in the slopes of the two promontories seen behind the low islands in Fig. 101. These formations cannot be due to postglacial erosion.

Hence, we have here a low level or strandflat along the coast, due to shore-erosion, and distinctly different from the higher general level of the land behind, which is seen as a fairly even surface on the peninsulas in Fig. 101 and also in Fig. 99 on the left hand side.

The peninsula of Langesund (Fig. 100) is built of sedimentary rocks (phyllite) and so are the low islands and the nearest promontory in Fig. 101, but the distant promontory in this picture, which has an especially distinct low point or strandflat under the steep shore cliff, is built of Archæan rocks.

Whatever the genetic origin of the higher, fairly level surface of this land may be, there can, in my opinion, be no doubt that the lower level

Fig. 96. Indications of a strandflat outside Spangereid, east of Lindesnes. Kjeholm in the foreground. To the right the point Kalvehaue on Imsa Island, with a well-marked strandflat. (July 25, 1911).

Fig. 98. Islands north of the entrance to Kragerø. (Sept. 4, 1911).

of the small islands and the points in this region is a regular strandflat of the same nature and origin as the strandflat of the Norwegian west coast where it has, however, a much wider extent.

It may be that this low level of the strandflat along the southeastern coast of Norway corresponds to the lowest level (12—17 metres high) of the strandflat of the west coast. The reason why it is here so much lower might be, in that case, that this southeastern coast has been less elevated than the west coast after the last development of the strandflat, because the denudation of this low land, and the amount of waste carried away from it after that time, have been considerably less than what was removed from the much higher and steeper west coast.

The Inner End of Christiania Fjord.

As Prof. W. C. Brøgger's well known investigations have proved, the Christiania Fjord is a fault trough, in the inner part of which the Silurian or Ordovician clay-slates have sunk down to levels below those of the Archæan region to the east and of the igneous rocks forming the hills to the north and west of the fjord. It is to a great extent by the subaërial and glacial erosion of these clay-slates, much less resistant than the Archæan and igneous rocks on the sides, that the depression of the fjord has been formed.

If one looks down upon the Christiania valley and the fjord from one of the heights round this valley, it must strike one that the surface of the many islands in the inner part of the fjord, inside Lågøi, Langåren, and Steilene, and also the peninsulas, Bygdøi, Fornebo, Snarøi, and Konglungen, forms a remarkably level plane, where the ridges generally rise to between 20 and 30 metres above sea-level, and very seldom above 40 metres (cf. Fig. 102).

The land of Archæan rocks to the east, *i. e.* the Nesodd Land and the land east of Bunde Fjord, rises abruptly, with a sharply marked fault

Fig. 99. Entrance to Langesund Fjord. (Sept. 4, 1911).

escarpment, above this plane, to 150 and 200 metres above sea-level, while the land in Aker, Bærum, and Asker, rises more gently in ridges to the foot of the higher hills to the north and west of the fjord. But even here there is often a distinct difference between the undulating slopes of these valley sides and the lower plane of the islands and peninsulas of the fjord, as is demonstrated by the profile Fig. 103.

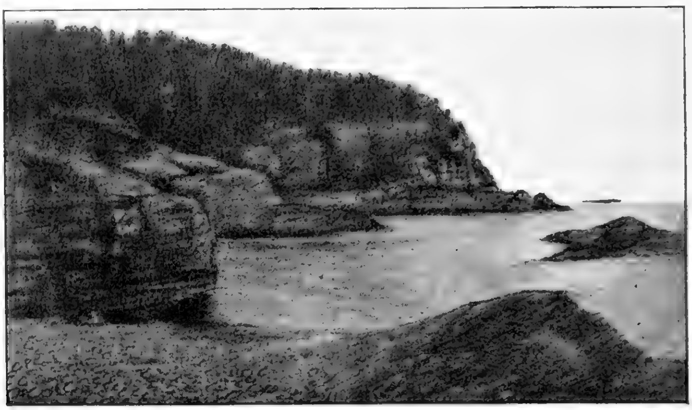


Fig. 100. Cliffs with low points on the southern end of the Langesund Peninsula. (July, 1904).

Fig. 104 gives a photographic view of Fornebo Peninsula and the islands and hills towards the south-southwest and west-southwest taken from the top of the writer's house on the hill marked × in Fig. 102 in the northeastern part of Fornebo Peninsula. The peninsula as well as the islands and the low land to the right in the picture, form a nearly horizontal plane, distinguishing itself sharply from the steeply ascending hills behind: Skogumsås, Vardeås, &c. As the land is covered with pine wood, the plane appears in the picture higher than it actually is. The Nesodd Land to the left in the picture, rises very steeply from the fjord, with

Fig. 101. Indications of a strandflat on the eastern side of Langesund Peninsula. (July, 1904).

Fig. 102. The inner end of Christiania. The *dark hatching* indicates the strandflat with heights lower than 30 metres.

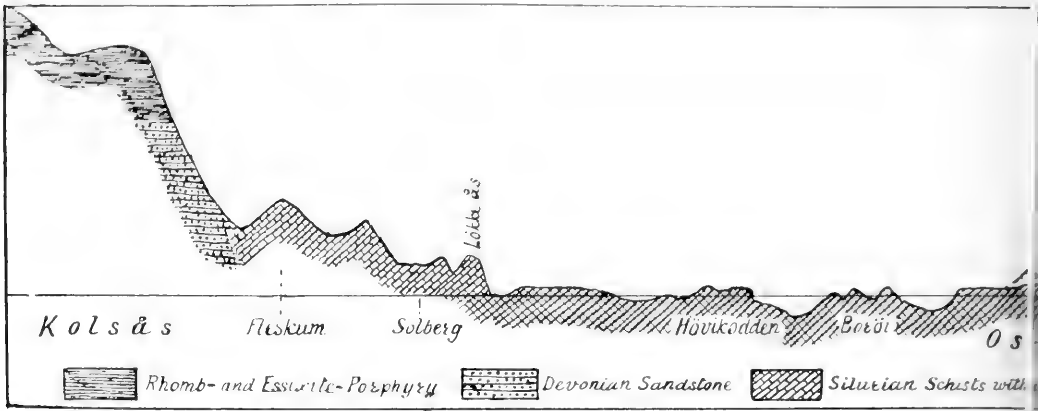


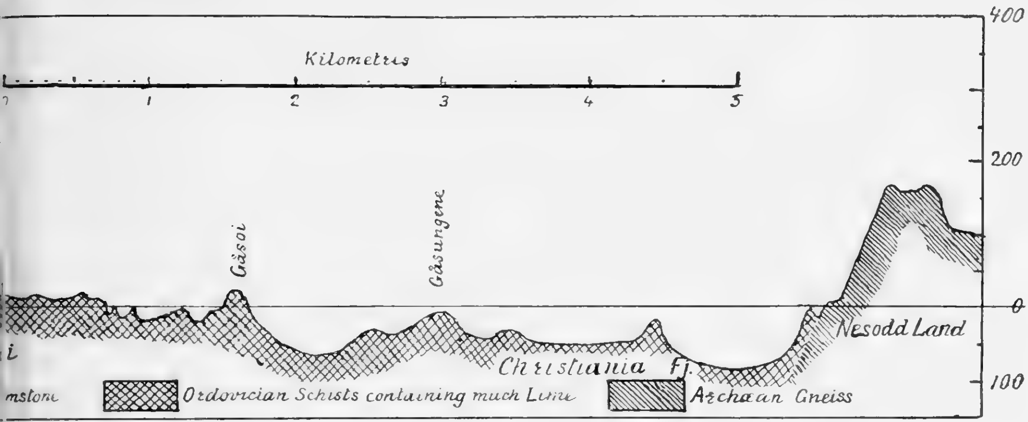
Fig. 103. Profile across the inner end of Christiania Fj

indications of a strandflat formed by the islands of Ildjernet (seen in the picture) and Steilene at the foot of the steep mountain side (cf. Fig. 102).

This plane cannot, in my opinion, have been finally formed by subaërial denudation, and still less by glacial erosion. These processes would have made the general surface of this land more sloping or more bowl-shaped. The plane must have been finally levelled by marine denudation, *i. e.* shore-erosion by frost, in a similar manner as we have seen (p. 37) that shore-ledges have been formed at present sea-level in postglacial time in this same region.

The shore-erosion has found very favourable conditions for work in this region of easily crumbling argilaceous schist, dissected by glacial erosion into numerous islands, peninsulas, and points with a very long shore-line for attack. It is therefore not surprising that, although the inner part of Christiania Fjord was probably filled by glaciers during the greater part of the various glacial epochs, there has still been time enough for the shore-erosion to cut this plane, extended over so wide an area, in a low dissected land where there was only a comparatively small quantity of easily crumbling rock to remove in order to level the surface down to sea-level.

The plane thus formed has afterwards been eroded by the glaciers of the last glacial period which have denuded more or less the weaker parts of the rocky surface, while the more resistant parts have been less affected and form ridges largely going in the direction of the strike of the folded schists. The fairly flat summits of these ridges have to a great extent nearly uniform heights of between 20 and 30 metres above sea-level. In some places, especially on Snaroi, Ostoi, Bronnoi, and Nesøi (see the white spots in Fig. 102) they rise above 30 metres, and only in a few cases they rise to 40 and 50 metres.



h Kolsås to Nesodd Land, from A to B in Fig. 102.

It is difficult to decide what the exact height of this plane may originally have been, because after its final planing, it has been denuded by glacial erosion. Most of the land on the Fornebo Peninsula, for instance, is lower than 20 metres, and a great deal of its area is even lower than 10 metres, but this chiefly consists of fields formed of loose material. The many long rocky ridges running in the direction of the strike (about WSW to ENE) [cf. Werenskiold, 1911] between the flat fields are mostly between 10 and 20 metres high, with their fairly flat summits slightly above 20 metres. They show, however, distinct traces of glacial erosion. Their summits are rounded and the dykes of diabase rise above the argilaceous schist with rounded, polished, and striated surfaces (cf. Fig. 17). These rocky ridges have, therefore, obviously been somewhat lowered by the glacial erosion, but it is difficult to say exactly how much. I think, however, that the general plane may be assumed to have been about 25 metres above present sea-level, or perhaps a few metres more.

The sides of the rocky ridges are frequently so steep and abrupt that they look like shore formations or shore cliffs somewhat modified by later glacial erosion.

Fig. 104. The plane of Fornebo Peninsula and the islands and land to the south-west, seen against the surroundung higher hills. View from south to west-southwest from the top of the writer's house near Fornebo. (April, 1922).

According to what has been said above, the low level region at the inner end of Christiania Fjord, may be considered to be a regular strandflat formed in a manner similar to that of the west coast.

Whether there are two different levels, or even more, in this region, is difficult to decide, because the original plane or planes have been more disturbed by the late glacial erosion than those of the strandflat of the Norwegian west coast. Another difficulty hampering the investigations is also that the strandflat in the Christiania region is almost everywhere wooded.

Although it may look as if there are indications of at least two levels in several places, I dare not express a definite opinion without having made more careful investigations.

IX. THE STRANDFLAT ALONG THE COAST FROM SOGNE FJORD TO VIKTEN.

The Region of Søndfjord, Nordfjord, and Stad.

The Norwegian west coast in the region of Askevoll and Floro north of Sogne Fjord has a distinctly developed strandflat in the shape of numerous low islets, skerries and sunken rocks, and in many places there is a low foreland in front of the mountainous coasts of the higher islands and the mainland. The rocks are here Silurian schists and later (upper Silurian and Devonian) sandstones and conglomerates; and in some few places (near Askevoll and on the southern side of Bremanger Land) granite. I have not had an opportunity of investigating the strandflat in this region. By a study of the charts of the coast one will notice that in many places the submerged platform with shoals and rocks is more widely developed in this region than outside the coast farther south.

Dr. Reusch gives [1901, p. 189] an illustrative drawing of the narrow strandflat (10 metres above sea-level) at the foot of the steep mountain side on the outer coast of Askroven Island in Søndfjord. Small cirques with nearly flat floors have there been carved by the shore-erosion into the mountain sides.

North of Bremanger Land the coast is built up of Archæan rocks, and the strandflat is less conspicuous.

Neither on nor outside the high Stad Promontory are there indications of a strandflat, excepting perhaps a few sunken rocks. In this respect the Stad Land forms an exception from almost the whole rest of the west and northwest coast of Norway.

Along the coast northeast of Stad Land there is again a strandflat consisting of a submerged platform with numerous skerries and rocks, and often a low foreland on the islands. The rocks are presumably Archæan.

The Region of Ålesund.

The high islands Godoi and Valderoi, outside Ålesund, have the typical shape of a hat swimming on the water, the low strandflat forming the flat brim above sea-level (Fig. 105). This shape, which was already

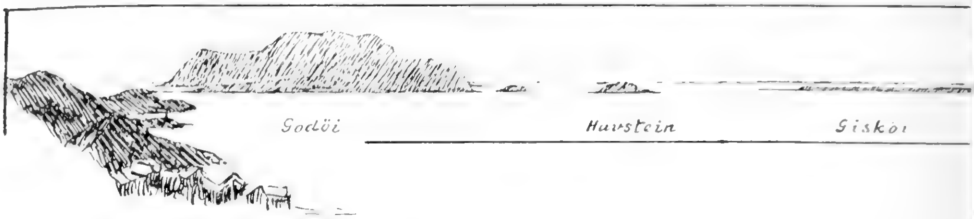


Fig. 105. Islan

described by Dr. Reusch as characteristic of the strandflat, is often seen even on small islets and holms.

I measured the heights of the strandflat on the southern and south-western side of Haroi to be between 17 and 25 metres above the sea, on the west coast of Mien Island 28 metres, and on the small Dronen Island, with the mountain Dronehatten in the middle, 18 metres. These islands are northeast of Ålesund, and the heights were measured with sextant from off the coast of Fjortoft Island, where I was lying at anchor on August 22nd, 1909. Owing to the distance the measurements cannot be expected to be very accurate.

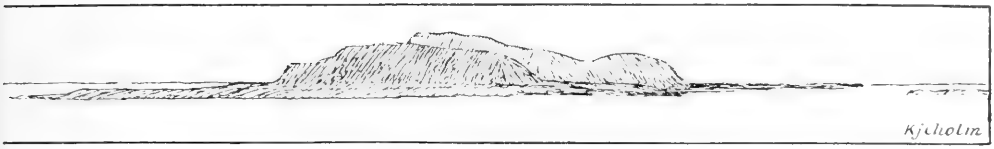
The Borgund Fjord, just south of Ålesund, is narrow and fairly well sheltered against the open sea outside. There is none the less a well developed strandflat along the northern coast of Suloi, and on the islands in the fjord (Fig. 106).

The mainland as well as the islands in the region of Ålesund are formed of fairly resistant rocks, generally supposed to be Archæan, but lately by J. Schetelig [1913] maintained to be younger eruptive gneisses of the great Caledonian "folding-ditch" of Northern Norway. The low parts of the row of islands north of Ålesund — including Giskoi, Valderoi, Vigra, Lepsoi, Haramsoi, Flemsoi, Fjortoft, and Haroi — are to some extent built up of quaternary (glacial) material. But the strandflat described above, is largely cut in solid rock.

From the seaward coast of these islands submerged platforms, with hundreds of rocks and shoals in or slightly below sea-level, extend 7 to 10 kilometres out into the sea.

It is a noteworthy fact that the submerged platforms with sunken rocks and shoals are much broader in these northern regions than anywhere along the Norwegian coast further south. Advancing along the coast northeastwards and northwards we will find the submerged strandflat increasing still more in width.

This striking difference in the development of the submerged strandflat cannot be explained by a difference in the geological structure of the coast, because in this region the coast is built up of very much the same kind of what is supposed to be Archæan rocks, as in many places



Valderoi

outside Alesund.

further south; the rocks of this region are at any rate not less resistant to erosion than those further south.

The natural explanation of the increasing development northwards of the submerged platforms of the strandflat is in my opinion that in these northern regions the marine erosion, and especially the shore erosion by frost, has been much more favoured by severe climates than further south. Hence, the quantity of rock cut away by shore erosion during past ages much increases northwards with increasing latitude.

There is also the likelihood that in these northern regions the climates have, probably always, been more stormy than farther south. As I have pointed out before, the transporting and erosive capacity of the waves increases with something beween the third and sixth power of the velocity of the wind. Along a coast like this, exposed to the full power of the sea, this may also be of much importance for the marine denudation.

The severer climates of the northern regions may also increase the subaërial denudation, but not sufficiently to explain the striking difference in the development of the strandflat and its submerged platforms. It is a striking fact that in these northern regions the submerged parts of the strandflat have considerable areas as compared with those of its emerged parts.

In the region of *Hustad* there is a conspicuous level strandflat extending over the low skerries outside the coast, as well as over the outer border of the mainland, where the steep, often precipitous mountain sides

Fig. 106. Strandflat in Borgund Fjord, inside Alesund.

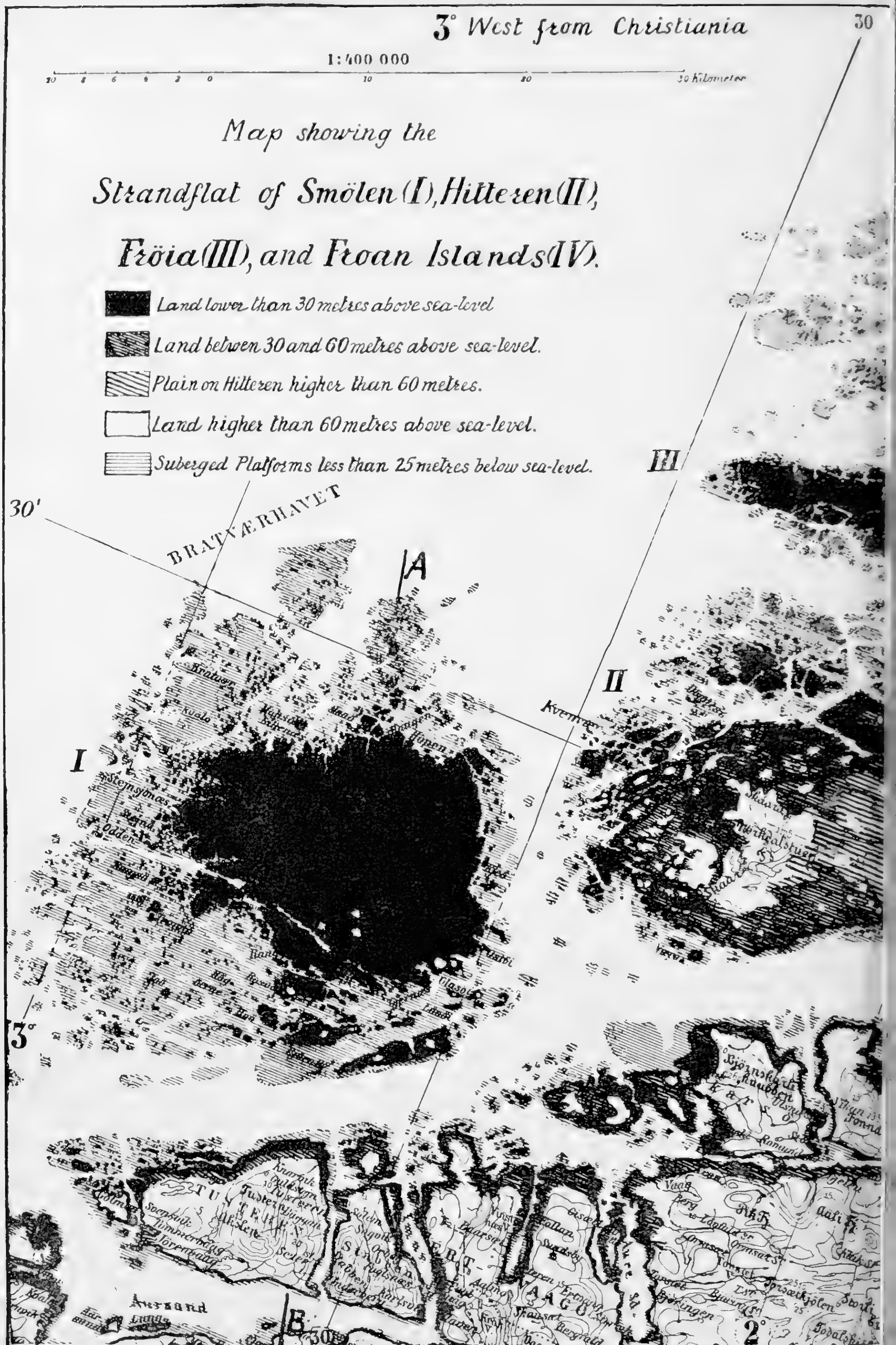
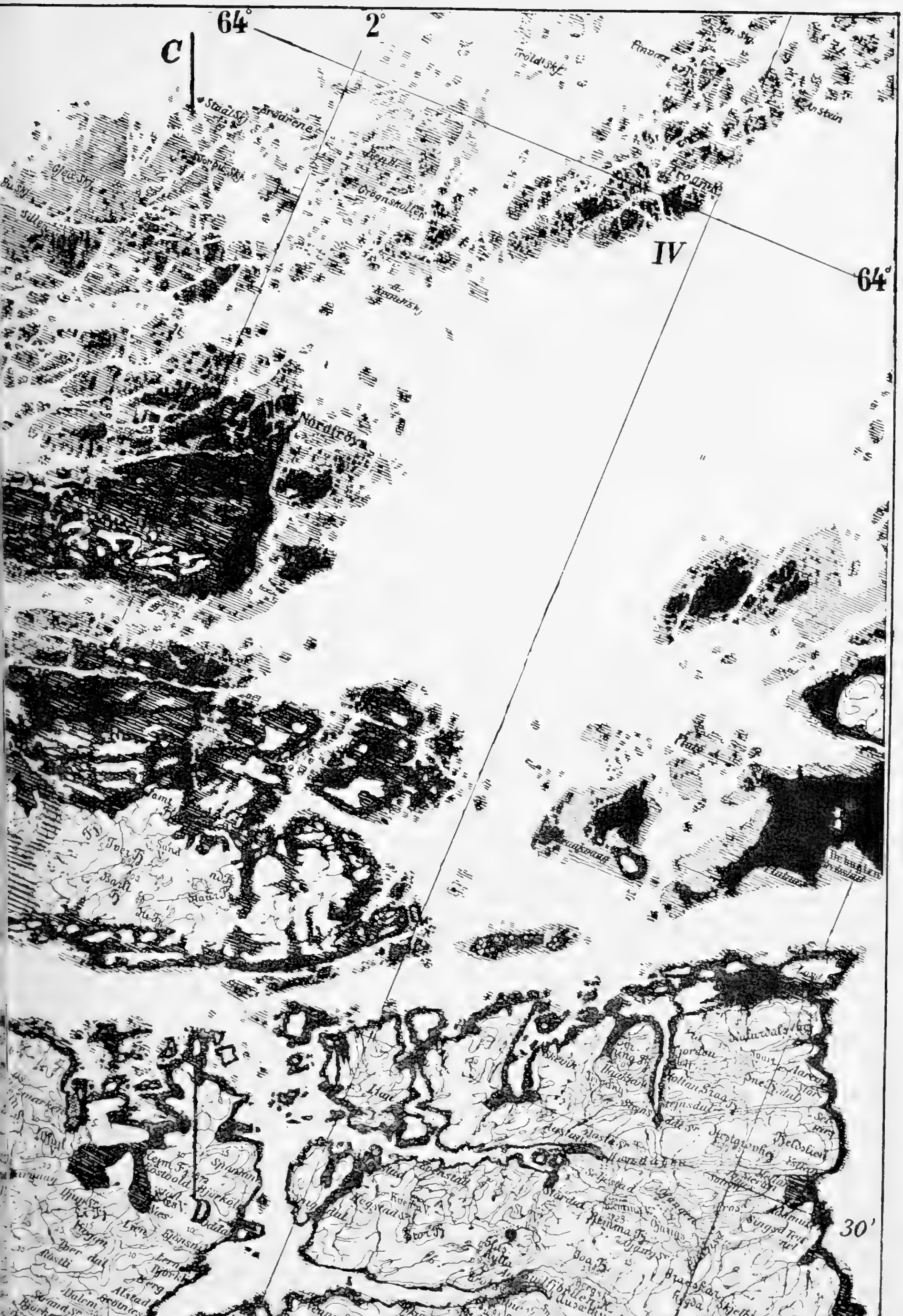


Fig. 107. Map showing the strandflat in the Region of



Solen (I), Hitteren (II), Froia (III), and Froan Islands (IV).

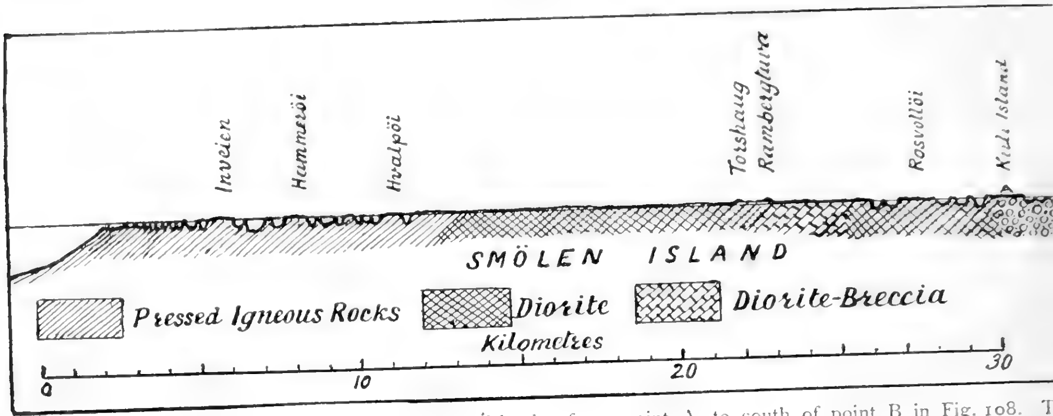


Fig. 108. Profile across Smolen and Tusteren islands, from point A to south of point B in Fig. 108. T gives the natural relati

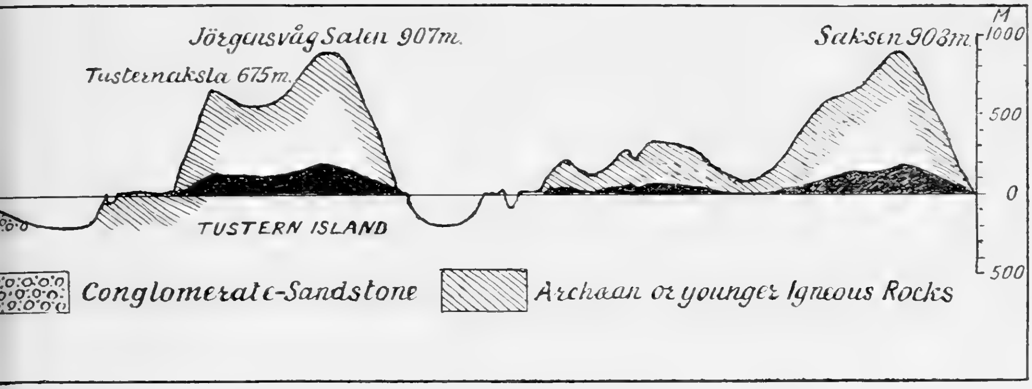
rise abruptly above the plane to heights of 600 and 700 metres above the sea. This coast gives a convincing impression of how the plane of the strandflat must have been cut horizontally into the oversteepened mountain sides [cf. Nansen, 1904, Pl. V, Fig. 5]. The high mountain Stemshesten is conspicuous, rising as a "stack" above the level plane which, however, is to a great extent formed of quaternary loose material on both sides of the mountain.

The mainland as well as the islands of this region is built up of rocks, supposed to be Archæan, but Schetelig [1913] considers them to be younger eruptive gneisses and igneous rocks.

The strandflat extends as submerged platforms with innumerable shoals and rocks 9 to 15 kilometres out to sea, a region much feared by all seafarers.

The surfaces of these submerged platforms are fairly uneven and are dissected by numerous depressions making the depths vary. As will be mentioned later, this is generally the case where the submerged platforms are built up of resistant rocks like granite or gneiss, &c. There are many scattered shoals and rocks near sea-level, or about 5 to 10 metres below it, some rocks and skerries also rise above the sea. It is difficult to decide exactly at what level the plane of these submerged platforms stands. There is no sharply defined edge of the plane, as the surfaces of the platforms slope towards the deeper sea on the sides, as a rule without any sharp break. If, however, the tops of the many shoals and sunken rocks may be taken to indicate approximately a plane, this stands very near present sea-level, or perhaps five to ten metres below it.

Outside the coast in the region of Christiansund, there is a series of submerged platforms with shoals and rocks and small islands, situated, as it were, on a submarine ridge running parallel to the average direction of the coast, and forming a continuation of a ridge on which are situated:



tical scale is 5 times exaggerated in relation to the horizontal scale. The profile in black on the land height to length.

Orskjærene north of Hustad, Ona (with Ona Lighthouse), and surrounding submerged platforms, Sandoi, and the before mentioned series of islands, Haroi, Fjortoft, Flemsoi, Haramsoi, Lepsoi, and Vigra. The high islands of Smolen, Hitteren, &c. are situated on the same ridge to the northeast (see later).

This ridge was probably formed during the great Caledonian mountain folding of this part of Norway. It is separated from the coast of the mainland, and the mountainous islands near it, by a channel (the fairway

Fig. 109. The surface of the strandflat on Smolen. Northward view from the Nelvikberg (67 metres above sea-level) towards Roksvåg. (Photograph by P. Schei. July, 1904).

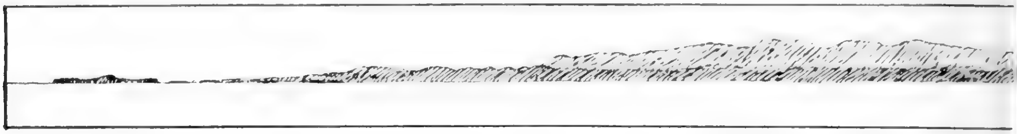


Fig. 110. Strandflat along the west coast of Hitteren, with the Skår Fjell behind, seen

or 'leden'), often more than 200 metres deep. The distance from the coast to the outer edge of these submerged platforms is in the region of Christiansund about 12 or 13 kilometres. The submerged plateau of *Grip* with numerous islets and skerries, outside Christiansund, may be especially mentioned.

These submerged platforms have uneven surfaces similar to those of the platforms, just described, to the southwest. The Grip Plateau seems, however, to have in parts somewhat more level surfaces with more distinctly defined edges. It may probably be built up of somewhat less resistant rocks, like those of the Smolen Plateau to the northeast.

The Region of Smølen, Hitteren, and Frøia.

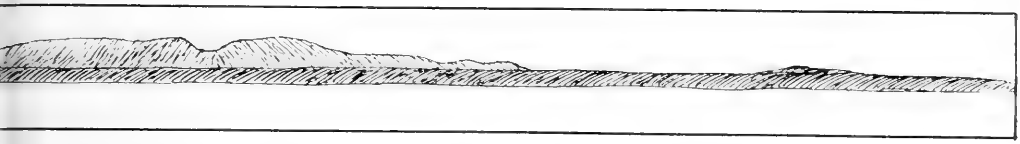
The region of Smolen, Hitteren, and Frøia is interesting because of the complexity of the geological structure, and the unusually well developed strandflat which cuts horizontally through the various geological formations, frequently without any appreciable break in its level plane (cf. Figs. 108 and 111).

Especially on *Smolen* and its neighbouring islands (see the map Fig. 107) we find the most perfectly developed plane of the emerged strandflat which occurs along the coast of Norway.

Smolen island is 16 kilometres from south to north and 20.7 kilometres from west to east. The whole of the island is one unbroken plain, which is especially even in its northern part where only two small hillocks (Dyrnestuva and Måbergtuva) rise slightly above the plane. The height of this almost perfect plane is 15 to 20 metres above sea-level. In the southern part of the island the plain is somewhat more undulating and a few isolated hillocks rise above it to 26 metres (Storsetberg), 33 metres (Hoaåsen), 35 metres (Torshaug), 39 metres (Rambergtuva), and one even to 45 and 67 metres (Nelvikberg) in the southeastern corner.

The northern part of Smolen consists of diorite with a belt of pressed igneous rocks along the northwestern coast [cf. Schetelig, 1913]. In the southern part there are various rocks, probably of Silurian age [Reusch, 1914, Schetelig, 1913] with enclosures of a limestone probably of Ordovician age [Holtedahl, 1914]. On the islands to the south of Smolen, on Kuli Island, Edoi, &c. there are conglomerate and sandstone, probably Silurian.

The profile Fig. 108 from the mainland (Saksen), across Tusteren Island, Kuli Island, Smolen, and the small islets to the north, gives the



from the eastern side of Smolen. (After photographs by P. Schei, July 11, 1904).

various rocks according to Schetelig's map [1913]. The strandflat is here about 36 to 39 kilometres broad, from the foot of the Tusteren mountains to the edge of the outer platform with skerries (see the map Fig. 107). This profile demonstrates the remarkable evenness of this strandflat, its plane cutting horizontally through the geological formations, southwards to the foot of the steep mountains. The depressions between the islands north of Smolen, at Hvalpøi, Hammerøi, Inveien, &c., are drawn much too deep in the profile (Fig. 108). These depressions are not deeper than 10 to 20 metres below sea-level, generally less. The same is also the case south of Smolen, at Rosvolløi and Kuli Island.

On the islands south of Smolen, built up of conglomerate-sandstone, there are a few small hills rising above the plane: two hills to 44 and 78 metres (on Kuli), two hills to 39 and 47 metres on Edøi, and one hill to 40 metres on each of the small islands Orten and Glasøi.

Fig. 109 is a photograph taken by Mr. P. Schei in Juli 1904 from Nelvikberg (67 metres high) on southeastern Smolen. It gives an illustrative picture of the even surface of the strandflat on Smolen. The rocks are here diorite and are rounded by glacial erosion. The flat plain of northern Smolen is to a very great extent covered with peat-bogs.

As our map Fig. 107 shows, Smolen is surrounded by a submerged strandflat which is about 12 kilometres broad at its broadest on the southwestern and the northwestern sides of the island. The area of this submerged strandflat is considerably greater than that of the whole island.

Our map gives the submerged strandflat at levels less than 25 metres below sea-level. Unfortunately lack of time has not allowed the writer to draw more detailed maps showing its surface topography. It is dissected by channels and depressions but not as much as the submerged platforms to the southwest which were described above. Its surface is more level than the surfaces of those, and in great parts it forms extremely level horizontal planes, near present sea-level. Hundreds of islands and rocks, rising above the sea, are scattered almost over its whole area, also near its outer edges.

If in a detailed chart the isobaths be drawn for 10, 20, and 50 metres of depth, it will be seen that the isobath for 20 metres has very complicated shapes, it comes almost everywhere close to the isobath for 50 metres near the outer edges of the platform, and even the isobath for 10 metres comes very near them to a great extent. This indicates that the edge of the submerged strandflat is fairly sharply defined, and is in most places

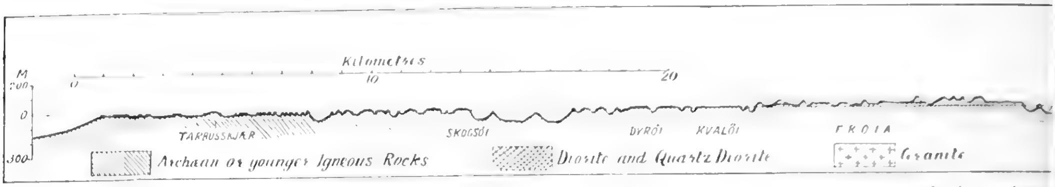


Fig. 111. Profile across Froia and Hitteren from point C to point D in Fig. 108. The vertical scale is 5 times between height

less than 10 metres below sea-level, *i. e.* the edge of the horizontal plane indicated by the summits of the many shoals and sunken rocks, where it is bounded by the steeper sideslopes of the platform.

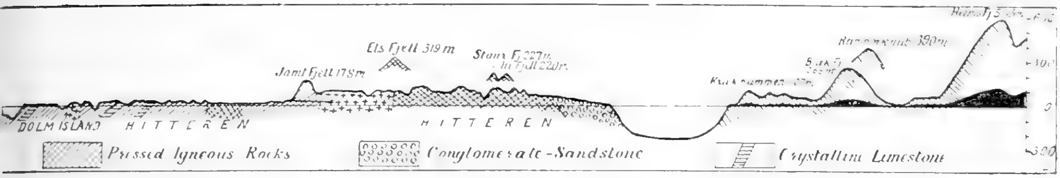
The topography of the large island *Hitteren* shows a considerably greater variation than that of Smolen, but there is a well developed strandflat, especially in its western (Fig. 110) and northern part (cf. Fig. 107). The strandflat is, however, not so perfectly level as on Smolen, and is on the whole somewhat higher, to a great extent above 30 metres. It cuts through a variety of geological structures.

The northern and northeastern part of the island is according to Schetelig [1913] built up chiefly of pressed igneous rocks, gneisses and gneiss-granites, with a belt of diorite passing across this region from west to east. The middle and southeastern part of the island consists of diorite, with a border of conglomerate and sandstone (probably of Silurian or early Devonian age) along the eastern half of the south coast. The western part of Hitteren is built up of comparatively young granite [cf. Schetelig, 1913, Reusch, 1914].

In the profile (Fig. 111), across Hitteren and Frøia, the occurrence of the various rocks is indicated according to Schetelig's map. The strandflat is seen cutting through the various geological formations to some extent, but in the southern half of Hitteren the land is higher (cf. Fig. 107). This region consists to a great extent of diorite. There are a good many hills rising to 160 metres above sea-level or more, some even to 220 and 227 metres, and Els Fjell to 319 metres. The strandflat extends almost horizontally to the foot of the higher hills (cf. Jamt Fjell in Fig. 111).

In the western granite region of Hitteren there is also a small sharply defined mountainous area, rising abruptly above the plane of the strandflat to heights of 150 and 200 metres, Skår Fjell even to 306 metres (Morvollstuva) and 369 metres (Morkdalstuva). Otherwise the strandflat is well developed in the coastal region of this western part of the island and on the many smaller islands outside the coast to the west and southwest, likewise consisting of granite, as well as on the small islands to the northwest (Sæbuoi, Stromsoi, Gjedsoi, Skåroi, &c.) consisting of diorite.

Although as was said above, the strandflat of Hitteren is not on the whole as remarkably level as that of Smolen, still it is extremely even in



exaggerated in relation to the horizontal scale. The profile in black on the mainland gives the natural relation and length.

many places, for instance in the region of Kvenvær, as Schetelig has pointed out to me.

Fig. 112 is a photograph of the mountain Tonningen (231 metres above sea-level) in the western granite region of Hitteren, taken by Prof. J. Schetelig. It demonstrates the abruptness with which the mountains rise with their steep sides above the denudation plane of the strandflat. This plane as well as the mountain is formed of the same granite and there is no difference in the geological structure to account for the configuration. Forms like these cannot therefore be formed solely by subaërial denudation, which would necessarily give to the mountains bounding the plane less abruptly ascending sides. They might be formed by glacial erosion, and the ridges of the surface of this strandflat have obviously been rounded by glacial erosion, as Fig. 112 shows. But if this glacial erosion had lasted long enough to produce mountain forms like Tonningen, the strandflat would necessarily have been deeply dissected into a much more uneven surface than we now find. The only natural explanation is that before the last glacial erosion (of the last glacial epoch) the marine denudation finally planed the surface of the strandflat which rises gently from the shore to the foot of the mountain slope probably at about 30 metres above sea-level.

Between the western granitic mountain area and the more extensive dioritic mountainous region to the east, a broad and flat plain extends across the island from the south coast to the northwest coast, forming a continuation of the strandflat, rising gently to somewhat more than 60 metres above the sea, but its greater part, especially in its northern and northwestern area is less than 50 metres high. According to kind information from Schetelig, this low region is built up of crystalline schists, mica-schists, and hornblende-schists which have been more easily denuded than the granite to the west and the more resistant diorite to the east.

The strandflat continues along the northern coast of Hitteren, formed of pressed igneous rocks, gneisses, and some granite and amphibolite, &c. The plane is well developed at heights of between 20 and 35 metres above the sea with some few hills rising to about 50 metres. The long Dolm Island to the north is also a continuation of the low strandflat with two isolated hills rising to 46 metres (Storvarden) and 70 metres (Hjertås) above the sea.

Frøia is chiefly built up of granite which in some places is pressed. Along its southern coast there is dioritic gneiss. Frøia is very low and most of its area belongs to the strandflat, with some hills and ridges rising above its plane, especially in the southern or southeastern part of the island (see Fig. 107), to heights of about 50 to 70 metres.

The height of the strandflat of Frøia is 20 to 30 metres above the sea in its western part and along the northern and eastern coast. In its inner and southern parts the land is mostly more than 30 metres high. The surface is considerably less even than the surface of Smølen, and has many ridges and depressions. This is obviously due to its geological structure, the granite giving often a rough and broken surface. As Schetelig has pointed out to me, the unevenness in this case may especially have been caused by alternations of regions with more resistant porphyric granite and regions with pressed granite or gneisses, less resistant to erosion.

Along most parts of the coast of Hitteren and also along the south and west (or northwest) coast of Frøia the submerged strandflat is comparatively narrow and is much dissected and uneven. This is also the case along the coast of the mainland (see Fig. 107). But to the north of Frøia a submerged strandflat with hundreds of islands and skerries extends 20 kilometres into the sea, and continues 50 kilometres towards the northeast, comprising the extensive region of the many low and flat Froan Islands (see Fig. 107). The surface of this submerged platform is much dissected as the map may give the impression. But in some parts, *e. g.* in the region of Sillen, Bu Skjær, and Gjeit Skjær northwest of Frøia (see map Fig. 107), the surface is extremely level over considerable areas, forming horizontal plains near sea-level or only a few metres below it, and having well defined edges at depths of less than 10 metres.

The width of the strandflat from the edge of this partly submerged platform to the foot of the higher land on Hitteren is 43 kilometres. But if we reckon it to extend across the Hitteren to the foot of the mountains on the mainland the width will be 58 kilometres. The width of the strandflat from the edge of the outermost submerged platform outside Smølen to the foot of the mountains on Tustern is 40 kilometres. The distance from the outer edge of the submerged platform of the Froan Islands to the foot of the high mountains on the mainland is about 46 kilometres.

The strandflat is here conspicuously much wider than in any region along the Norwegian coast to the south, and is partly developed to fuller maturity. The reasons may be several.

On the one hand the geological structure has favoured the formation of a strandflat. By the Caledonian mountain folding a fairly low land was made to emerge along the top of one or two folding ridges far out in a stormy sea, where it was exposed to the full fury of the marine denudation. This low land was to a great extent built up of rocks, dioritic

Fig. 112. The mountain Tonningen, seen from the north-western shore of Laugen Lake, which is seen in the foreground. (Photograph by J. Schetelig, 1909).

schists and pressed schistose igneous rocks, which were fairly liable to erosion by subaërial denudation as well as by marine denudation.

On the other hand the erosion, the subaërial as well as the marine erosion, has been much more favoured by a severer climate in this northerly latitude than it was along the coast further south. The severe and frequent frosts of a beginning glacial period would commence much earlier here and last much longer than along the southern coast of Norway. The subaërial denudation would be much increased by the disintegrating effect of the frosts, and the shore erosion (by frost), assisted by the stormy sea, would become very vigorous, planing down the low land, which was already dissected into numerous small islands during previous glacial periods.

Finally the probability is that these islands out in the sea, were covered much later by the inland ice than the coast of the mainland, and they were therefore exposed to the destructive forces of a glacial climate, combined with the attack of the sea, during a much longer period than other parts of the coast.

It seems to me that these are reasons giving a satisfactory explanation of the occurrence of a very wide and fully developed strandflat in this region, as well as along the coast of Nordland to the north, as we shall see later.

It has been maintained, by Ahlmann and others, that the glacial erosion might have helped to plane the strandflat. Such a view seems contradictory to what may now be considered as an established fact, namely that it is greatly the glacial erosion which has dissected the coast into its thousands of islands and skerries. If, for instance, we look at the map Fig. 107, it would indeed be difficult to understand why the glacial erosion should have helped to plane the surface of Smolen and Frøia while it has dissected the surrounding land into those swarms of islets, often with deep sounds between them. It would seem absurd to think that the same agency could have had such entirely opposite effects in the same region, where moreover there would be no apparent differences in the geological structure to account for it. The fact is obviously that the geological erosion has generally and everywhere a pronounced tendency to dissect the land surface and not to plane it.

It might be asked why the strandflat of Smolen is somewhat lower and much more even than that of Hitteren and also to some extent than that of Froia. The reason may chiefly be differences in the geological structure, the rocks of Smolen having been more easily and more evenly eroded. The situation of the islands may also have been of some importance. Although in my opinion, the shore erosion by frost has been the most vigorous factor for the marine denudation, the work of the waves (the surf) has also been very important especially for the transport of the waste, and it is obvious that Smolen and to some extent Frøia has always been exposed to a more effective wave action than the more protected Hitteren, as in this region the prevailing winds were probably always southwesterly, as long as the Norwegian Sea was not ice-covered.

I have pointed out before that the wave action on a coast exposed to the full fury of the open sea, may also have a tendency to wear down the strandflat cut by the shore erosion by frost to a level somewhat lower than the initial one. I do not believe, however, that this would be a feasible explanation of the comparatively low flat level of Smølen, because in that case its plane would naturally be expected to slope somewhat seawards, and could not be so almost perfectly horizontal as it actually is, differing only some few metres in height from north to south.

It is, however, a question whether there are not two levels of the emerged strandflat in this region as in other regions of the Norwegian coast. In that case we may expect the plane of Smolen to belong to the lower level, it having almost exactly the same height as the lower level of the strandflat at the mouth of Sogne Fjord.

From Trondhjem Fjord to Vikten.

Along the coast between Trondhjem Fjord and Folla Fjord there is a distinctly developed strandflat in front of the steeply ascending mountains, and there are many submerged platforms with swarms of islets and skerries outside the coast. The width of the strandflat from the foot of the mountains to the edge of the submerged platforms, at less than 20 metres below sea-level, is not very considerable in this region, and decreases northwards from about 17 kilometres in the region of Melstein and Lovoi (63° 56′ N. Lat.) to a few kilometres in Folla Fjord.

The coast of this region is built up of pressed igneous rocks generally considered to be of the Archæan age, but which Schetelig [1913] holds to be younger.

To the north of Folla Fjord a group of numerous islands, with a submerged platform outside, extend far seawards from the coast of the mainland. It is Vikten with its innumerable islets and skerries built up of granite. These islands and platform are probably situated on a continuation of the large folding ridge or anticline on which the Froan Islands are situated to the southwest [cf. Nansen, 1904, Pl. XI].

A strandflat with heights less than 30 metres above sea-level, extends over a great part of Inner Vikten island. But many small hills rise above the level of the strandflat to altitudes of 40 and 50 metres and more, and several greater hills or ridges even to between 100 and 150 metres. On the whole the strandflat has not been developed to any high degree of maturity on this island and that is still less the case on Outer Vikten, but the islands to the north: Kalvoi, Borgan, Rodoi, &c., are very flat with a conspicuous strandflat, and only some few isolated hills rise above 30 metres.

It is obvious that the general level of the strandflat in this region, wherever it has been developed, has a height of less than 30 metres or perhaps nearer 20 metres above sea-level. The area with heights between 30 and 60 metres is only a very small part of the low land, and the foot of the hills, surmounting the plane of the strandflat, may as a rule be considered to be below 30 metres above the sea. This is still more marked further north along the coast of Helgeland.

In this respect there is a difference between the strandflat of these northern regions, and the strandflat of the Norwegian west coast further south. For instance, in the regions of Radøi, Store Sotra, Bømlo Island and Stord Island, &c. the greater part of the low land forming the strandflat is somewhat higher than 30 metres above sea-level, on Stord Island even higher than 40 metres. In the regions of Karmoi and Stavanger a considerable part of the strandflat is higher than 30 metres, although a great part of it is about 20 metres high or even less. On Smølen the whole strandflat is less than 30 metres high, to a great extent about 20 metres or less. On Frøia a great part of the strandflat is less than 30 metres high, but about an equal area is between 30 and 60 metres or largely between 30 and 40 metres. On Hitteren Island the strandflat is largely somewhat higher than 30 metres, though along the northwestern coast of the island a considerable part of it is lower. The many islands north of Frøia are lower than 30 metres and largely about or lower than 20 metres, and so are the Froan Islands, where only three or four solitary hills on Værøi, Risoi, and Kunna rise to 31, 35, and 49 metres above the sea.

On the whole the emerged strandflat seems consequently to be somewhat lower along the northern part of the Norwegian coast, north of the Romsdal region, than we have found it to be south of the Sogne Fjord region.

Outside the Vikten islands, to the south, west, and northwest, there is a submerged platform, 10 to 17 kilometres broad, with a perfectly bewildering number of low islets, skerries, and shoals. The great majority of the thousands of shoals and sunken rocks on this platform is very nearly at sea-level or only a few metres below it.

By far the greater part of this submerged platform has depths of less than 15 metres below sea-level, and its general level is less than 10 metres below the water. It forms a fairly even and horizontal plane extending over many kilometres. It is traversed by many narrow channels, sometimes 50 to 100 metres deep, and at its outer border the sea-bottom falls abruptly towards depths of 150 to 200 metres of the sea outside.

The edges of the platform along the traversing channels as well as along its outer border are as a rule very sharply defined at depths of less than 10 metres.

It is the same kind of platform as those extending northwest of Smolen, and north of Frøia, with a general horizontal level at only some few metres below sea-level and sharply defined edges along the outer borders as well as along the many traversing channels.

It seems obvious that after these channels and depressions had first been formed, the initial projecting peninsulas and islands have been truncated at a level some few metres below present sea-level, to form these very even horizontal planes, which may have been still more even at first before they had been exposed to the subsequent erosion of glaciers.

Along the coast of Helgeland to the north, similar platforms have a still wider extent, and when describing that coast we shall return to the question of their formation.

X. THE STRANDFLAT OF NORTHERN NORWAY.

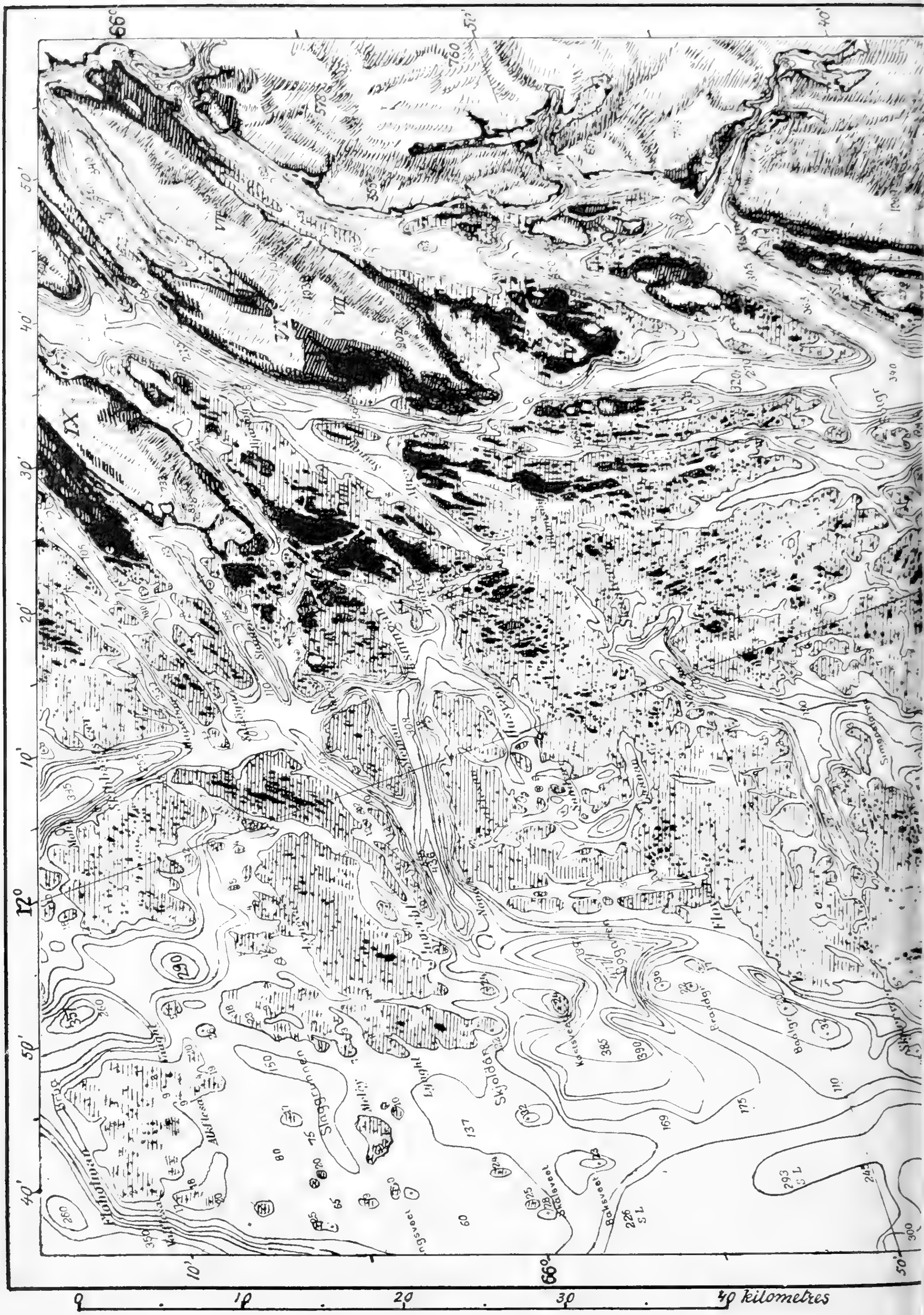
Helgeland.

The strandflat is very conspicuous and extremely well-developed along the coast of Helgeland between Vikten and Vest Fjord. It consists partly of an as a rule sharply marked plane or planes extending over the hundreds of low islands and peninsulas, and to a still greater extent of very flat submerged platforms with thousands of skerries, rocks, and shoals. It has an average breadth of 40 to 45 kilometres as stated by J. H. L. Vogt [1900]. In some places it may even be 50 kilometres wide, or more, from the steep mountain sides on the mainland to the outer edge of the submerged platform out to sea at less than 20 metres below sea-level.

The strandflat of Helgeland has been described by J. H. L. Vogt [in 1900 and in 1907], and after him by several authors, especially Høgbom [1913], Oxaal [1914], Sahlstrøm [1914], and Rekstad [1915]. In the two latter papers there are given some most illustrative pictures of the strandflat and the isolated mountains rising abruptly like 'stacks' above its plane. The present writer has also previously [1904] described the strandflat along the coast of Helgeland.

This coast has a very complex geological structure, and is built up of a great variety of rocks. They are chiefly mica-schists, granites, young gneisses, limestone, gabbro, some syenite, and some serpentine. These rocks vary much in their power of resistance to erosion, the granites and gabbros and also the serpentine (on Leka) and the gneisses are as a rule

Fig. 113. Map of the coast of Helgeland from Bindal Fjord to Donna Island. Scale 1 : 350,000. *Black* areas on land are lower than 30 metres above sea-level. The *dark hatching* on land indicates areas between 30 and 50 metres above sea-level. The *light hatching* in the sea indicate submerged plateaus with depths less than 25 metres below sea-level. *Isobaths* are drawn for every 50 metres of depth. *i. e.* for 50, 100, 150, 200, 250, &c. The *black spots* Indicate rocks and skerries above sea-level. The *small crosses* indicate sunken rocks and shoals. *crosses with spots* indicate rocks near sea-level, and *dotted areas* shoals near sea-level. The figures on the land and in the sea give the heights and depths in metres.
I Vega Island. II Sola Island. III Ulvingen Island. IV Hamnoi. V Tjotta Island. VI Alsten Island. VII The mountains „Syv Sostre“ (Seven Sisters). VIII Heroi. IX Donna Island.


66°
12°
IX
VII
Skjoldan
Slagrunnen
0 10 20 30 40 kilometres

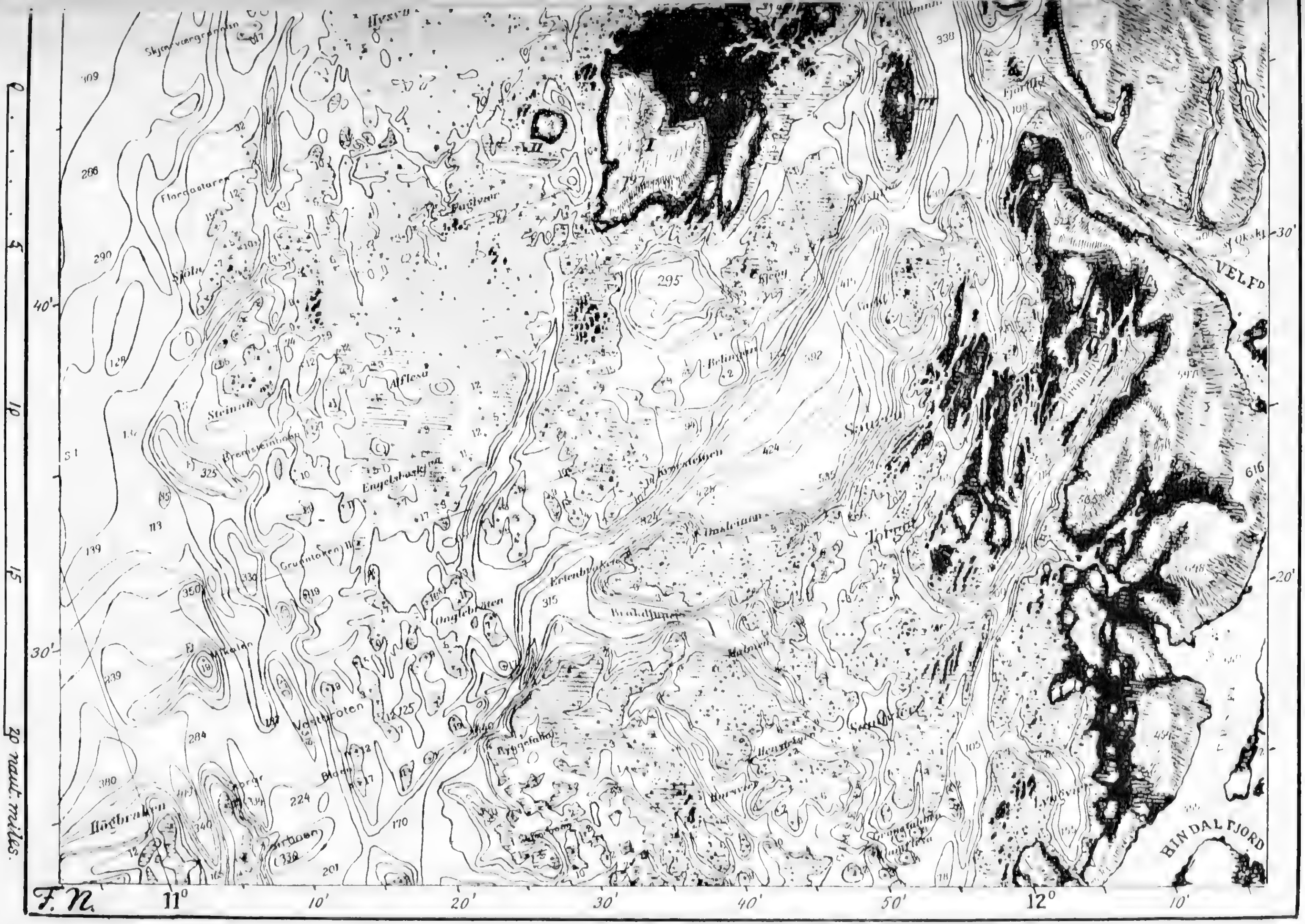


Fig. 113. Explanation on preceding page.

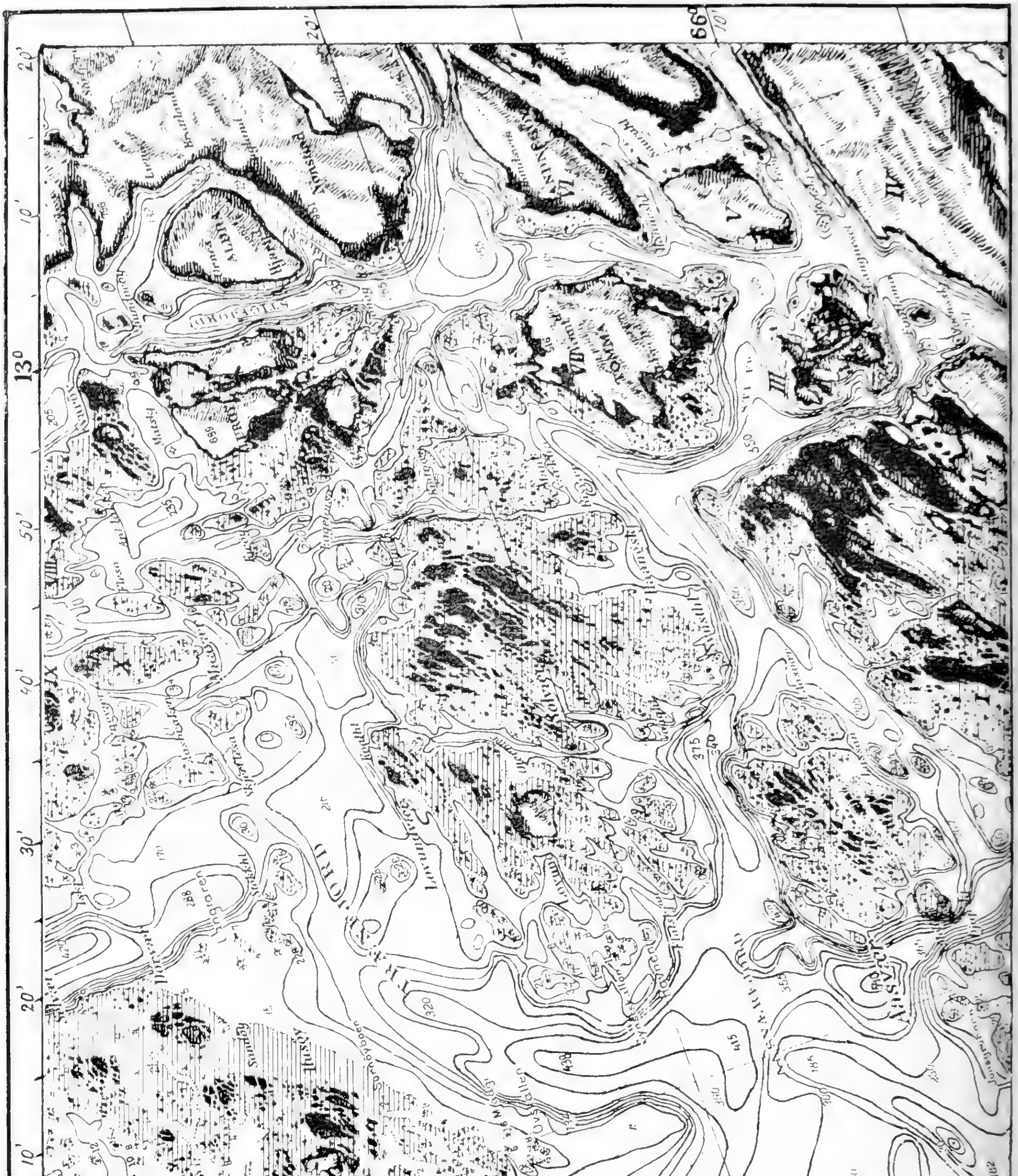


Fig. 114. Map of coast of Northern Helgeland, northward Continuation of the map Fig. 114. Besides the Isobaths for every 52 metres of depth, the Isobath for 25 metres is drawn with *dotted line*.

I Vandved Island. II Donna Island. III Lokta Island. IV Lifjell on the mainland. V Hugla Island. VI Handnesoi. VII Tomma Island. VIII Hestmannoi. IX Nesoi. X Sornesoi and Lyngvær.

more resistant than the limestone and the mica-schists. None the less the strandflat often cuts horizontally through the various rocks, without any appreciable difference in height, straight to the foot of the mountains and hills rising abruptly and steeply above its plane.

The region of Solvær and Lovunden (see Fig. 114) may be mentioned as an illustrative example. The many islands of Solvær consist of mica-schist and limestone on the southeastern islands, gabbro on the south-western islands, granite on the northern, and mica-schist, limestome, gabbro, and granite on the northeastern islands. Lovunden mountain, as well as the low islets to the east, south, and west of it, are built up of gneiss, while the low islands of Lovundvær to the north and northeast consist of granite, gneiss, mica-schist, and limestone. All these many islands, built up of rocks varying so widely in their power of resistance, are cut down to an almost perfectly horizontal plane at about 10 metres above sea-level, and the plane extends at the same level to the foot of Lovunden, which rises abruptly as an isolated 'stack' to 619 metres above the sea [cf. Nansen, 1904, Pl. V, Fig. 1].

This is a convincing piece of evidence that the plane of the strandflat has been cut by an agency working horizontally, *i. e.* by the shore erosion, and cannot have been formed by the vertically working subaërial denudation, nor by glacial erosion, which would necessarily have produced a marked difference in height between the regions of more and of less resistant rocks. The plane cuts in many cases so evenly across areas of entirely different rocks that it can only be explained as an effect of the shore erosion by frost. The wave erosion cannot have had very great direct effect, because it would produce greater difference in the level of the rocks with different power of resistance. In other cases there is such a difference, which may be accounted for by the wave erosion.

The mountains rising as 'stacks' above the strandflat consist very often of granite, *e. g.* on Vega and Sola islands, but in some cases, *e. g.* on Lovunden and Hestmannen (Hestmannoi), they are built up of gneiss, although the gneiss in other regions has been much denuded, and forms parts of the very low and level plane of the strandflat.

The reason why the strandflat is so well-developed along the coast of Helgeland may be especially two fold: On the one hand the severe climate of this northern region has been especially favourable for the subaërial denudation as well as for the shore erosion. It is for this latter reason that in postglacial time the now raised shore-ledges have been so well-developed in this northern region, and still better further north in Tromsø Fylke and Finmark, while they are hardly seen along the coasts of southern Norway.

On the other hand the rocks forming the outermost coast of Helgeland are on the whole less resistant to erosion than the rocks of the Romsdal and Søndmøre region and also on the whole less resistant than the igneous rocks of Lofoten and Vesterålen. It is furthermore probable that the initial outer coast land of the Helgeland region was comparatively low, and that no great quantity of rock had to be planed down for the formation of the strandflat, after this land, consisting of the low outer folding ridges of the great Caledonian mountain folding of Northern Norway, had been dissected into thousands of islands by the glacial erosion.

The stage of development of the strandflat varies somewhat in the different parts of the coast. In some regions, *e. g.* in Herøi, Dønna, and Solvær, the emerged surface is quite unusually level, whilst in other regions, *e. g.* on the Vikten islands, in the region of Torghatten, &c., the surface is undulating with more hills and ridges rising to different heights above the plane of the strandflat. This depends naturally on the degree of maturity to which the strandflat has been developed. In regions with less resistant rocks, or where the land was more dissected into smaller islands, and where there was much less rock to be planed down, the strandflat was sooner developed to full maturity than in regions where the conditions were less favourable. Along a coast where the conditions differ much in this respect we may therefore expect to find the strandflat in all stages of maturity.

It has to be admitted that if one considers the strandflat to have been formed solely by wave erosion, it might be difficult to understand how any strandflat at all could have been formed in regions where numerous hills and ridges are still rising above the plane of the strandflat, with no great distance between them. One would expect that the waves would have had to wear down the hills on the seaward side first before they could obtain the necessary force to erode a strandflat further inland.

But in a severe climate the effective shore erosion by frost works simultaneously along all shore-lines, on the outer as well as the inner sides of the islands and peninsulas, and in all small creeks and bays. The islands will thus be attacked from all sides, and by the joint action of subaërial denudation, the shore erosion by frost, and the waves carrying away the débris, the strandflat may gradually be developed to different stages of maturity in the whole indented and dissected coastal region at the same time.

Fig. 113 gives a map of the strandflat along the coast of Helgeland from Bindal Fjord to Dønna Island. As material for the drawing of this map, I have used the excellent detailed charts in the scale of 1 : 50,000, and the maps ("Gradavdelingskarter") in the scale of 1 : 100,000, published by the Norwegian Geographical Survey ("Norges Geografiske Opmåling"). The *black* areas on the land have heights lower than 30 metres (100 feet) above sea-level, the *dark hatching* on the land indicates areas with heights between 30 and 50 metres above sea-level, and the *light hatching* in the sea indicate submerged plateaus with depths less than 25 metres below sea-level. The black spots in the sea indicate islets and skerries rising above sea-level, and the small crosses mark sunken rocks and shoals. Isobaths are drawn for every 50 metres below sea-level. The figures on the land and in the sea give the heights and depths in metres.

Maps of the same coast have been published by J. H. L. Vogt [1900, pp. 36—37] giving the emerged and submerged strandflat in less detail, and by J. Rekstad [1915] giving the isobaths of the sea.

Our map Fig. 113 shows that the greatest part of the emerged strandflat has heights less than 30 metres, and the areas with heights between 30 and 50 metres are comparatively so very small that it may seem doubtful whether they can be considered as actually belonging to the strandflat, the base of the steeply and abruptly ascending hill-sides being as a rule lower than 30 metres above sea-level.

It has already been (p. 127) pointed out that the general level of the emerged strandflat is on the whole lower in this northern region than along the coast of Norway further south. I have not had an opportunity of actually measuring the height of the strandflat along the coast of Helgeland, but as far as I can make out from the maps, from my photograps, and from the most accurate measurements made by previous investigators, especially Sahlstrom, the general level of the emerged strandflat of Helgeland seems to be between 10 and 20 metres above sea-level, and in some places even somewhat lower [cf. Sahlstrom, 1914].

I shall return to this subject later, but wish first to draw attention to another striking feature in the formation of the strandflat of this region brought out very clearly by our map. It is the wide extent of the very flat submerged plateaus of the strandflat. In this respect the strandflat of Helgeland differs entirely from that of Southern Norway. Along the coast south of Sogne Fjord, the submerged strandflat is insignificant as compared with the extent of the emerged strandflat. Along the coast northwards the submerged strandflat increases in extent. In the region of Smolen and Froia the area of the submerged part of the strandflat at least equals that of the emerged part (cf. Fig. 107) and in Helgeland the area of the emerged strandflat is very small as compared with that of the submerged strandflat.

The depth below sea-level of these submerged plateaus, indicated by the light hatching, is less than 25 metres, and by far the greater part of them have depths less than 10 metres, as is demonstrated by the detailed map Fig. 115 of the Hysvær Plateau to the northwest of Vega and Sola islands. This map is based upon a small part of No. 54 of the Norwegian

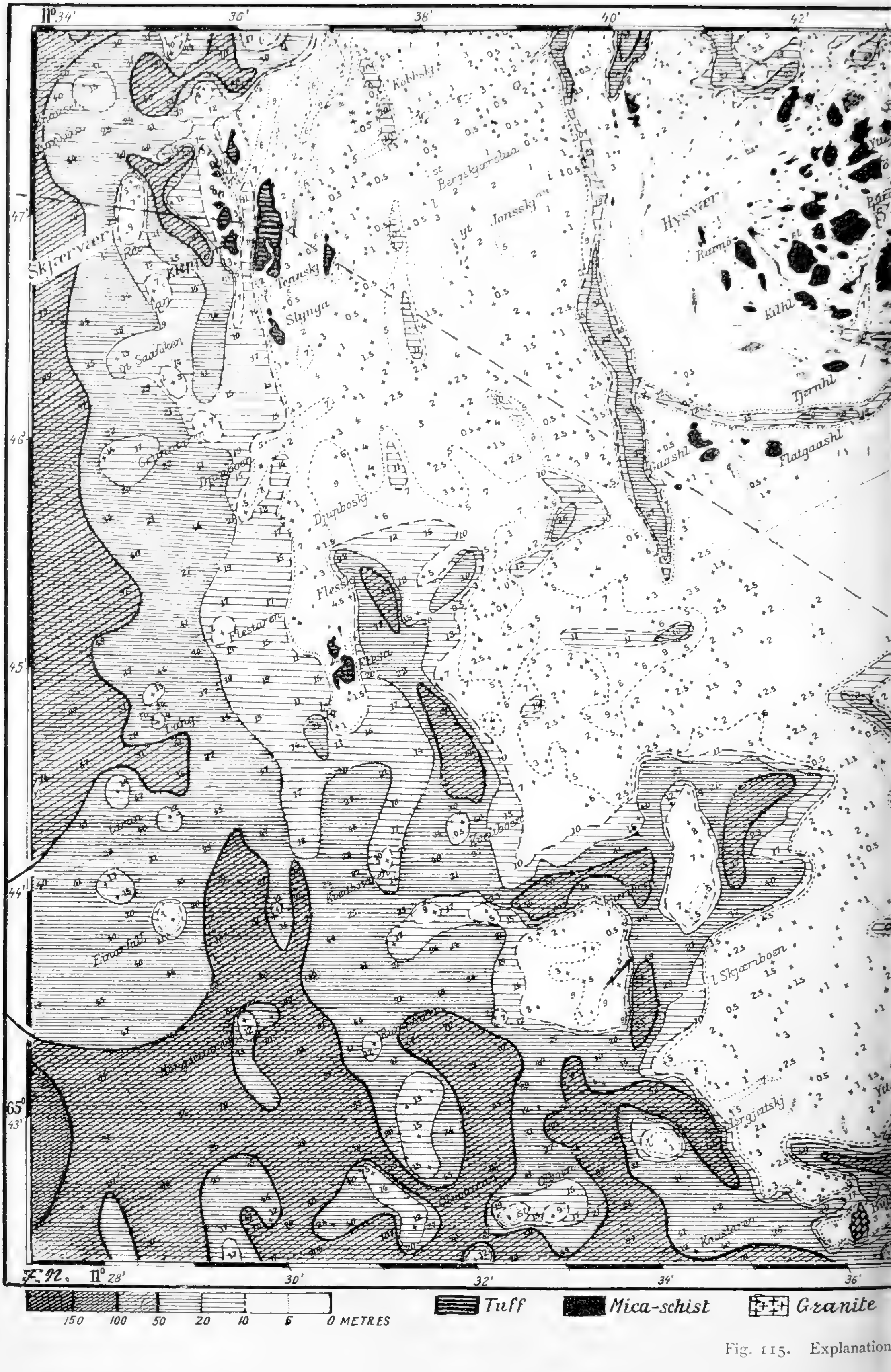


Fig. 115. Explanation


44'
46'
48'
50'
52'
Runlø
Hogö
Stokkskj
Sandvær
Hyskaasskj an
Hyskaas
Vasskj
Vastholm
Vasthl
VEGA
45'
42'
40'
65°
32'
Kongensskj an
Rundskj an
Brennö
Sola
SÖLA
Salvsjen
38'
40'
42'
44'
46'
0
1
2
3
4
5
6
7 Kilometres
4 naut. miles

i next page.

Fig. 115. Chart of the Hysvær Plateau, northwest of Vega and Sola islands, based upon the Chart No. 54 published by „Norges geografiske Opmaling". The figures in the sea indicate the depths in metres below low-water level, which is about 1.5 metres below mean water-level.

detailed charts of the coast of Norway. It is given here as a characteristic illustration of the detailed surface relief of these submerged plateaus. The figures give the depths in metres below lowest water-level, which is about 1.5 metre below mean water-level. Isobaths are drawn with dotted lines for 5 metres, with broken lines for 10 metres, with thin lines for 20 metres, and with thick lines for 50, 100, and 150 metres of depth below lowest water-level.

The isobath for 10 metres follows as a rule very closely and at a very short distance the isobath for 20 metres, so that the area bounded by the latter contour line is not substantially larger than that bounded by the 10 metres line. The isobath for 5 metres demonstrates that the greater part of the surface of the plateau is even less than 5 metres below lowest water-level, and over great areas the depths are between 0.5 and 3 metres. The general horizontal level of this plateau may be said to be between 2 and 7 metres below mean sea-level, and in its northeastern part near the islands of Hysvær, it is almost in the sea-surface.

Fig. 116 gives a profile across this plateau along the broken line in Fig. 115, passing across Sola Island northwestwards to Skjærvær and thence seawards. This profile demonstrates the remarkably horizontal evenness of the plane of this plateau, in which the channels and hollows form sharply defined depressions with well marked edges, mostly at 3 to 4 metres below mean sea-level.

The even surface of this submerged plateau has obviously much resemblance to the even planes of the emerged strandflat, *e. g.* on Dønna and Heroi, described by Sahlstrøm and mentioned later.

The other submerged plateaus shown in Fig. 113, have a similar surface relief, but their outer parts in the northern and southern regions of this map are somewhat more broken and irregular. The Hysvær Plateau has a width of about 15 kilometres, and the other submerged plateaus have a similar extent.

Several writers, the present one included, have stated that *the edge of the submerged strandflat* of Helgeland is at 20, 30 or 40 metres below sea-level. This is hardly correct and is apt to give an entirely wrong impression that the plane of the strandflat slopes to such a low level. As we have just seen the almost perfectly horizontal plane of the submerged strandflat lies very near present sea-level, and, as Fig. 115 demonstrates, the edge of this plane is sharply defined at depths of less than 10 metres below the water surface.

It may be asked whether these extensive horizontal plains have actually been cut in solid rock. The many hundreds of islets and skerries, scattered over their surface and rising above sea-level, prove, however, that they must be rocky plateaus, although this does not make it impossible that their surface may to some extent be levelled by loose material. The sharply defined channels traversing them, with well markel edges and the sharply marked edges on their outer seaward borders where they are exposed to the full fury of the ocean, creating a violent surf, seem, however, to prove that the horizontal plane of these plateaus is actually to a very considerable extent cut in solid rock.

It is obvious that horizontal, rocky plateaus, with wide dimensions such as these, cannot have been formed in postglacial time, nor can they be cut by wave erosion. They must have been finally planed by shore erosion by frost at some period or periods before the last glacial epoch. As they have so much wider an extent than the plains of the emerged strandflat on the islands and the mainland they may possibly have needed a longer time for their formation than the latter, although we have to consider that the previous strandflat over these now submerged plateaus was probably low, and that it was much dissected.

In the region of *Donna* and *Heroi* Sahlstrom [1915] has studied the emerged strandflat, and has by very accurate levelling constructed some instructive profiles across the northern flat part of Donna, across Southern Heroi, and across Blomsoi (Fig. 113). The strandflat forms here quite remarkably flat and extensive planes.

On the northern part of Donna (see Fig. 114, II) the plane is 9 to 10 metres above sea-level, and in some places (Rolvåg) 11 metres. There are numerous small depressions and small valleys, but they are as a rule only some few metres below the uniform level of the solid bare rocks projecting in the surface of the ground, and are often not so large that in my opinion a great many of them may not more or less have been formed originally when this strandflat was planed by the frost in the shore and by the waves, and have only been slightly modified later by subaërial denudation and by glacial erosion. As mentioned before, there is a great resemblance between these planes and the level surface of the submerged plateaus in the sea outside.

Some few isolated hills rise above this plane to heights of 21 to 35 metres above sea-level, and near the east coast of the island to 42 and 50, or a few even higher. The plane extends horizontally to the foot of these hills and there is as a rule a quite sharp demarkation line, almost like a shore-line, which, however, is often covered by shore gravel, and talus débris.

The region of the strandflat of the northern part of Dønna is built up of mica-schist, gneiss, and to some smaller extent of crystalline limestone.

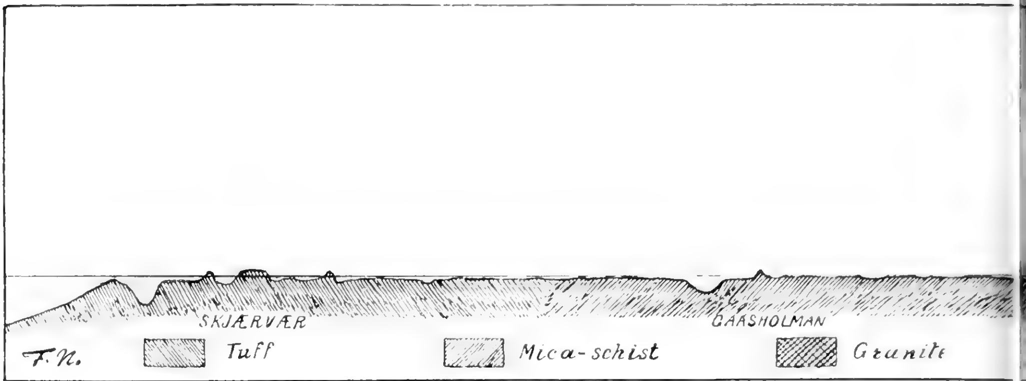


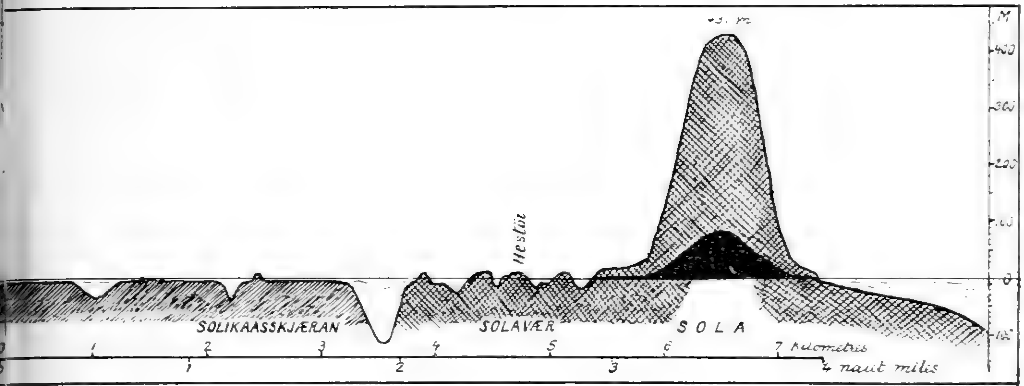
Fig. 116. Profile along the broken line in the map Fig. 115 north-westwards from Sola Islands across
the horizontal scale. The profile in black on S

The northern part of Southern Heroi, south of Donna (see Fig. 113), consists of gneiss-granite, mica-schist, and limestone. This region also forms a strandflat with a very level surface 8 metres above the sea. The same level plane with the same height of 8 metres also occurs on Northern Heroi (Fig. 113, VIII) to the east and, as Sahlstrom points out, it is noteworthy that the small rock in the sound beween the two islands has a flat surface at just the same level. This is convincing evidence that the plane has been formed by marine denudation (*i. e.* shore erosion by frost) after the sound had been deepened approximately to its present shape by glacial erosion. The relief of this level surface cannot have been much modified by glacial erosion after this small rock had been truncated, for otherwise its flat top surface would certainly have been rounded and worn down to a lower level. Across the middle part of Southern Heroi the strandflat forms a very level plane between 6 and 7 metres above the sea. The ground is composed of gneiss and limestones which are planed to exactly the same level.

In the southern part of Southern Heroi the plane of the strandflat is between 4 and 5 metres above the sea, but not quite so level as further north, ridges of gneiss-granite often rising slightly above the crystalline limestone which forms the greater part of the surface.

As Sahlstrom points out, it is noteworthy that on the remarkably even strandflat described above two kinds of rock so very different as to their power of resistance as granite and limestone, are in some places planed to exactly the same level, and in other places the difference of denudation is only a couple of metres.

According to Sahlstrom's measurements, as mentioned above, the plane of the strandflat slopes slightly southwards, from about 10 metres above the sea in the northern part of Donna to 4 or 5 metres in the southern part of Southern Herøi. Sahlstrom considers it possible that



…svær Plateau to Skjærvær and thence seawards. The vertical scale is 5 times exaggerated in relation to …nd gives the natural relation of height to length.

this might be due to the fact that the limestone of Southern Heroi is less resistant to erosion than the harder rocks in the north.

It is of much interest that real shore formations, striated by later glaciers, were actually observed by Sahlstrom on the surface of this level strandflat. The lines of demarkation along the foot of the hills rising above the plane of the strandflat are in some places so sharply defined, that they might be called shore-lines.

The surface of the many hundreds of very low and flat islands and skerries in the region of Solvær and Lovunden, north of Donna (see Fig. 114), is obviously at the same low level which was measured by Sahlstrom on Donna and Heroi. Pictures illustrating the even flatness of the islands of Solvær and the islands surrounding the solitary mountain of Lovunden are given by Rekstad [1912, Pl. I, Fig. 1], Sahlstrom [1915, Fig. 14], and the present writer [1904, Pl. V, Fig. 1]. Rekstad [1915, Pl. II, Fig. 1] gives a most illustrative view of the many islands in the region of Heroi, Husvær, and Skålvær (cf. Fig. 113), west of Alsten Island with De Syv Sostre (Seven Sisters). It demonstrates the extreme flatness and low altitudes of the many islands in this region.

There is a striking difference between the low altitudes of these level planes of the emerged strandflat of Helgeland and the heights, generally stated to be between 30 and 40 metres, of the inner boundary or upper limit of this strandflat. Sahlstrom could find no traces of this higher level in the region studied by him. He found the plane with a height of about 8 to 10 metres extending to the foot of the mountains.

J. H. L. Vogt [1907, pp. 20 f.] says that, according to his investigations along the coasts of Helgeland and the Lofoten Islands, the upper limit of the strandflat, or the demarkation-line ("Knickpunkt") between its nearly horizontal plane and the steeply ascending mountain-sides stands everywhere at almost exactly the same level. In numerous profiles taken he found it slightly higher than 30 metres above the sea, and he thinks that it may be put approximately at 40 metres above sea-level. From occasional observations during short visits to the coast further north (Andoi, Bjarkoi, &c. in 69° N. Lat.) as well as further south (in the Romsdal region, Karmoi, Haugesund, Bomlo Island, &c.) Vogt draws the conclusion that the upper limit of the strandflat is fairly exactly at the same level along the whole of the Norwegian coast. He adds, however, that it is impossible to determine the height of the upper limit of the strandflat within an accuracy of some metres, and that the estimate will to a certain degree depend on the observer. But he thinks "that greater errors than 15 to 20 metres are excluded". As he does not say that his estimate of the heights of the strandflat is based on accurate measurements by levelling, we may conclude that his figures are not meant to be very accurate, and with possible errors of 15 to 20 metres they give us a broad margin.

Though the emerged strandflat of Helgeland may possibly to some extent, like the strandflat of southern Norway, have two levels, a widely extended lower one, like that described by Sahlstrom, and a much less extended higher one, still I think we ought to receive these statements of the higher levels of between 30 and 40 metres with some caution as long as they are not based on actual measurements by levelling on the spot.

There has obviously been a tendency towards establishing general rules for the heights of the strandflat along the entire coast of Norway, and the limits of these heights have been put at 30 to 40 metres above the sea, and 30 to 40 metres below sea-level. We have seen that along the coast of Helgeland as well as in the region of Smolen, Hitteren, and Froia, where there are well-developed submerged plateaus, this estimate of the lower limit is not correct, the outer edge of the submerged strandflat being there rather less than 10 metres below sea-level. We have not yet obtained sufficiently accurate measurement to establish the height of the inner edge, or the upper limit, of the emerged strandflat of Helgeland. It seems at any rate to be somewhat lower there than along the west coast of southern Norway.

In Fig. 118 from northern Helgeland the demarkation-line between the low flat strandflat and the very steep mountain-sides is seen. The inner part of the strandflat is to a great extent covered by the scree or talus heaps, formed in postglacial time by stones tumbling down from the mountain-sides, but it is obvious that the plane of the strandflat, hardly 15 metres above the sea, continues under the scree to the foot of the rocky walls at about the same height. J. H. L. Vogt's description [1907, p. 14] of the strandflat, as a plain sloping gently seawards from its inner higher parts 30 to 40 metres above sea-level to its outer submerged edge 30 to 40 metres below sea-level, is also in my opinion somewhat misleading. The strandflat is not really one sloping plane, but consists rather of several more or less horizontal planes. As we have seen, there is in Helgeland one almost perfectly horizontal plane of the submerged platform at a level of some few metres below the present sea surface — and there is at least one plane above the sea, measured by Sahlstrom on Heroi and Donna at a level of about 8 to 10 metres Whether there are more planes in this region is not quite certain.

Træna.

Far out to sea, northwest of Lovund and Lovundvær, separated from their plateau by a deep sea, the Træn Fjord, up to 438 metres deep and 12 kilometres broad, is a submerged plateau with the island-group of Træna (see Fig. 114). We may call this plateau the Træna Plateau. It is 31 kilometres long from SSW to NNE, and about 9 to 12 kilometres broad. Its islands are much scattered, and subdivided into several smaller groups: the Træna Islands proper, in the southwestern part of the plateau, with the biggest islands Sanda (with the high peak Trænstaven, 338 m.) and Husoi, built up of pressed granite, gneiss-granite, Sandavær just north of this group and built up of the same kind of rock, Sandoi (Sandoy, of gneiss-granite) and to the north of it Torvær (young gneiss) in the middle of the plateau, Dorvær to the northeast, built up of not pressed granite, Arvær and Båsan or Rosoian (young gneiss) to the northwest of Torvær and Dorvær, and finally Selvær in the northeastern part of the plateau, built up, in its southern part of mica-schist with layers of crystalline limestone, and in its northern part of gneiss [cf. Rekstad, 1912, geological map].

The geology of the islands of the Træna Plateau has been described by J. Rekstad [1912]. John Oxaal [1915] has given an interesting general description of the island-group and its strandflat.

There are on these islands many evidences of the vigorous marine erosion, or shore erosion, to which the land has been exposed. As such evidence may be mentioned the precipitous sides of the mountains rising abruptly above the strandflat, the many big caves, the frequently cirque-like valleys ('botten' valleys) with almost vertical sides.

The erosion by frost, especially along the shores, has obviously been of the very greatest importance for the development of these formations. When the shore-erosion by frost is greatly intensified during periods with a severe climate, and is assisted by the violent wave action of a stormy sea on an exposed coast, as in this region, this erosion will become extremely effective, and will have a great ability to cut away the land. Thus the shapes of the mountains of Træna are simply explained: the shore-erosion has cut away the land, but on the higher and more resistant islands it has not been able to plane down the whole islands, and the high mountainous parts with their precipitous sides, or shore walls, especially on Sanda Island (pressed granite) and Buøi in Dørvær (granite), remain, indicating the initial height of the land, and having on their top often the old surface, or Palæic land surface, extending almost unaltered to the edges of the precipitous mountain sides, which is a convincing proof that, during the time when the strandflat was formed, the effect of the subaërial denudation was of but little importance as compared with that of the shore-erosion, where the latter was as effective as in this region.

Other convincing evidence of the efficacy of the shore-erosion are the many big caves on the islands of Træna. As the floors of these caves are at levels between 29 and 56, and some even at about 70 metres, above the sea [cf. Oxaal, 1915, p. 72], and consequently above the level of the strandflat, they must have been formed during comparatively short periods when the land was temporarily submerged to these levels.

The fact that caves such as these formed in granite or gneiss, only occur near the coast and especially on the most exposed parts of it, indicates that they have been formed by shore erosion.

In my opinion, the chief agency which has helped to form them is the frost. This is already indicated by the fact that such caves are especially numerous in the northern parts of the Norwegian coast, and the great majority of them do not occur near present sea-level, but at levels to which the land was submerged during the glacial periods, and when there were cold climates. In more arctic latitudes, *e. g.* on Bear Island and Spitsbergen the caves occur mostly at the present sea-level.

As has been pointed out by Rekstad and Oxaal and previous writers, the caves are formed along fracture lines, or lines of weakness, in the rock. Here the frost had easy work by breaking loose blocks along the many fissures of the rock. Where the water in the rock was permanently frozen, its temperature would be near melting point where the rock surface was near the sea water, and frequent daily changes in temperature above and below freezing point would be caused by the temporary contacts with the warmer sea water, especially due to the tide, but also occasionally to storms.

The stones thus loosened by the active frost will tumble down from the roof and the walls of the caves. They will also easily be broken away by the waves, especially during storms, and where the caves have the required shape for it, the alternate compression and expansion of the air in the caves by the waves, may have a considerable effect in breaking loose the stones, as was pointed out by Rekstad [1912, pp. 59 f., cf. also Oxaal, 1915, pp. 74 f.]. The stones thus broken loose, will accumulate on the floor of the caves, where they will be exposed to a vigorous disintegration by frost when the floor is alternately submerged and left dry by the tide. Especially during winter, ice is also formed on the floor, and when shifted and broken loose in summer, it may help to carry away material. That the wave action generally is of little direct importance for the disintegration of the stones is proved by the fact that as a rule little rolled material, pebbles or boulders, are found in the caves.

The often cirque-like valleys with precipitous sides on the Træna Islands have also, in my opinion, been formed by the shore-erosion to a very great extent. Oxaal [1915, p. 79] thinks they have been formed by the wave erosion, but I consider it probable that in their formation also the frost has been the chief causal agent, although it has been effectively assisted by the wave action. It may be doubtful whether it is justifiable to make such an absolute difference between these kind of formations and the ordinary cirque valleys. I think the first commencement of these valleys may often have been small regular cirques eroded by small local glaciers or accumulations of snow and ice, in the manner I have discussed before (cf. p. 27, and Fig. 8). This erosion has then been continued by the frost erosion in the shore, of the kind described in Chap. V (pp. 28 ff.), which is to some extent of the same nature as the erosion of the small cirque glaciers. The shore-erosion by frost has at times been vigorously aided by the violent wave action, breaking and carrying away all loosened material. In this manner the combined erosion of frost and waves advances comparatively rapidly along the lines of fracture and weakness of the rock, and forms small cirque valleys which may develop into narrow passes breaking through the mountain ridges.

Considering the vigorous marine denudation, to which the Træna Plateau has been exposed, it was to be expected that it would have a well-developed strandflat, although it is to a great extent built up of comparatively resistant rocks.

It would have been of much interest to know exactly the height of the emerged strandflat and especially its upper limit in this region, as we might expect to find it fairly sharply defined at the foot of the steep mountain sides. Oxaal mentions this strandflat, but unfortunately he does not seem to have actually measured its heights, and neither his description nor his illustrations give any clear indication of the actual altitude of its level plane or of its upper limit at the foot of the mountains.

According to the maps ("Gradavdelingskarter", in scale 1 : 100000) marked "Trænen" and "Lurøy", the many islands are in general less than 30 metres above sea-level, and only on some few of them does the low land rise to heights of between 40 and 45 metres. The probability seems to me to be that on the many low islands there is, to a great extent, a low level similar to that measured by Sahlstrøm on Donna and Herøi. Whether there is also a somewhat higher level approaching 30 or 40 metres is doubtful, but may be possible.

The method employed by Oxaal, consisting in measuring with a planimeter the areas between the contours for each thirty metres of height above the sea, and for each ten metres of depth below sea-level, and then drawing a profile of the heights and depths of the plateau accordingly will give an idea of which heights and depths predominate on the strandflat, but cannot as a rule be of much value for finding the indications of its original, nearly horizontal levels or planes. In exceptional cases where the contours run more or less concentrically and parallel to each other, it may give fairly satisfactory results. But where, as in most cases, the planes of the strandflat are dissected by numerous channels and depressions of varying depths, and where only a part, and perhaps even a comparatively small part, of the area of the strandflat actually indicates its plane or planes, although these may be extended over ridges approaching the outer edge (cf. the Træna Plateau, Fig. 114), there Oxaal's method will give results entirely misleading for the determination of these planes and their heights. The probability is that it will generally give a more or less gradually sloping profile of the strandflat with no distinct breaks, and where the planes disappear more or less.

From his computations of the kind mentioned above, Oxaal draws the conclusion that the outer edge of the submerged strandflat of the Træna Plateau is at 30 to 32 metres below sea-level. This is hardly correct, and the actual edge of the original plane of the submerged strandflat is probably nearer the water surface (cf. Fig. 114). But its depth is difficult to determine with accuracy along the outer side of this plateau, as there is no sharply marked break between the plane of the submerged strandflat and the slope of the sea bottom outside, which slopes gently towards the surface of the continental shelf.

In this respect there is a striking difference between the outer edge of the strandflat in this region, and the sharply defined edge of the almost perfectly horizontal plane of the submerged strandflat to the south, in the region of Vega (see Fig. 113). We have seen that in the latter region the extremely level surface of the extensive submerged plateau stands only some few metres below the sea surface (see Fig. 115) and extends very nearly to the isobath of 50 metres, which is often quite close to the isobath of 100 metres, there being a sharply marked edge at less than 10 metres (or near 5 metres) below mean sea-level, and a distinct break between the horizontal plane and the slope of the sea bottom outside..

But the surface of the submerged Træna Plateau is much more irregular, with greater and more varying depths, and especially on its outer side there is often a considerable distance between the very irregular isobath of 25 metres and that of 50 metres, and the latter is largely more distant from the isobath of 100 metres than from the islands (see Fig. 114).

Along the eastern or northeastern side of the Træna Plateau, at Selvær and northeast of Dorvær, it is different. The isobaths of 25, 50, 100, 150, 200, and 250 metres are there closer together (see Fig. 114), and the surface of the submerged strandflat is more level and nearer the sea surface, with a sharply defined edge at depths of about 10 to 20 metres.

Oxaal [1915, p. 87] thinks the probable explanation of this fact to be that the eastern, lower part of the submerged strandflat has been cut away by the deep channel, excavated along the inner side of the Træna Plateau. and this channel should then to some extent be younger than the strandflat. The probability of this explanation might seem to be supported by the fact that the channel is deepest, with depths of 420 metres, just east of Selvær, where the submerged strandflat is especially level and high, with a sharply marked edge at about 10 metres below sea-level, while further south, southeast of Dorvær, where the channel is less deep (288 metres), the edge of the strandflat is at depths of about 30 metres, and still further south or southwest, south of Dorvær and east of the Træna Islands (Husoy), where there is no deep channel, the submerged strandflat has no sharply defined edge. Along the south-eastern side of the Træna Plateau there is also a very deep channel with depths more than 300 metres (and even 438 metres), but the submerged strandflat has no sharply defined edge in this region.

Relation between the Differences in the Surface Topography of the Submerged Plateaus and Differences in the Nature of their Rocks.

When we come to look at it, however, it is striking that the differences in the surface relief and the depths of the edge of the submerged strandflat of the Træna Plateau coincide to some extent with differences in its geological structure. Selvær and the northern part of the Træna Plateau, where the eastern edge is so sharply defined at about 10 metres below sea-level, are built up of mica-schist and young gneiss, while Dorvær is built up of granite and the islands of Sandoi and Træna to the southwest of pressed granite, and here the surface of the submerged strandflat is deeper and it has a less distinctly defined edge. There is a similar difference in the slope of the sea bottom outside the western side of the plateau. It is much steeper off its northern part built up of young gneiss than west of the southern part built up of pressed granite.

It may be difficult to find a satisfactory explanation of these features. It might seem probable that the greater depths and the more sloping surface of the submerged strandflat of the Træna Plateau, as compared with that of Lovundvær and Solvær region inside and the regions of Gåsvær, Lyngvær, Flovær, Skjærvær, Fuglvær, &c., to the south (see Fig. 113), may, to some extent, be due to the effect of a violent wave erosion, which has been especially effective on the much exposed Træna Plateau, and which has eroded the strandflat after its first planing by the joint effect of the shore-erosion by frost and the wave action. It might be objected that the plateaus, for instance at Lyngvær, Flovær, Skjærvær, &c., have been almost equally much exposed to the fury of the waves, and still there is a striking difference in the depths and evenness of the surfaces of the submerged plateaus and their outer edges, which are so very sharply marked in the latter regions. There is this difference in the situation that between Lyngvær in 66° 4′ N. Lat. and the Engelsbo Skerries (Engelsboskjæran) in 65° 31′ N. Lat. the outer coast or edge of the now submerged plateau has been almost continuous (see Fig. 113), while the isolated Træna Plateau has been exposed to the full fury of the sea almost on all sides, but least on the northeastern side where the edge of the plateau is sharpest. It might therefore be expected that the effect of the wave erosion has been greater on this plateau and that especially all loose material has been more completely swept away, while it may to some extent have accumulated in the hollows and depressions of the extensive plateau to the south. It is noteworthy that the more isolated submerged plateaus in the northeastern part of the map Fig. 113, at Slaggrunnen and still more at Floholman, have less horizontal and more irregular surfaces than the plateaus to the south and their depths are greater. They resemble the surface on the outer side of the Træna Plateau. The surface of the platform north of Skibåtsvær in 66° 10′ N. Lat. (see map Fig. 113) and at Jonsgrunnan in 66° 12′ N. Lat. (see map Fig. 114) is still more irregular. Outside Slaggrunnen the sea is less deep and the bottom is also sloping less steeply seawards than along the edge of the submerged plateau to the south (see Fig. 113). This is also the case outside Jonsgrunnan (see Fig. 114), but not outside Floholman where there is a fairly steep slope (see Fig. 113).

It is, however, a striking fact that just the last mentioned regions at Lyngvær, Slaggrunnen, and Floholman, where the submerged surface has so great a resemblance to that of the southern part of Træna Plateau, are also built up of granite, and so are Skibåtsvær and Jonsgrunnan [Rekstad, 1915, pp. 19 f.]. It is noteworthy that the submerged plateau west and southwest of Lovund and Lovundvær has an irregular surface like that of the western side of the Træna Plateau. It is built up of comparatively resistant gneiss and partly of granite. The much dissected plateaus of Nesoi, Sornesoi, Lyngvær, and Måvær, east of Træna (Fig. 114, IX and X) are built up of granite.

On the other hand, the most level submerged plateaus with the most sharply defined outer edges, like those of Flovær and Lånan — and Sorvær to the east-southeast of them as well as the plateaus at Ytre Flesan to the north — are built up of limestone, and so are the northern parts of Vega and the plateau to the north of it (at Kilvær). The extremely level plateaus at Husvær and Sandvær, and at Hysvær are built up of mica-schist, and at Skjærvær of a kind of metamorphic tuff (see Fig. 115). The plateaus to the south of the latter region, at Fuglvær and westwards to Sjola and southwards to Steinan and Engelsbo Skerries (see Fig. 113), are largely built up of granite, and so are Sola, the southern part of Vega, and the group of islands called Mudvær to the south of the latter. At Alflesa north of Engelsbo Skerries there is granite and limestone.

Although the inner parts of the submerged plateaus of this granite region, *e. g.* south of Fuglvær, may be almost as level as the plateaus of mica-schist and limestone to the north, their outer parts, towards west and southwest, are less regular, as the map Fig. 113 shows, and their outer edge, *e. g.* at Sjola, Steinan, and Engelsbo Skerries, is less sharply defined than in the regions of mica-schist and tuff, at Skjærvær, and of limestone, at Flovær and Ytre Flesan to the north.

The outer parts of the submerged plateaus of the granite regions have thus a resemblance to the Træna Plateau built up of granite.

On the whole as regards their surface relief there seems to be a typical difference between the submerged plateaus built up of granite, or similarly resistant rocks, and those built up of limestone, mica-schist or other less resistant rocks.

But irrespective of the differences in geological structure it is natural that the surface of more or less isolated submerged plateaus far out to sea and exposed to the full effect of the breakers, should be somewhat lower and more outward sloping, with a less sharply marked edge We may also find this in the region of the mica-schist and limestone, *e. g.* on Skjærværgrunnan outside Skjærvær (see Fig. 113) where the smallest depth is 17 metres and there is no sharply defined edge. At the outermost edge the plateau southwest of Skjærvær (and west of Hysvær at Flesa, Langtaran, Einarfall, &c., see Fig. 115) also exhibits similar features. We do not know, however, whether the rock may not be granite in this region, although the island Flesa consists of highly metamorphosed tuff. We find granite quite near to the south at Sjola which is obviously situated on the same ridge as Skjærværgrunnan (see Fig. 113).

The plateaus at Onsteinen, Ertenbraken, and Storbraken (northeast of Ryggefallan, see Fig. 113) are built up chiefly of mica-schist and to some extent of limestone (*e. g.* Storbraken). They have the very level and horizontal surfaces near sea-level, with sharply defined edges and very steep side slopes, which are typical of plateaus cut in these rocks.

At *Horsvær* to the south the rock is to some extent gneiss, and the islands are more scattered, and the surface is less regular (see Fig. 113). West of Horsvær and south of Ryggefallan the submerged surface is very irregular and resembling that of a granite region, and some rocks rising above the sea actually consist of granite.

The banks at *Høgbraken* (southwestern corner of map Fig. 113) may possibly also consist of granite, although they have perhaps more the features of plateaus of mica-schist, with fairly level surfaces, well-marked edges bounded by steep side slopes.

South of Hogbraken, and far out to sea, in about 65° 12′ N. Lat. and 11° E. Long., is an isolated plateau with the small island-group *Sklinna* which is built up of granite. The islands are somewhat scattered as is generally the case on granite plateaus, but on the outer southwestern, western, and northwestern side of the islands the surface of the plateau is very level, forming a horizontal plane some few metres below the sea-surface with a sharply defined outer edge and very steep outer side slopes descending abruptly to depths of more than 300 metres. This is more like the typical features of plateaus of mica-schist or limestone. But on the inner side of the islands, towards northeast, east, southeast, and south, the plateau has a more typical sloping granite surface, with greater depths and with no definite horizontal plane, and no sharply marked edge.

The plateau of *Horta*, east of Sklinna, in about 65° 12′ N. Lat. and 11° 25′ E. Long., is built up of gabbro containing a great deal of carbonate of lime. Its submerged surface is extremely level forming a horizontal plane a few metres below the sea-surface with a very sharply defined edge at the same depth, and with a great number of low small islands, skerries, and rocks scattered over its whole area.

As was mentioned on p. 128, the island-group of Vikten built up of granite, and extending far into the open sea, is surrounded on its outer sides by broad submerged platform, exhibiting an almost horizontal plane only a few metres below the sea-surface, with no appreciable seaward slope, and with a sharply defined outer edge at about the same depth, or at least at depths less than 10 metres. The surface of this plateau is, however, less level and more dissected by channels and depressions than the very level surface of *e. g.* the Hysvær Plateau built up of mica-schist.

As a result of the above cursory investigation of the relation between the surface topography of the submerged plateaus and their geological structure we may establish the following general rules:

The typical plateaus built up of granite (and also of gneiss) have an uneven surface, the islands on them are lying scattered, their surfaces are much dissected by channels and depressions, and their depths vary much and are often comparatively great. Their surfaces slope outwards, with no well-marked edge, and often the sea outside is not very deep and has an outward sloping bottom, with no very deep channels or hollows, and there is no very sharp difference between the sloping bottom of the shallow parts of this sea and the submerged plateaus of the strandflat.

The typical plateaus built up of mica-schist or limestone (or similar less resistant rocks) have a very different surface topography. The islands on them are flat and lying close together, only separated by narrow and shallow sounds. The submerged surface is very level with small depths, forming a horizontal plane near present sea-level or only some few metres below it, and the outer edges are sharply defined at about the same depth. The side slopes are generally very steep and there are often channels and hollows with considerable depths just outside or on the sides of these plateaus.

It may seem difficult to find a satisfactory explanation of this difference between the two kinds of plateaus. One might have expected that the plateaus of less resistant rocks should have been more attacked by recent erosion, and more denuded, and consequently lower, than the granite plateaus.

The only explanation I can find, is that the plateaus of rocks with little power of resistance have formerly had a greater extent, and have formed fairly compact land masses rising above the sea. After the land had been more or less worn down, the outer part of these plateaus have been much cut back, also during the last glacial period, by the glaciers excavating the deep channels and hollows outside them, where the weak rocks offered especially favourable conditions for the glacial erosion. This is the reason why there are often such deep channels and hollows with very steep side slopes outside these plateaus.

It is probable that the erosion of glaciers in rocks with comparatively little power of resistance to frost erosion, produces a very different sculpturing above and below the water surface. Above the sea the mountain slopes on the sides of the glaciers are much attacked by the frost erosion, and the result is comparatively broad valleys with sloping sides. Below the sea this is entirely different, the rocks are protected by the sea against the frost erosion, and there will only be erosion on the under side of the moving glaciers. They will therefore cut narrower channels with steeper side slopes, and sharply defined edges bounding the flat plateaus which will not in interglacial time be attacked and rounded off by frost erosion or subaërial denudation against which they are protected by the sea.

The still remaining middle parts of the plateaus were truncated by the shore erosion comparatively recently. They are, therefore, very level, standing near present sea-level, as there has been but little time for the wave erosion or for glacial erosion to wear them down to greater depths.

It might be asked where are the older plateaus cut in this kind of rock? and why do we not find them at lower levels? The answer may be that where the older plateaus were cut in weaker rocks, they have been more or less cut back by the glaciers during the subsequent glacial periods, and they no longer exist as parts of the submerged strandflats.

The map Fig. 113 also shows that the outer edges of the plateaus of mica-schist and limestone, *e. g.* at Flovær and Skjærvær, are cut back more than the edges of the granite plateaus at Lyngvær, Slaggrunnen, and Floholman to the north, and at Sjola and Steinan to the south. The plateaus at Ertenbraken and Storbraken are also cut back with deep channels and hollows round them.

Fig. 117. Southward view from Meloivær towards Amoi. Strandflat cut in granite. (Sept. 9, 1912).

The plateaus built up of granite, or hard gneiss or similar resistant rocks, have not been cut back by the glaciers like the plateaus of weaker rocks. Their surfaces are therefore to a great extent older, and the sea outside them less deep and with more gradual slopes, as the glaciers had more resistant rock to work in. The surfaces of the plateaus are more uneven because, during the length of time after they were first formed, they have been exposed to much glacial erosion, dissecting them and making them more irregular and sloping. The channels between the islands have also been widened, producing the appearance of more scattered islands. The wave erosion must also have had some appreciable effect upon the surfaces, especially of the outer parts of these plateaus, during the long time they have existed; and may have lowered them. Smaller and more isolated plateaus outside the greater ones, may have been lowered to various depths by glacial erosion, as well as by wave erosion, and owing to the resistance of their rock they have not been cut away by the glaciers like those of weaker rocks.

Coast of Northern Helgeland and the East Coast of West Fjord.

The outer coast of northern Helgeland, north of Solvær and Lovund, and the coast farther north along the eastern side of Vest Fjord is chiefly built up of granite and to some small extent of gneiss, *i. e.* rocks with much power of resistance to erosion. It is therefore in accordance with what might be expected, that neither the emerged nor the submerged strandflat are developed to any great width in this region. But the emerged strandflat is seen almost everywhere along the shores, forming a flat, low foreland in front of the steep mountains (cf. Fig. 118) on the peninsulas of the mainland and on the high islands, and its low plane extending seawards over the various groups of small low islands (see Figs. 3, 117, and 119). Being largely cut in granite the surface of these islands is often somewhat uneven, with small rounded knolls (see Fig. 117). Rekstad gives [1913, Pl. I, Fig. 1] a most interesting illustration of the uneven surface of the strandflat cut in granite on Briksvær Island, in 67° 16′ N. Lat. and 14° E. Long. It consists of a great many rounded

Fig. 118. Strandflat cut in granite at the foot of steep granite mountains near Kunna south of Salt Fjord. (Sept. 9, 1912).

knolls with steep sides and fairly deep depressions between them. But the summits of the knolls are to a great extent at the same level of about 30 metres or somewhat more above the sea.

I have had no opportunity of measuring the heights of the strandflat along this coast, but judging from the impression made when seen from the sea (cf. Figs. 117, 118, 120, and 121), I believe that there is, at least to some extent, a low level similar to that measured by Sahlstrom on Donna and Heroi. There is possibly also a higher level as, for instance, indicated by the summits of the many rounded knolls on Briksvær Island, mentioned above.

Ahlmann says [1919, p. 205] that on the seaward side of the fairway between Sandnessjoen and Bodo "there occur continuous level surfaces at 5—10 metres and at 20—30 metres altitude above sea-level".

The picture Fig. 119 of the island Landegode, north of Bodo, shows two levels, the low level of the south-westernmost point of Landegode and of the islets to the west, and a higher level on the southwestern part of the island in front of the steeply ascending mountain side (partly covered by a fog in the picture). As pointed out by Rekstad [1913, p. 15] this plateau is about 100 metres above sea-level, and cannot therefore belong to the strandflat we are discussing in this paper. But it has obviously been cut by shore erosion. It is noteworthy that it has very nearly the same height as a similar plateau (or "shore-line") at Torghatten which is about 109 metres above the sea [cf. Rekstad, 1915, p. 45 and Pl. VII, Fig. 2]. I consider it probable that these plateaus may be remnants of an earlier strandflat, perhaps formed at the beginning of the first Great Ice Age. They are in both these cases cut in granite and have thus been able to survive later erosion. Remnants of an old strandflat at a similar level may perhaps also be found at other places, *e. g.* on the Viker Mountain (granite) northwest of Torghatten where there is a fairly extended plateau, on the coast of the mainland inside on the southern side of Sonnesviken, on the southwestern corner of Vega (granite), &c.

Fig. 119. Low land on south-western end of Landegode Island, with strandflat on small islands outside. (Sept. 9, 1912).

The submerged strandflat round the islands has no great extent along northern Helgeland and the coast to the north, and it rapidly dimishes in width northwards towards Vest Fjord, forming only a narrow strip along the coast of the mainland, and small platforms round the island-groups out in the sea.

Its surface is on the whole uneven and irregular and has much the same type as that of the southern part of the Træna Plateau. There may, however, be some difference: All the submerged plateaus with small island-groups built up of granite have very uneven surfaces, dissected by numerous channels and depressions, and especially far out to sea their surfaces are sloping outward towards the deeper sea on the sides without any sharply defined edge, and the depths of the plateaus vary much, so that it is difficult to find any special depth which might be said to indicate the levels of their initial planes. Outside these plateaus of granite there are also as a rule a great many isolated small shoals standing at various depths and indicating no definite plane. As examples of submerged granite plateaus of the above kind may be mentioned the plateaus of *Myken, Valvær,* and *Skjærvær,* northwest of Træna, with numerous isolated shoals, and the plateaus of *Rorstapvær* and *Gronna* far out to sea in about 66° 54′ to 67° 3′ N. Lat. and 13° 3′ to 13° 18′ E. Long. with very typical surfaces. Some parts of the submerged surface of these plateaus stand very near present sea-level with numerous shoals and rocks almost in the water surface or only some metres below it. One might get the impression that a plane has been cut approximately at this level, but then the ground slopes outward on all sides without any marked edge, and this makes it extremely difficult to decide what the depth of the level actually is. In many cases the surfaces of the plateaus slope more gradually outwards on their outer, seaward side than on their inner, landward side, where there may even sometimes be more of a well marked edge. This might seem to indicate that the surfaces of these granite plateaus have been eroded to some extent by the wave action, which has lowered their initial levels and made them more sloping.

It is very characteristic that the submerged plateau of *Fugloivær* (consisting of granite) in 67° 3′ N. Lat. and 13° 36′ E. Long. has the typical outward sloping surface of a granite plateau, while *Fleinvær* only 6 kilometres to the northeast which is built up chiefly of crystalline lime-

Fig. 120. Engeloi with the strandflat on Lundoi in front, cut in granite. (Sept. 8, 1912).

stone [Rekstad, 1913, p. 4], has a comparatively horizontal surface, with a great number of low islands, and a fairly well marked edge with steep slopes outside not far from the outer border of the islands.

The plateau of *Helligvær*, in about 67° 24′ N. Lat. and 13° 54′ E. Long., east of Landegode, has a quite similar surface with a sharply defined outer edge near present sea-level and steep side slopes. It is built up of mica schists [Rekstad, 1913, p. 13]. But the plateau of *Lyngvær* just inside and separated from Helligvær, only by a narrow channel consists of granite and has the typical outward sloping surface of granite plateaus.

The small plateaus of *Kjærvær* (chiefly granite) and *Steinsvær* (granite), between Fleinvær and Helligvær, have the typical surfaces of granite plateaus. It is also a quite common feature with the granite plateaus that their islands are more scattered, while on the plateaus of less resistant rocks, like limestone and mica-schist, the islands lie as a rule closer together with narrower sounds between them, cf. for instance the striking difference between Lyngvær and Helligvær lying close together.

The small plateau of *Terra* is built up of a kind of schistose hornblende rock. Its surface is most like the granite surface.

The plateau of *Givær* far out to sea north of Fleinvær is built up chiefly of a coarse mica-schist. It has a fairly horizontal submerged plane with well-marked outer edges some metres below sea-level.

The plateau of *Karlsoivær*, in about 67° 33′ N. Lat. and 14° 38′ E. Long., on the southern side of the entrance to Folla Fjord, is built up of mica-schist [Rekstad, 1917a, p. 16 and map], and has the typical surface of a plateau of rocks of little resistance, with the numerous islands close together and a sharply defined outer edge some metres below sea-level, and comparatively steep side slopes, while *Slovær* consisting of gneiss, and situated just to the northeast and separated from Karlsoivær only by a narrow channel, has more the surface of a granite plateau with more scattered islands and less sharply defined outer edges.

Still more characteristic in this respect is the plateau of *Husvær* (with Husoi), in about 67° 43′ N. Lat. and 14° 23—44′ E. Long., north

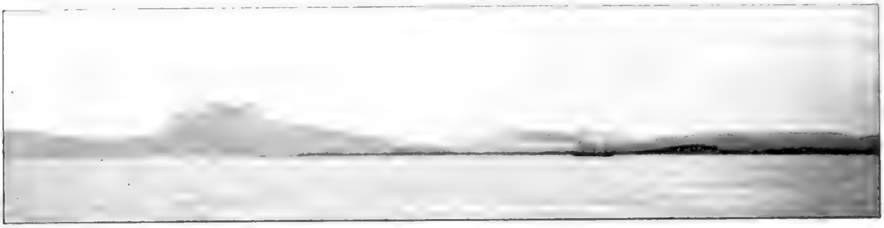


Fig. 121. Strandflat cut in granite and syenite at Tranøi Lighthouse on Hamarøi, near the inner end of Vest Fjord. (Sept. 8, 1912).

of Folla Fjord. It is chiefly built up of gneiss [Rekstad, 1919, p. 27 and map]. It has a great many scattered islands, skerries, and sunken rocks, and its submerged surface slopes outwards with no sharply marked edge.

Lofoten and Vesterålen.

The islands of Lofoten and Vesterålen are to a great extent built up of very resistant igneous rocks: gabbro-monzonites, granites, &c. And as the initial land was high the development of the strandflat must have been a very slow process in this region in spite of the severe northern climate and the exposed situation of the coasts out to sea.

The strandflat is therefore naturally narrow along the coasts of Lofoten and Vesterålen, but in many places it is very conspicuous and sharply marked at the foot of the high steep mountains (cf. Figs. 1 and 2), frequently forming deep horizontal incisions in the mountain sides, with precipitous rock walls or cliffs behind them.

Descriptions of the strandflat of this region have been given by J. H. L. Vogt [1907] and Th. Vogt [1912] and also by Ahlmann [1919] who, however, holds the view that whilst in some places like Værøi its plane is, at least partly, formed by wave erosion, it is along the rest of the coast, what he calls the "distal base-levelled plain".

Th. Vogt gives [1910, Pl. II and III] some very illustrative photographs of the strandflat at Gaukværoi and Hasseloi in Vesterålen, which seem to me to demonstrate clearly how utterly impossible it is that these planes extending horizontally to the foot of the steep mountains can have been formed solely by subaërial denudation (see also Fig. 1 of this treatise).

The previous writers have given no accurate heights of the emerged strandflat of Lofoten and Vesterålen, based upon actual measurements by levelling, nor has the present writer had an opportunity of measuring its height. J. H. L. Vogt [1907, p. 20], obviously basing his estimate on the official maps ("Gradavdelingskarter" in scale 1 : 100,000), says that the inner edge of the strandflat in Lofoten lies in numerous profiles (probably made from the maps) just a little higher than 30 metres above sea-level.

Judging from the impression which the emerged strandflat gave, when seen from the sea in various regions of Lofoten and Vesterålen, and also judging from the many photographs taken, I estimate the height of a great part of it to be about 20 metres or less above sea-level. It is possible that the height of its inner margin, at the foot of the mountains, may be somewhat higher and frequently approach 30 metres above the sea, but its actual height will generally be difficult to determine, as it is to a great extent covered by the scree.

In his excellent description of the topography of the south-western part of Lofoten Th. Vogt expresses himself in a very similar manner. He says [1912, p. 15] that at the foot of some headlands of Værøi, there are low points the inner boundary of which at the foot of the almost vertical cliffs is about 35 to 40 metres above sea-level, but he did not directly measure them. "As a rule the demarkation line between the precipitous cliffs and the strandflat is much lower both on Værøi and on the Rost islands, in some places nearly at sea-level, but it is frequently hidden by the heaps of stones and gravel fallen from the cliffs."

The *submerged strandflat* of the Lofoten and Vesterålen Islands has a remarkably small extent, considering the exposed situation of the islands. Its surface topography is on the whole most similar to that which we have found to be typical for submerged plateaus built up of granite or other resistant rocks. It has in general fairly great depths, is sloping more or less outwards from the islands, and its outer edge is less sharply defined than that of the submerged strandflat of southern Helgeland.

The submerged strandflat of Lofoten is most perfectly developed on the two small submerged plateaus farthest out to sea towards the south-west. On the one are situated the two islands *Værøi* and *Mosken* and some scattered skerries, and on the other the islands of *Røst*. These islands are built up of gneiss and other crystalline schists. Only the rocky island Mosken near the north-eastern end of the Værøi Plateau is built up of gabbro and granite.

Th. Vogt [1912] has given a most interesting description, with a sketch-map and illustrations, of the emerged as well as the submerged strandflat of these plateaus. Their submerged topography may be studied in much detail in the charts Nos. 70 and 71 (in the scale 1 : 50,000) of "Norges geografiske Opmåling".

Both plateaus are oblong with their longitudinal axes in the direction SW to NE. They are much alike as to shape and size. If we take the isobath for 25 metres as boundary the Rost Plateau is about 25 kilometres long, from SW to NE, and about 11 kilometres broad at its broadest. The Værøi Plateau is about 19 kilometres long (from SW to NE) and about 11 kilometres broad.

Their submerged surfaces are comparatively even, and considerably more so than that of the Træna Plateau, to which they otherwise have resemblances in several respects. Along their middle parts the surface is near sea-level or only some few metres below it forming horizontal planes which on both plateaus extend towards the north-western side, where they come near the outer slopes with fairly sharply defined edges at depths of about 5 or 6 metres below mean sea-level. Towards the opposite, *i. e.* the south-eastern, sides of the plateaus their surfaces are more sloping, with less sharply defined edges, perhaps at about 20 metres or more below sea-level. Towards the south-west the surfaces of both plateaus slope more or less gently, and in most places with no well marked edges at any special depth. In their north-eastern parts they have, however, more sharply defined edges at some few metres below sea-level.

Rostoi, the biggest island of the Rost Plateau, is situated near its north-eastern end and is quite flat, its highest part being only 11 metres above sea-level. Most of the many other islands on this plateau are also quite low and flat, but some of them form isolated 'stacks' with steep sides rising abruptly above the plane of the strandflat to heights of about 100 to 167 metres above the sea [cf. J. H. L. Vogt, 1907, p. 12, Th. Vogt, 1912]. They are obviously the last remnants of the old land, which the shore erosion has not managed to plane down to sea-level. On the fairly flat tops of most of these 'stacks' (called 'nyker') the old, Palæic, land-surface still remains, almost intact, extending with its rounded undulating forms to the abrupt edges of the precipitous side walls [cf. Th. Vogt, 1912, pp. 7 ff.].

This is still more striking on the islandVæroi, where this old land-surface is of a greater extent with sharply marked edges above the precipitous side cliffs [cf. Th. Vogt's illustrative drawing, 1912, Fig. 8].

Here again we have thus convincing proof that, during the last period when the strandflat of this region was planed to its present shape, the effect of the subaërial denudation has been insignificant as compared with that of the shore erosion.

As was already pointed out by Th. Vogt, it is striking that on the Rost Plateau as well as theVæroi Plateau, the high islands, being the remnants of the initial land, are all of them situated along the eastern or south-eastern sides of the plateaus, with the greater part of the submerged strandflat on the outer side towards the west and north-west. The natural explanation might seem to be that this is due to the marine denudation which has attacked the plateaus most vigorously on their outer sides. But the above mentioned fact that the surfaces of the plateaus are most level, and nearest the sea-surface in their north-western parts and have the most sharply defined edges along their north-western sides might seem contradictory to this explanation.

Another feature is also of interest in this connection. Both plateaus are dissected by shallow submerged bays and channels along their south-eastern sides, while there are hardly any such formations along their outer north-western sides. These channels generally indenting the plateaus in northerly or north-westerly directions may be 15 to 17 metres deep and in some places even deeper than 20 metres. The emerged land is to some extent indented in the same manner. The island Rostoi has several similar narrow bays on its southern and south-eastern side. But it is especially conspicuous on Væroi. The north-western coast of this island is high and steep and is not indented while its whole south-eastern coast is indented by two or three cirque-like bays, which Th. Vogt assumes to be formed chiefly by marine erosion. I think he is right, but it is the shore erosion by frost and not the wave erosion which has been of chief importance, the same as on Træna (see p. 145). I also consider it to be probable that these bays may originally have been more or less cirques formed by local glacial erosion.

But if the marine ersosion (*i. e.* the shore erosion) has formed these bays and channels along the south-eastern sides of the plateaus, why has it not produced similar formations along their north-western sides and why is not, for instance, the north-western coast of Væroi indented? It might be answered that on the latter side the marine erosion has been so vigorous that it has cut back the coast sufficiently to obliterate these formations, but this answer would hardly be satisfactory, *first*, because an increased marine erosion might rather be expected to increase the bays if they are partly formed by it, and *secondly*, because it might at any rate be expected that traces of these bays and channels should occur on the submerged strandflat outside the coast. This strandflat is, however, very level especially on the north-western sides of the plateaus, and stands nearer sea-level there than on their south-eastern sides.

It might be assumed that these channels and bays have to some extent been sculptured by local glaciers on these plateaus, at an earlier time before the land was so much cut back by marine denudation, and the level submerged strandflat, especially on the north-western sides of the plateaus, may then be expected to have been formed by shore erosion during later periods, and to have become so perfectly even because the land was not previously as much dissected in those inner areas. In that case we might, however, expect to find traces of similar submerged channels along the outer north-western slope of the plateaus, but this is not the case, and the edges are well defined near the side slopes of the plateaus in these regions,[1] and are near sea-level.

Even if we could assume that because of the meteorological conditions, the glaciers especially occurred on the south-eastern sides of the plateaus, this could hardly give a satisfactory explanation.

To me it seems most probable that these features in the topography of the submerged strandflat of these two plateaus are due to the special structure of the gneiss forming them. The fact that at least some of the submerged channels have more or less parallel directions may also indicate their dependence on the structure of the rock.

It may be pointed out that on Moskenesoi to the north-east, there is a similar difference between the coasts, the inner, eastern coast of the island being indented by fjords and dissected by valleys, while along the outer, western coast there are no fjords, and the coast is very steep with an almost continuous mountain-ridge along this side of the island [cf. Th. Vogt, 1912, Fig. 11]. The fjords and valleys of this island are cirques or cirque valleys sculptured by local cirque glaciers. The explanation that the absence of fjords along the outer coast of Moskenesoi is due to the fact that this coast has been cut back by the marine denudation is hardly satisfactory, because we might then at least expect to find traces of the deep fjords on the submerged platform outside the coast.

If the difference in the topography of the two coasts cannot be explained by differences in the structure of the rocks, I think it probable that the meteorological conditions may have been more favourable for the formation of cirque glaciers and for the cirque erosion on the south-eastern and eastern side of the initial land than on its outer, western and north-western side.

The strandflat of *Moskenesoi* is entirely different from that of the Væroi and Rost Plateaus. This may to some considerable extent be due to the difference in the rocks, which are very resistant, consisting of monzonite (augite-syenite), gabbro, and labradorite rocks. As pointed out by Th. Vogt, a narrow but well marked *emerged strandflat* occurs in several places along the inner, eastern coast of the island, *e. g.* at Å, Sørvåg, and Reine, and on its northern side, at Mevold and Valle. But along the outer, western coast there are hardly any indications of an emerged strandflat, the mountains falling steeply into the sea.

In the case of the *submerged strandflat* it is quite different; there are hardly any indications of it along the inner coast of the island, the sea bottom sloping without any appreciable break from the coast towards the deep hollow of the Vest Fjord. Outside the outer coast there is, however, a submerged platform, which at least in some places has a fairly well-marked edge. But the depths of this platform and of its outer edge are as a rule much greater than those of the submerged strandflat of Helgeland. In some places there are somewhat higher banks on the platform, with depths of about 20 to 28 metres below sea-level, but to a great extent its depths are about 35 to 40 metres or even more. In some places the surface of the platform slopes gradually from the coast to the depths of the continental shelf without any noticeable edge.

If the isobath for 40 metres of depth be assumed to form the boundary of the platform its width varies between 7 and less than 2 kilometres.

As pointed out by Th. Vogt the submerged strandflat is most distinctly developed outside the coast at Refsvik (near the southern end of the island) where the land is built up of labradorite rock. He thinks this might be due to the fact that this rock is somewhat less resistant to erosion than the other gabbros of Lofoten. There is here a platform nearly 2 kilometres broad, with numerous shoals and rocks near sea-level and some emerging above it, and the outer edge of the platform is sharply defined.

It seems doubtful whether the greater part of the submerged platform outside Moskenesoi with its surface at depths between 30 and 40 metres and even between 40 and 50 metres, can actually, in its present shape, be considered as a submerged strandflat. It seems hardly probable that it can have been formed at a level so deep below present sea-level.

Th. Vogt may be right in thinking that the reason why there is less of a strandflat round Moskenesoi than on the Værøi and Rost Plateaus, may be that there has been a more vigorous glacial erosion under the high mountains of this island. It seems to me probable that it is the glacial erosion which has lowered the level of the submerged platform along the outer coast of Moskenesoi, although the surface of this platform is more even and less deeply dissected by channels or hollows than is generally the case where there has been an effective erosion by glaciers. It seems also difficult to understand why there is no submerged strandflat along the inner coast of Moskenesoi. The less effective marine erosion on the inner, less exposed coast is not sufficient to account for this fact, for we would at any rate expect some indications of a submerged platform, even though narrow, especially as there actually is an emerged strandflat, and there are parts of a submerged one along the coast further to the north-east in Vest Fjord, and a well developed submerged strandflat often occurs along more sheltered coasts.

Is it perhaps possibile that the big glacier which deepened the Vest Fjord, has cut away the submerged strandflat?

It is, however, also obvious that the nature of the rocks has some connection with these differences in the development of the submerged strandflat, for here again we find the same feature, that the submerged platforms cut in more resistant rocks have greater depths and more sloping surfaces than those cut in weaker rocks. The gneiss of the Værøi and Røst Plateaus is certainly considerably less resistant to glacial erosion as well as to shore erosion than the rocks of Moskenesoi.

It seems probable that these platforms cut in very resistant rocks where the initial land was comparatively high, have required a very long time for their formation. They are therefore comparatively old, and have been exposed to much glacial erosion during several glacial periods. The result is that they have been more or less lowered, so that their depths have been much increased, their surfaces have become more or less outward-sloping, and their outer edge has been rounded off and is less sharply marked. As was pointed out above, it is, however, strange that the glacial erosion has not sculptured deeper valleys and channels on this platform, similar to those that occur on land.

As has been pointed out by Th. Vogt, some mountains and mountain ridges on Moskenesoi have flat tops formed by the initial, Palæic surface of the land, which still exists more or less intact, extending with its undulating level surface to the very sharply defined edges over the precipitous side walls of the many cirque valleys.

This proves that in this region during the period when these valleys were finally formed, the effect of the subaërial denudation has been very insignificant as compared to that of the erosion of the cirque glaciers, which works to some extent in a manner similar to the shore erosion by frost, cutting back the sides of the cirque valleys into the mountain block with the initial fairly flat surface on top. The sharp edges between this surface and the mountain walls have thus arisen.

Along the south-eastern coasts of *Vest-Vågøi* and *Öst-Vågøi* (north-east of Moskenesoi) and the south coast of *Hinnøi*, bounding Vest Fjord to the north-west, there is a distinctly developed, although narrow strand-flat, consisting to a large extent of a platform with numerous small islands and skerries at the foot of the steep mountains (see Figs. 1 and 2). The surface of the submerged platform between the emerged islands and skerries is uneven and irregular with depths varying between 10 and 50 metres or even more, as they might be expected to be where the platform has been much exposed to glacial erosion.

The rocks of this region are gabbros and granites.

Along the outer, north-western coast of *Flagstadøi, Vest-Vågøi, Grimsøi,* and *Öst-Vågøi* there is a narrow submerged platform. In some places, *e. g.* north of Flagstadoi, it is flat and fairly even, at depths of about 12 to 16 metres below sea-level, having a fairly well marked edge at this level up to 7 kilometres from the coast. In other places it is more irregular. North of Grimsoi there is a 5 kilometres broad and very even platform with depths less than 10 metres, to a large extent between 1 and 6 metres below sea-level. To what extent these plateaus are levelled by recent sediment cannot be decided.

Along the outer coast of Vesterålen, further north, there is an irregular submerged platform similar to that along the outer coast of Lofoten. The islands of this region are likewise built up of gabbros, monzonites, and granites. There is also a well-marked emerged strandflat along the coasts of the islands [cf. Th. Vogt, 1910, photographs Pls. II and III].

Fig. 122. Strandflat west of Komag Fjord on the southern side of Sorøi, view towards Kobbe Fjord and Öi Fjord. July 6, 1912.

Senjen to Ringvasøi.

As there are few detailed charts of the coast north of Vesterålen, it is difficult to study the submerged strandflat in this region, but on the whole it seems to have very much the same character as along the outer coast of Lofoten and Vesterålen. Outside the great island of Senjen (where there is a detailed chart, No. 87) the submerged platform is in places as much as 9 kilometres broad, but has a very irregular much dissected surface, with varying depth. The outer coast of this island is also dissected by long, deep fjords. The rocks are to a great extent granites.

A submerged strandflat of very much the same character as the one just described to the south-west, extends along the outer coast north-eastwards as far as Rebbenesoi, Grotoi, and northern Kvaløi (70° 16′ N. Lat.). In some places, *e. g.* outside southern Kvaløi, it attains a width of 18 kilometres (in about 69° 55′ N. Lat.). It is much dissected, and carries a great number of scattered islets, skerries, and shoals. The coast is supposed to be built up of igneous rocks similar to those of the coast to the south-west.

Finmarken.

There are only few indications of a strandflat, above or below present sea-level, along the coasts east of the region of Ringvasoi, northern Kvaloi, and Vannøi. This sudden disappearance of a fairly well developed strandflat coincides in a striking manner with the sudden change in the geological structure of the coast, as I have already mentioned on pp. 50 f., where this fact has been discussed at some length. The lack of detailed charts of this coast with sufficiently numerous soundings prevents us from studying the detailed topography of its sea-bottom, and of possible submerged platforms at deeper levels.

In some places, *e. g.* on Sorøi (Fig. 122) where there are igneous rocks (gabbro) I have observed indications of what may be considered to be an emerged strandflat. But on the whole there are very few such formations along the coasts of Finmarken, which as a rule is extremely steep on the outer, seaward side. It is, however, possible that the low land extending along the coast from Vardo to Vadso and along the north side of Varanger Fjord may be considered as a strandflat, as Reusch has indicated on his map [1894]. As I have pointed out [1904, p. 119] it is also possible that there are indications of an emerged strandflat in the inner parts of the Finmark Fjords, *e. g.* in the inner end of Porsanger Fjord.

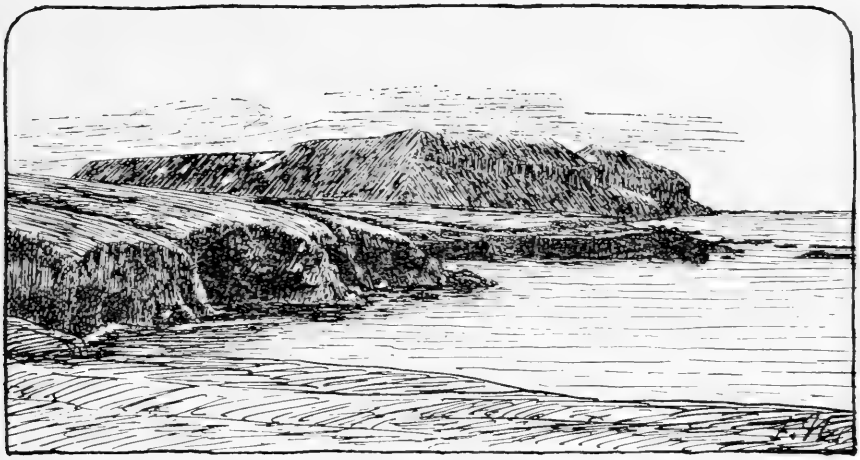


Fig. 123. Norwegian Harbour (Norske-havn) and Mount Misery, seen from the south. July 11, 1912. [From Nansen 1920].

XI. THE STRANDFLAT OF BEAR ISLAND.

The northern part of Bear Island, comprising nearly two thirds of its whole surface, forms a very flat and low plain (cf. Fig. 124, "Lavt, flatt slettelann"), cutting horizontally through the various geological formation and rocks, and through several faults (cf. Fig. 125), without any appreciable difference in height. Its flat surface is composed of sandstones, shales, limestones, and conglomerates of the Carboniferous and Devonian systems [cf. J. G. Andersson, 1900 a, and Olaf Holtedahl, 1919].

This plain is about 13 kilometres broad, and about 9 kilometres wide from the north coast to the foot of the mountains which rise steeply from the plain in the southern part of the island (cf. Figs. 124 and 125).

Seen from the sea, this plain gives the impression of being perfectly level (cf. Fig. 127). It is bounded along the shore on all sides by a vertical cliff (Figs. 11 and 128), which, according to Joh. Gunnar Andersson, is between 25 and 30 metres high above the sea. Only at some few isolated places is there a gentler slope from the plain down to the shore.

Professor Holtedahl informs me that according to his observations the height of the shore cliff may exceed 30 metres and even approach 40 metres on the north-west coast of the island, while it may be but little more than 20 metres above sea-level on the north-east coast in Coal Bay ("Kulbukten") near the Norwegian coal station (see Fig. 124). Personally I have not been ashore in this northern part of the island.

Joh. Gunnar Andersson [1900 a, p. 248] says that "from the said height of the cliff (25—30 m.) at the shore the plain rises uniformly by almost imperceptible degrees landwards to the region between the

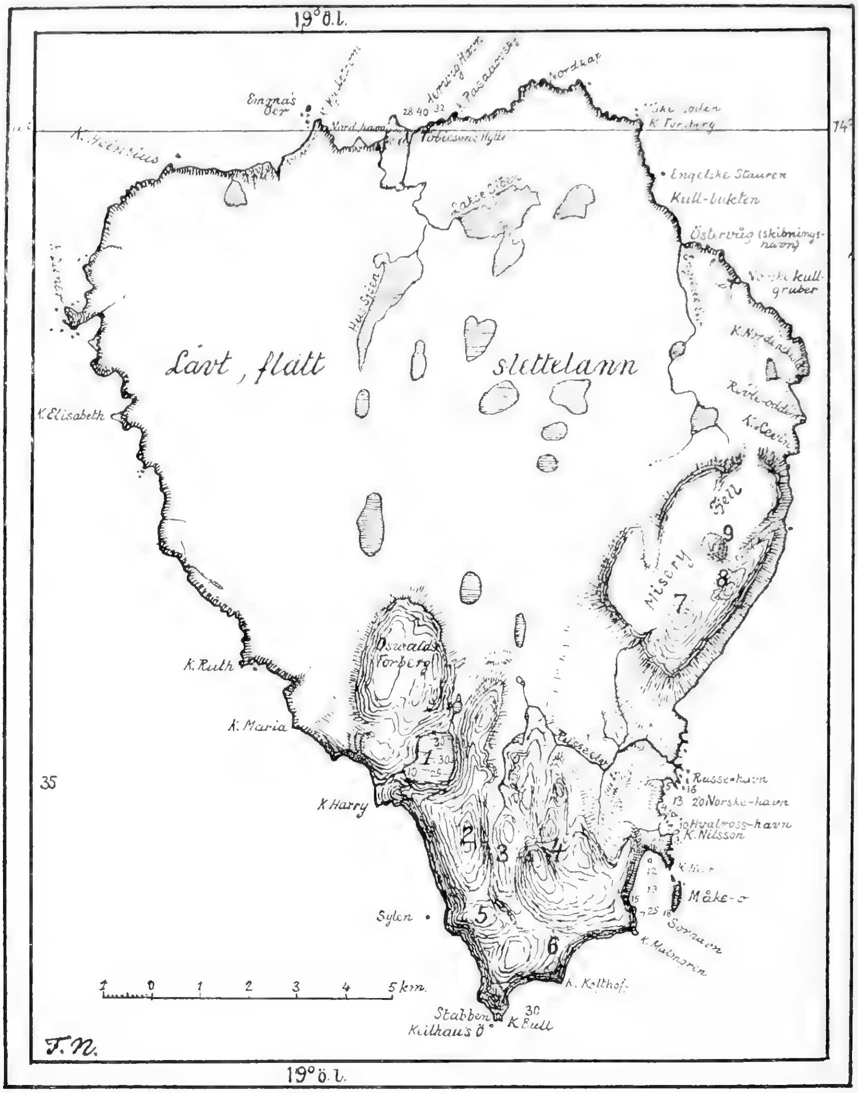


Fig. 124. Map of Bear Island, according to the survey of C. J. O. Kjellstrøm and A. Hamberg in 1898, with additions by J. Kessler 1899, and O. Holtedahl 1918.
1 Ella Lake. 2 Alfred Mountain. 3 Ymer Valley. 4 Antarctic Mountain. 5 Hamberg Mountain (424 metres). 6 Fugle Fjell (Bird Mountain). 7, 8 and 9 Three peaks Urd (539 metres), Verdandi (465 metres) and Skuld (464 metres) on Mount Misery. *Lavt flatt Slettelann* is the low, flat plain of the northern part of the island. [From Nansen 1920].

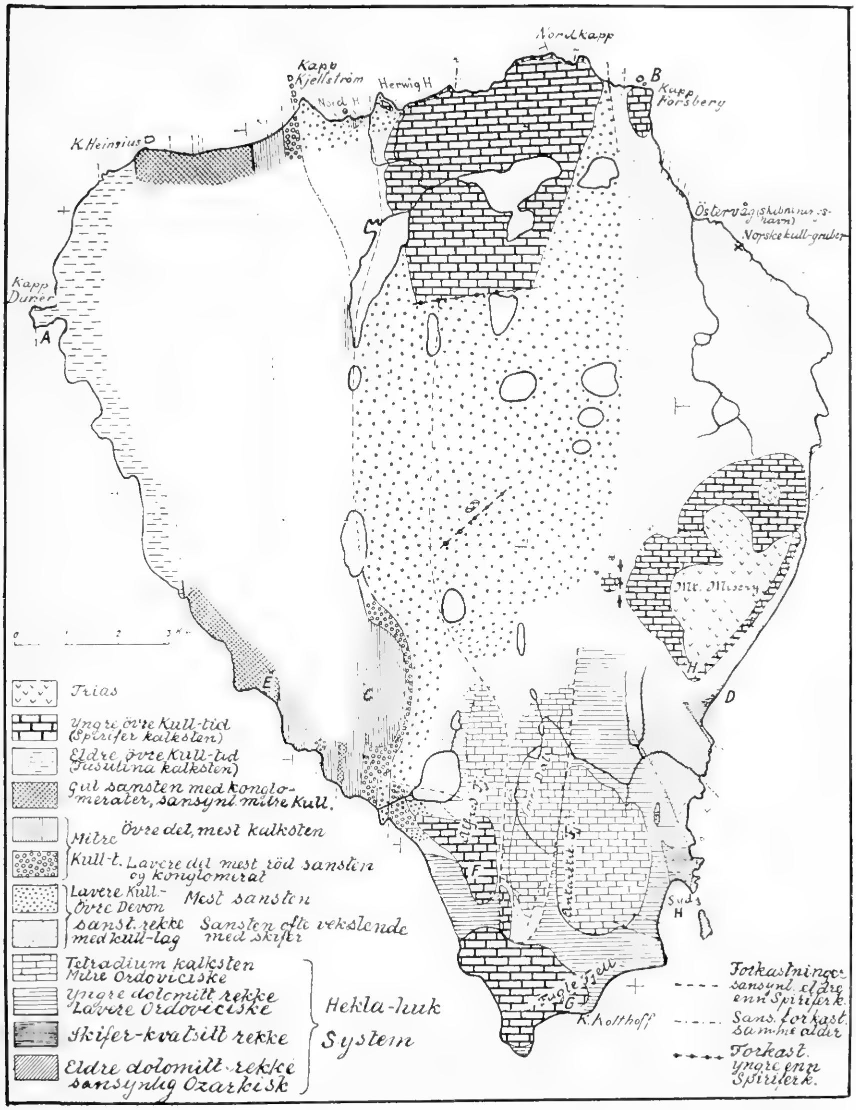


Fig. 125. Geological map of Bear Island by O. Holtedahl, based on his investigations in 1918, and those of J. G. Andersson in 1898. [Holtedahl 1919].

Translation of explanation, to the left: 1 Trias. 2 Younger Upper Carboniferous (Spirifer-Cora-coral limestone). 3 Older Upper Carboniferous (Fusulina limestone, &c.). 4 Yellowish sandstone with conglomerates, probably Middle Carboniferous. 5 & 6 Middle Carboniferous. 5 Upper part chiefly limestones with limestone conglomerate at the top. 6 Lower part chiefly red sandstone and conglomerate. 7 & 8 Lower Carboniferous and Upper Devonian sandstone series with coal seams. 7 Chiefly sandstone. 8 Sandstone often interbedded with shale. 9 Tetradium limestone, Middle Ordovician. 10 Younger dolomite series, Lower Ordovician. 11 Slate-quartzite series. 12 Older dolomite series, presumably Ozarkian.

9—12 Heclahook System.

Explanation to the right: 1 Faults, probably older than the Spirifer limestone. 2 Probable faults of the same age. 3 Faults younger than the Spirifer limestone.

northernmost part of Oswald Promontory (Oswald's Forberg, Fig. 124) and the western corner of Mount Misery, where its altitude may amount to about 100 metres".

Judging from my observations made from the sea, I understand that it is only in the southern central part of the plain that its surface attains altitudes as high as this estimate. On the south-eastern side of the island, south and south-west of Mount Misery, inside Russian Harbour and Norwegian Harbour ("Russe-havn" and "Norske-havn" Fig. 124, see also Fig. 125, D) there is a low land rising gently inland with somewhat similar heights (cf. Fig. 123).

During the Isachsen Expedition to Spitsbergen in 1910, Adolf Hoel visited the northern plain on June 24th and kindly gives me the following extract of his diary:

"24/6, 1910. Together with Koller, Håvimb, and Malme I went out to take the levels of the plane of abrasion north of Mount Misery. A profile southwards from the north point of Bear Island looks like this:

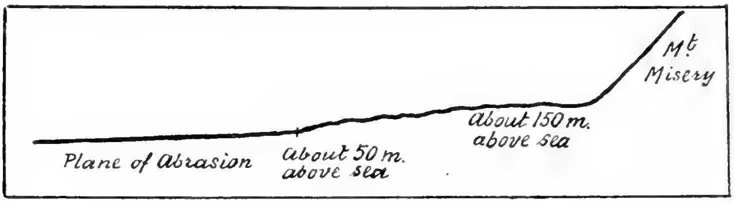


Fig. 126.

The plane of abrasion extends (from the coast) to a point a good distance north of Mount Misery. South of that point a low, but more broken land begins, which is not a plane of abrasion at all."

Hoel adds that unfortunately the time was too short for carrying out the intended measurements by levelling, the heights given in the above profile Fig. 126 are, therefore, based on aneroid readings, and are not accurate. The altitudes 50 metres and especially 150 metres may be too high.

Holtedahl also informs me that in its central southern parts the plain is somewhat less even than further north, and that it rises gently in low ridges towards the higher mountain slopes to the south (cf. Fig. 129).

The general level of the very flat northern part of the plain, and of its marginal parts east and west, is between 30 and 50 metres above the sea. On the north side of Mount Misery there is at this level a sharply defined boundary between the level plain and the steeply ascending mountain side (see Fig. 127). I estimate the height above the sea of this demarkation line at the foot of the mountain slope, to be about 30 or 35 metres on the east coast near Cape Levin, and it rises gently with the plain inland.

Fig. 127. Bear Island — its southern part, Mount Misery, and a part of the low northern plain. View from the north-east. [From Nansen 1920].

Fig. 128. West coast of Bear Island, showing the horizontal plane of the strandflat, and the hills rising steeply above it. (Photograph by O. Holtedahl 1918).

J. G. Andersson says that in its western part the plain is perfectly level. The surface consists there of Carboniferous limestone and sandstone which by weathering form a boggy argilaceous soil. The region of Spirifer limestone east of North Harbour (Nord-havn) is somewhat undulating, and so is also the extensive area of Devonian sandstones. Over the whole plain there are numerous shallow depressions, with hundreds of small lakes, but no indications of any valleys.

Most part of the plain is covered by débris, big, and small stones, obviously formed *in situ* by frost disintegration, but in some places, especially in its inner higher part, low flat ridges of bare rock are seen (Fig. 129), as is mentioned by Holtedahl.

Andersson considers this remarkable plain to have been formed in preglacial, and posttriassic, time by marine abrasion (*i. e.* wave erosion), in the manner suggested by Richthofen. "In the weak and easily disintegrated Devonian and Carboniferous layers which build up this low land, the abrasion has advanced relatively rapidly, while the Heclahook-massive to the south has offered much greater resistance" [1900 a, p. 278].

I think there can be no doubt that Andersson is right in assuming that this is actually a plane of marine denudation, at any rate the lower and flattest part of it, as there is no other process that can cut an extensive level surface like this in solid rock with no valleys and no actual drainage system, only numerous shallow lakes with accidental outlets. According to my view, however, it is not the wave erosion, but the shore erosion by frost that has been the chief agent for the development of this plane as well as that of the Norwegian strandflat. The wave action has been of

Fig. 129. From the sandstone area in the central part of Bear Island. To the right where the ground is darker is seen a part of a small isolated ridge of Spirifer limestone north of Alfred Mountain. (Photograph by O. Holtedahl 1918).

great importance mainly by washing away the débris of the shore erosion, and also by wearing down the outer parts of the plain.

We can at present observe this denudation process going on along the shores of Bear Island, where it has formed the vertical shore cliffs, with many small accumulations of ice and snow lying on the beach at their foot during a great part of the summer (see Fig. 11).

That the wave erosion also has much direct effect along this weather-beaten coast is demonstrated by the many caves formed in the present-day shore-line [see Nansen, 1920, Pl. III]. I have observed such caves in South Harbour ("Sorhavn", Fig. 124), in Walrus Harbour ("Hvalross-havn", Fig. 124), and in Norwegian Harbour ("Norske-havn", Fig. 124). Holtedahl has found deep caves penetrating far inland on the south-west coast of the island. The caves are generally formed along lines of fracture in the rock.

As I have pointed out before (p. 144) the disintegration by frost is, in my opinion, of much importance also for the formation of caves in this cold climate. Where the average temperature of the rock is below freezing point of water, there will easily be alternate thaw and frost according as the rock surface be washed by the sea or left dry. As far as I have seen, it is on the whole striking to what a small extent the walls of these caves exhibit traces of direct wave erosion, *i. e.* forms rounded by the waves. The surfaces are generally rough like that of rock exposed to disintegration by frost, and the edges are only to some small extent water-worn.

Where there are limestones or dolomites, or where there are fractures in the rock filled with limestone, the lime may be dissolved by the sea-water, or also by fresh water, provided that the low temperature of the rock does not prevent liquid water from percolating through the fractures

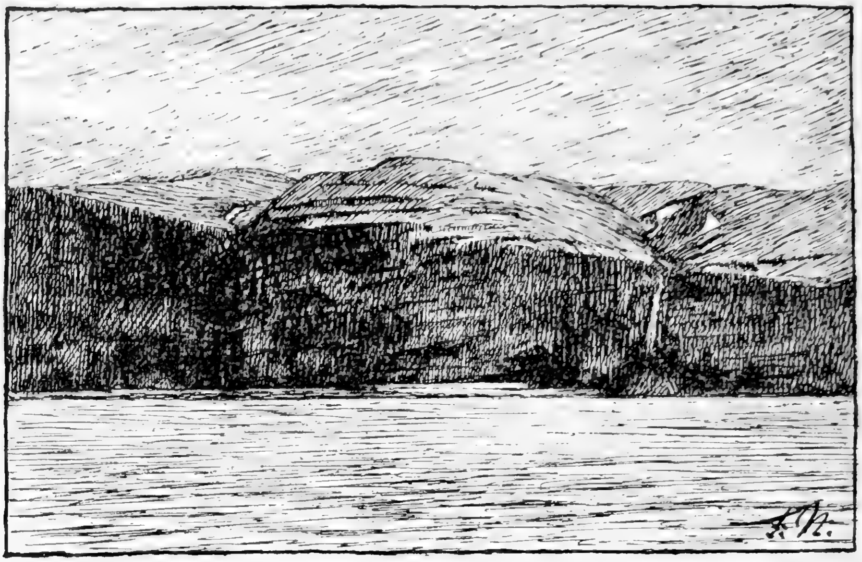


Fig. 130. The vertical cliff and the older, undulating mountain surface, on the west side of South Harbour („Sørhavn"). July 10, 1912. [From Nansen 1920].

The efficacy of the shore erosion on Bear Island is clearly demonstrated by the vertical cliffs, often some hundred metres high, along the southern coast. In most places they bound the older undulating mountain surface of the island with sharply defined edges (Fig. 130). This mountain surface has probably been developed partly by the subaërial denudation in the length of time and partly by glacial erosion. Although the subaerial denudation is obviously very effective in this region where the rocks have so little power of resistance, and where the disintegration by frost is so very active, it has not been able to keep pace with the shore erosion and round off the edges of the cliff to any appreciable degree, along the exposed parts of the coast.

Traces of a strandflat at the same height as the outer parts of the northern plain of the island may also be found along its southern coast where it forms parts of a horizontal platform at the foot of the steep mountain slope (see Fig. 131). Along this part of the coast it has, however, to a great extent been cut away by the effective marine denudation of more modern time.

It is a striking fact that there are very few traces to be found of a *submerged part* of the strandflat near present sea-level round the coasts of Bear Island. In some few places there are narrow submerged ledges, with depths less than 20 metres and with some few rocks emerging above water here and there, but they are hardly more than a few hundred metres broad, and as a rule the sea-bottom near the shore sinks steeply down to depths of 30 and 40 metres. At about this level there is, however, a

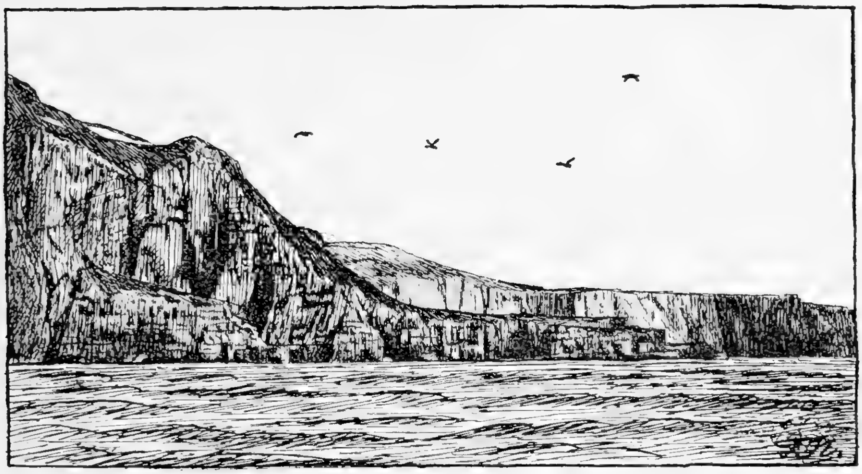


Fig. 131. Fugle Fjell (Bird Mountain) on the south side of Bear Island. After a photograph by A. Hamberg 1898. [From Nansen 1920].

submarine platform 9 to 20 kilometres broad, surrounding Bear Island. A similar submarine platform evidently surrounds Hope Island to the north-east, and on the submarine ridge connecting these two islands the soundings indicate three flat banks at the same level, with depths about 30 to 40 metres below the sea surface.

The question is whether these platforms ought not to be considered as parts of the strandflat which during times of emergence have been cut down to somewhat lower levels than the Norwegian strandflat. The probability is that they are built up of rocks with relatively little power of resistance to erosion, like those of Bear Island and Hope Island, and they have, therefore, easily been planed off during periods of emergence, even though these may have been relatively short.

In my opinion it is impossible that the emerged strandflat of Bear Island (the northern plain) can have been developed to its present shape during preglacial time, neither by marine denudation nor by subaërial denudation. In the latter case a drainage system would have been developed on the emerged, gently sloping plain. It might be objected that all traces of the broad, shallow valleys of this system have been obliterated by later glacial erosion. But if so, this glacial erosion would naturally have dissected the plain and made it more uneven. By whatever process this strandflat was formed, it is obvious that no preglacial plain, as level as this and cut in rocks with so little power of resistance, could have survived the destructive erosion of the glaciers of the great Ice Age.

It seems to me probable that this emerged strandflat was planed off to its present level surface by the shore erosion, as I have previously described, during periods when the island was standing somewhat lower (at least 30 to 50 metres) than now. Before that time the island had been much denuded by subaërial erosion, intensified by the frost in a climate for the most part severe, and during milder climatic periods by fluvial erosion which developed a drainage system of broad flat valleys, which, however, have been obliterated by the subsequent glacial erosion and shore erosion.

During the Ice Ages the land has probably been much denuded by glacial erosion, which, however, has not cut very deep valleys and fjords in this region of soft rocks.

Another process which has been of importance for the surface forms and the planing of the land in this region, is the flowing soil ("solifluction") [cf. G. Holmsen, 1915], which J. G. Andersson [1900] has studied on Bear Island.

By the disintegration of the frost the soft rocks are in many places transformed into an argilaceous mud which, when soaked with water by the melting of snow and ice in the spring and summer, becomes semifluid and slowly flows down the slopes even though they be very gentle. The freezing of the water in this boggy soil and the melting of it again, greatly helps this movement. In this manner the moving soil has a tendency to flow down into the small valleys and depressions and to some extent protect them against the frost erosion, while the higher sloping parts are more or less deprived of their coating of soil and their solid rock is more exposed to the disintegration by frost. This process may have some effect towards planing the land surface, and may help to obliterate the valleys [cf. Nansen, 1920 & 1921, Chap. II]. The northern plain is, however, to a very great extent covered by stones formed by the disintegration of the sandstone, and the above process cannot have been of so much importance in those regions.

After its final formation the strandflat has been covered by a local glacier during the last glacial period of the island. This glacier has not, however, eroded the surface of the strandflat to any appreciable extent, but on the surface of the rocks in some places, striæ still occur, radiating from the central part of the island towards the coast, as was first discovered by Nathorst [cf. J. G. Andersson, 1900, p. 438]. It is possible that the very shallow depressions now forming the many lakes, are due to this glacial erosion.

After the last glacial covering the bare rock-surface has been much disintegrated by frost, but as there has been very little transport on this flat plane the débris has to a great extent remained *in situ*.

It might be more difficult to decide the age of the now submerged strandflat of Bear Island — and between that island and Hope Island — now standing at a level of about 30 to 40 metres below the sea-surface. The probability seems to me to be that this part of the strandflat has been developed during the glacial periods.

It is a striking fact that no traces of a postglacial elevation of the land have been discovered on Bear Island, as has been mentioned by

Nathorst and J. G. Andersson [1900, p. 439]. As the latter points out it is possible that such marks might have been obliterated along these shores where the rocks have but little power of resistance and the postglacial erosion, especially by frost, has been considerable. But if there had been shore-lines or shore-cliffs on the strandflat further inland, it seems none the less probable that some traces of them might have been found somewhere.

As long as there is no evidence to the contrary we may therefore assume as most probable that this island has had no postglacial elevation, as seems also to be the case on other small island plateaus like that of the Færoes, Shetland, and possibly Jan Mayen.

It might be more probable that there has been a positive movement of the shore-line in postglacial time, otherwise it may, for instance, be difficult to explain why there is not a broader submerged shore bench near present sea-level round the island, if the present-day shore was exposed during the whole of postglacial time to the very effective shore-erosion now going on. In the few places where a quite narrow shore bench with shallow water has been developed, *e. g.* Walrus Harbour, Norwegian Harbour, Herwig Harbour, North Harbour, and west of that region, the shore is built up of rocks, with very little power of resistance to erosion, and where it cannot have taken a long time to erode the existing submerged shore benches.

In spite of the considerable postglacial elevation of the land that has taken place in Scandinavia to the south and on Spitsbergen to the north, and also on Franz Joseph Land, the disappearance of the ice cap has probably caused no appreciable postglacial elevation of the crust in this region, for during the last glacial period the island was probably covered by a small local glacier only, the weight of which depressed the crust less than the sea-level was temporarily lowered by the reduction of the volume of the Ocean owing to the accumulation of frozen water on land.

But of more importance in this respect is probably the considerable displacement of the semi-plastic 'magma' underlying the rigid Earth's crust, which must have taken place when by the weight of the ice caps Scandinavia to the south was depressed 300 metres, or more, in its central parts and Spitsbergen some hundred metres to the north. By the displacement of the 'magma', the intervening region of Bear Island has probably been raised, and when, after the disappearance of the ice-caps, the displaced 'magma' again 'flowed' slowly back to its former position more or less, and the previous equilibrium was restored, there would be a slow subsidence of the crust in the region of Bear Island.

If in this manner, the shore-line in the Bear Island region stood during the glacial time about 30 or 40 metres lower than now, the platforms may have been formed which now are submerged about 30 and 40 metres below present-day sea-level.

The vertical range between the uppermost level above the sea and the lowest submerged level of the apparent strandflat is thus considerably greater on Bear Island than is generally the case along the Norwegian coast (with the exception of Finmark perhaps). This may be due to the fact that the rocks of the Bear Island region have so little power of resistance that the vigorous shore erosion may have managed to plane down fairly broad platforms during relatively short periods. The planes cut at temporary high or low levels at which the shore-line may have stood during vertical movements of the land crust or of the sea-level, may therefore in this region appear as though they belonged to the strandflat. In Norway, however, a much longer time has generally been required for the development of broad shore benches. The Norwegian strandflat was therefore formed during long periods when the land crust stood at its normal level of equilibrium (cf. p. 42), while the higher shore levels lasting for shorter periods have left few conspicuous marks only in the shape of old raised beaches and shore-lines.

While there can hardly be any doubt that the outer flattest parts of the plain of Bear Island have been levelled by shore erosion, it is very difficult to decide how its inner part, higher than 50 metres and rising to 100 or, according to Hoel, even to 150 metres above the sea, has been formed. We have seen that Hoel does not consider it to be a plane of marine abrasion because it is more uneven than the outer very level plain. On the other hand there is as a rule a fairly well marked boundary between this higher plain and the more steeply ascending mountain sides along its southern margin, especially at Mount Misery. Although there may be some difference in the power of resistance of the rocks of the mountains and of the plain, it is hardly sufficient to account for the difference in slope, and it seems to me to be possible that also the inner, higher part of the plain may have been formed by shore erosion, but during a more remote period than the lower flatter part, and by exposure to later erosion it has become more uneven. On the other hand it is difficult to believe that, during some comparatively recent period, the land has been submerged up to these higher levels for sufficiently long time to have an extensive plain like this cut by shore erosion.

This higher plain of Bear Island has a certain resemblance to the plain across Hitteren in Norway, previously described (p. 123), rising gradually above 60 metres in the middle of the island (cf. map Fig. 107). It has likewise a width of 13 kilometres. On Alsten Island at the foot of the "Seven Sisters" there is a similar plain (about 8 kilometres across) rising above 60 metres in the middle of the island. It is probably cut in mica-schist although to a great extent it is covered by quaternary marine deposits and moraines.

If it were not for the small areas of these islands one might be tempted to assume that these plains have been gradually raised by isostatic movements during and after the formation of the strandflat. We do not know yet within how small areas the isostacy may produce more or less local uplifts; but the gradient of lateglacial and postglacial upheaval sometimes seem to vary appreciably within comparatively short distances. Besides the rigidity of the crust has not prevented the formation by mountain folding of ridges no broader than these islands.

On Bear Island as well as on Hitteren, and probably also on Alsten, considerable quantities of rock have been removed, which originally covered the areas of the plains. The mountains on the sides of the plains may give some indication of the initial height of the land. Where the rocks are so extremely weak as those forming the top of Mount Misery (539 metres above the sea) it is also obvious that a great thickness of rock has been removed from the top of the mountains during the long time that has elapsed since the development of the present strandflat commenced.

The removal of the weight of hundreds of metres of rock from above the present plains has caused a slow elevation of the crust in the region of the islands. During this continuous elevation of the original strandflat its outer parts have been gradually lowered by the shore erosion, and thus a gentle outward slope from the inner parts of the plains has been formed. As the elevation was much slower during its latest stage, the outer part of the plain became most horizontal.

It might be objected that, if this explanation be correct, the extremely level plain of Smolen (cf. pp. 120 f.) ought to have been elevated in a similar manner. The probability is, however, that the initial land of Smolen was much lower, the isostatic elevation was therefore much smaller and much slower, and while the shore erosion was still most vigorous, it had time to plane down the whole plain, and make it almost horizontal.

This might seem a rather bold hypothesis, and it has to be admitted that weighty objections may be raised. If the isostatic compensation can assert itself, to some extent, within such small areas, it might be difficult to understand why the strandflat now stands at levels which are very similar over extensive regions although the quantities of rock removed may differ greatly. These problems will be discussed in a later chapter.

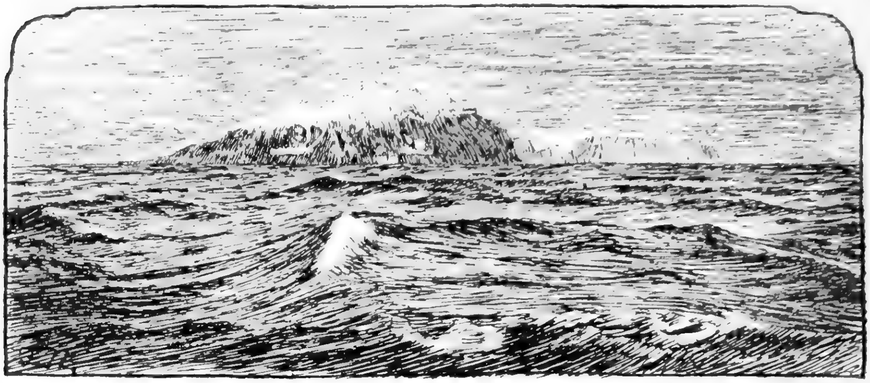


Fig. 132. Vogel Hook, the northern point of Prince Charles Foreland, seen from the north (July 27th, 1912). The difference between the steeper west side of the island, and the more sloping east side with a broad strandflat is noteworthy [from Nansen 1920].

XII. THE STRANDFLAT OF SPITSBERGEN.

The emerged strandflat is a very conspicuous feature in the landscape along the coasts of Spitsbergen. It is very different from the Norwegian strandflat as it forms more or less continuous low plains in front of the often oversteepened mountain sides, and it is not split up into numerous islands and skerries.

Literature.

Adolf Hoel [1909, 1914] has subjected it to special investigations. He says [1914, pp. 25 ff.] that "along the whole of the Spitsbergen coast which he had an opportunity of examining, from Ice Fjord to Wood Bay, the coast, between the sea and the mountains, is surrounded by a border of low land from which the mountains rise abruptly and partly vertically forming a rather conspicuous precipice".

"The boundary between the plain and the mountain is often covered by quaternary marine terraces, or by a talus (scree). But it also often appears very sharply marked, and at a certain distance one always gets the impression of a well defined line of demarkation."

"These coastal plains are missing only in the inner parts of the fjords, *e. g.* in the inner part of Cross Bay. They are especially well developed along straits, thus along Foreland Sound 10 to 20 kilometres wide, they attain a considerable width on both sides of this sound. They reach their maximum development at prominent points, *e. g.* at the north-east corner of Prince Charles Foreland, at Quade Hook, at Cape Guissez, and Cape Mitre."

"Under otherwise equal conditions, they are wider where the rocks are less resistant, *e. g.* Carboniferous limestones and schists of the Hecla Hook system, and are narrower where more resistant rocks predominate."

Hoel states that, in the region between the southern end of Prince Charles Foreland and Cross Bay, the inner margin of the strandflat, at the foot of the steep mountain-slopes, is about 25 and 30 metres above sea-level.

He thinks that this strandflat is a plane of marine abrasion, formed by wave erosion in the manner suggested by Richthofen. It is a plane of perfect regularity, much more level than the Norwegian strandflat is generally.

He agrees with my views [1904] as to the age and formation of similar strandflats, and does not consider it possible that this strandflat can be of preglacial age, but assumes it to be "more recent than the time of maximum development of the ice covering: it seems impossible that a plain could preserve so perfect an evenness as it has here, if it had been traversed by inland-ice". He also considers it to have been formed after the excavation of the fjords by the glaciers; and gives several convincing pieces of evidence [1914, p. 27] to prove that such has been the case.

On the other hand, he thinks that, "after the development of the strandflat there has been a period when the glaciation was more considerable than at present. At that time erratic blocks and moraines were left in several places, *e. g.* on the south-east extremity of Danes Island."

"The geological conditions as regards this coastal plain prove that the glacial covering has varied considerably on Spitsbergen, and that the plain has been formed by marine abrasion at a time when the glaciation was relatively less considerable."

Adolf Hoel maintains that the sea must have remained at its present level for a long time along the coast of Spitsbergen, for the wave erosion has had time to form typical shore cliffs in numerous places along the open coast and in the great fjords. At the foot of these cliffs there is generally a sandy beach, dry at low water. This beach is often continued in a narrow submerged platform sloping gently seawards, till the bottom suddenly descends by a steep escarpment to depths of 200 and 300 metres. This submerged platform must be a plane of marine abrasion, which he has especially observed in Cross Bay.

Gerard de Geer has also discussed the strandflat of Spitsbergen, but tries to explain its formation by his theory of dislocations (faults), and considers it to be thus preserved remnants of a peneplain, an explanation which, according to my view, is especially improbable on Spitsbergen, for several weighty reasons. *First* there are strandflats backed by steep mountain sides in many places where there are no traces whatever of any faults or dislocations, as proved by the investigations of Hoel and Holtedahl.

Secondly the surface of the strandflat of Spitsbergen is decidedly not that of a regular peneplain. As Hoel has pointed out, it is often

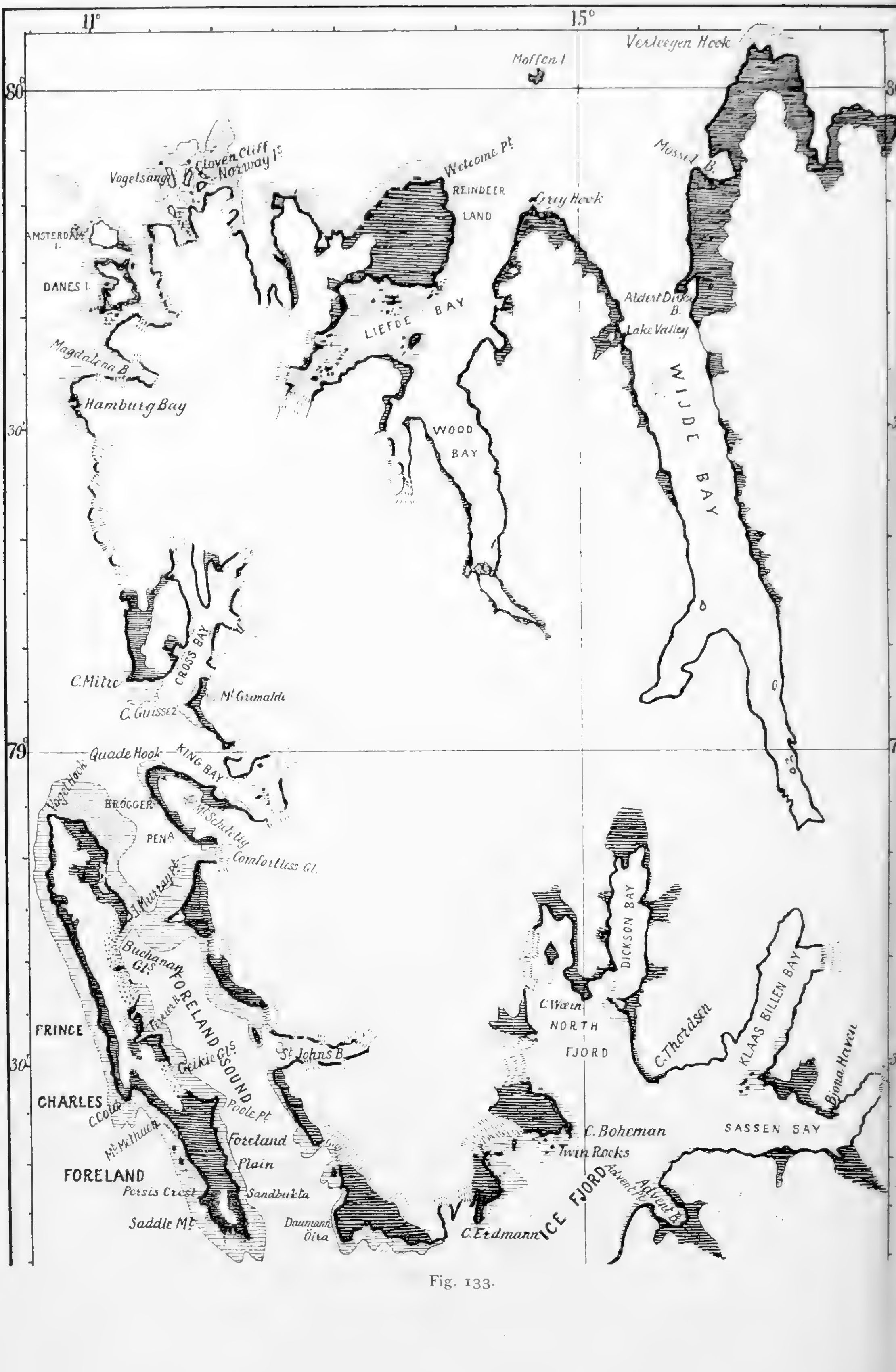

11°
15°
80°
30'
79°
Verleegen Hook
Moffen I.
Mossel B.
Welcome Pt
Cloven Cliff
Norway Is
Vogelsang
REINDEER LAND
Grey Hook
AMSTERDAM I.
DANES I.
LIEFDE BAY
Aldert Dirks B.
Lake Valley
Magdalena B.
Hamburg Bay
WIJDE BAY
WOOD BAY
CROSS BAY
C. Mitre
Mt Grimaldi
C. Guissez
Quade Hook
KING BAY
Vogel Hook
BRÖGGER PENA
Mt Schetelig
Comfortless Gl.
Murray Pt
DICKSON BAY
Buchanan Gls
FORELAND SOUND
KLAAS BILLEN BAY
C. Waern
NORTH FJORD
C. Thordsen
PRINCE
St Johns B.
Geikie Gls
Bjona Haven
CHARLES
C. Cold
Poole Pt
SASSEN BAY
Mt Methuen
Foreland Plain
C. Boheman
Twin Rocks
FORELAND
Persis Crest
Sandbukta
ICE FJORD
Advent Pt
Advent B.
Saddle Mt
Daumann Öira
C. Erdmann

Fig. 133.

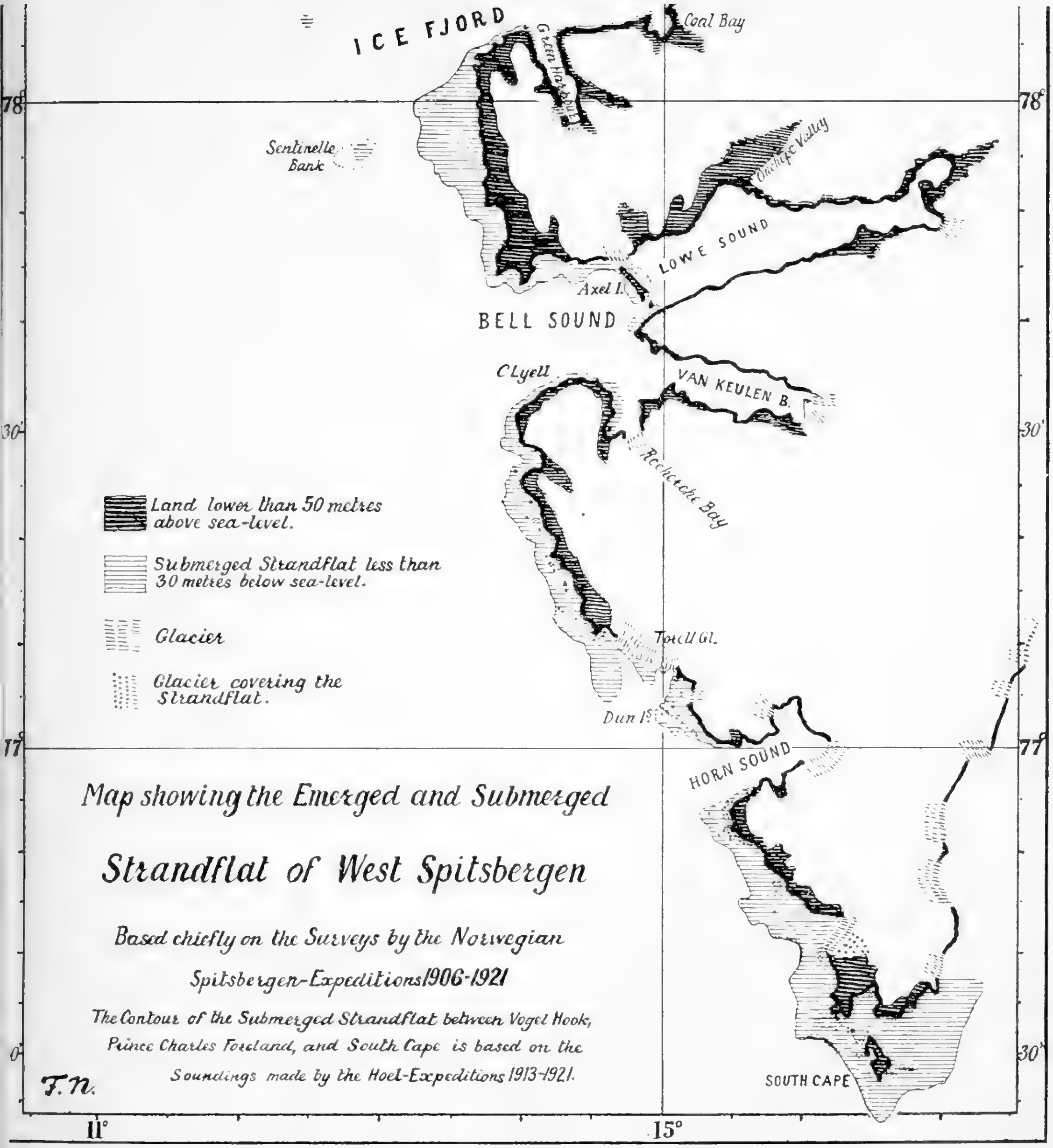


Fig. 134.

Figs. 133 & 134. Map of the North and West coast of Spitsbergen, showing the distribution of the Strandflat. Fig. 134 is a direct continuation of Fig. 133.

perfectly even, and it shows no indications of any drainage system, which must be the typical feature of a peneplain. There may be a good many shallow lakes on this surface, draining through more or less accidental channels of postglacial origin, but there are no indications of older valleys on the flat planes.

Bertil Hogbom has not studied the strandflat of Spitsbergen, but like Hoel he points out [1914, p. 294] that shore-cliffs are characteristic of the Spitsbergen fjords, and are well developed even in places where the wave action can only have been quite insignificant.

He maintains that the surf and the ice drift are essential for the transport of the waste, and are therefore necessary for the formation of a cliff-shore, but their direct power of erosion may be of minor importance. The destruction of the rocks by the frost must be much more effective. The fact that accumulations of snow ("snow-foot") frequently remain on the beach at the base of the small cliffs during a great part of the summer without being washed away by the breakers, also disproves the direct importance of the waves for the development of the cliff.

He thinks that by keeping the cliffs always wet, the freezing sea-water must have much disintegrating power, especially as even open crevices are kept full of water. The sea-water will furthermore thaw the frozen rock, and by alternate high- and low-tide a regular "regelation" may thus be produced.

Where the coast is relatively much exposed, and the surf can assist the frost in breaking loose the material and carrying it quickly away, a considerable abrasion may be produced, and he assumes that the submerged flat platforms, 1 kilometre broad, outside more exposed coasts in Ice Fjord — *e. g.* between Cole Bay and Advent Bay and at Cape Thordsen — have been thus formed.

As may be seen, the views of the present writer coincide in several respects with those of B. Høgbom. He justly points out that, although a great dislocation may probably have occurred along Ice Fjord, as suggested by Gerard de Geer, this cannot explain the formation of the submerged platform, intervening between the deep channel of the fjord and the steep mountain side.

B. Høgbom does not think it is possible to decide finally at present whether or to what extent, these platforms with their shore-cliffs have been formed in postglacial time.

His view obviously is [cf. 1914, p. 295] that the Norwegian strandflat has been formed in a similar manner.

Angus M'Ewen Peach [1916] describes the strandflat (which he calls the Preglacial Platform) of Prince Charles Foreland, and also along various parts of the coast of the mainland of Spitsbergen. He

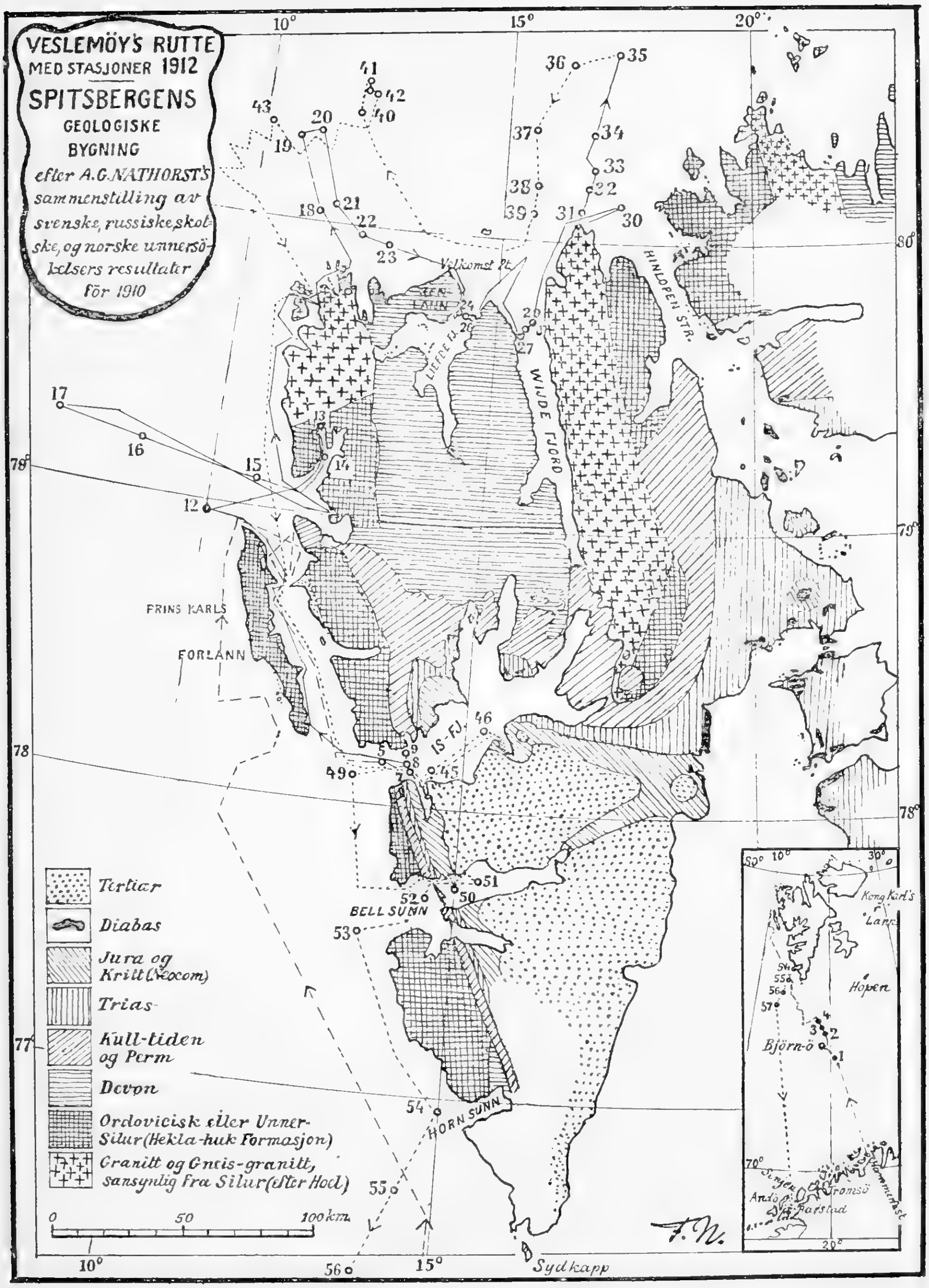


Fig. 135. Geological Map of Spitsbergen, chiefly after A. G. Nathorst, based on the Swedish, Russian, Scottish, and Norwegian researches before 1910. The *broken* and the *dotted lines* indicate the course of the "Veslemøy" in 1912, with the oceanographic stations. [From Nansen 1920]. Translation of the explanation in the lower left corner. 1 Tertiary. 2 Diabase. 3 Jurassic und Cretaceous (Neocomian). 4 Trias. 5 Carboniferous and Permian. 6 Devonian. 7 Ordovician or Under-Silurian (Hecla-Hook Formation). 8 Granite and gneiss-granite, probably Post-Tertiary (according to Hoel).

states that "this shelf (on Prince Charles Foreland) has in general a rocky surface, planed or carved partly out of nearly vertical members of the Heckla Hook series. It rises gently from near sea-level towards the slopes of the central hills, terminating inland at an altitude of about 150 feet (46 metres). The constancy of level maintained by this inner margin and the fact that it is often marked by lofty cliffs or at least precipitous slopes, indicate very clearly that the platform is the result of marine erosion." . . . "Beach deposits occur here and there on the platform, but it is clear that they have no genetic connection with it. They are obviously of postglacial age, while the rock platform itself is obviously preglacial."

His reasons for the latter conclusion are 1) that the surface of the platform "has been shown to be striated in several places", 2) "it is frequently strewn with iceborne erratics from the mainland of Spitsbergen, while patches of drift containing foreign boulders have been found here and there covering its surface."

The probability that these striæ, erratics, &c. may be due to the last advance of the glacial covering is, however, not considered, nor is it explained how this remarkably level platform might have been able to preserve its evenness if it had been exposed to the erosion of the big glaciers of the Great Ice Age.

The platform is in several places on Prince Charles Foreland and on the mainland of Spitsbergen described as rising from the shore to a general level of between 100 and 150 feet (30 and 46 metres); while it is said to rise to about 200 feet (61 metres) at the base of the over-steepened hills, in several places on the mainland of Spitsbergen, *e. g.* at Quade Hook, at the mouth of St. John's Bay in Foreland Sound, in Lowe Sound (Van Mijen's Bay), in Recherche Bay, on the south-west side of Advent Bay near Advent Point, south of Sassen Bay.

Peach considers it to be beyond a doubt that the cutting of this platform was a later event than the partial submergence of the old river-valley system, by which according to his view the fjords originated, consequently in preglacial time.

His view is that "the Spitsbergen rock-platform is clearly the same as that of the coast of Norway", and a platform of similar type "is found also on the west coast of Scotland, at a height of 100 to 140 feet (30 to 43 metres) above sea-level. There is also a platform of marine erosion of preglacial age a short distance above sea-level in England and in the south of Ireland."

Fig. 136. The Saddle Mountain, with the strandflat on both sides, on the southern end of Prince Charles Foreland, seen from Foreland Sound on July 16th, 1912. [From Nansen 1920].

Relation between the Development of the Strandflat and the Geological Structure of the Land.

The strandflat of Spitsbergen is to a great extent cut in rocks with relatively little power of resistance to the frost erosion. It has therefore easily been levelled to a fairly regular plane in most places, rising gently inland from the shore. Where, however, the rock is more resistant, the strandflat is much narrower, or is poorly developed, with a more uneven surface. This is, for instance, the case in the region of the north-west corner of Spitsbergen, where there are gneiss-granites and granites (see Fig. 145). The strandflat is here poorly developed, and its surface is uneven like that of the Norwegian strandflat cut in resistant rocks.

On the east side of Wijde Bay the land is built up of gneiss-granites, and in its northern parts of mica-schists and other crystalline schists. There the strandflat is well developed, with a flatter, more regular surface, obviously because the rocks are less resistant.

A comparison between the geological map Fig. 135 and the map Fig. 133 and 134 may give some idea of the relation between the distribution of the strandflat and the geological structure of the land.

Prince Charles Foreland.

The emerged strandflat is well developed on Prince Charles Foreland, and it is a noteworthy fact that in the northern part of the island it is wider along the relatively sheltered east coast than along the west coast exposed to the violent wave action of the open ocean, and where we might expect to find it especially well developed.

The explanation may to some extent be that the strandflat has chiefly been finally planed by the shore erosion by frost after the land had been much denuded especially by the local glacial cirque erosion, while the main importance of the wave action has been to carry away the débris formed by the shore erosion. For this purpose there has been sufficient wave action in the Foreland Sound, now 10 to 20 kilometres broad, and

Fig. 137. East coast of Prince Charles Foreland northwards from the Foreland Plain

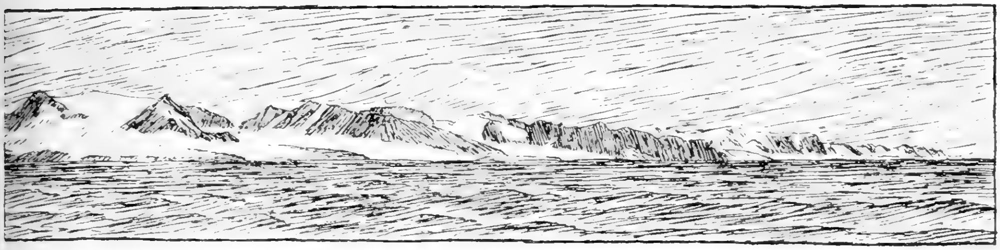
formerly, when the shore-line stood higher during the planing of the strandflat, even broader.

It is, however, striking that the highest mountain ridge of the northern part of the island is much nearer its west coast than its east coast and is steeper and less dissected by valleys along its west side than along its east side (cf. Fig. 132), where there is also a greater accumulation of glaciers. These are features somewhat similar to those previously mentioned on Moskenesoi, and also on Værøi and Rost, in Lofoten (see p. 160). This similarity may be accidental, and may be more or less due to the geological structure of the land. But it is also possible that the greater accumulation of glaciers on the eastern side of Prince Charles Foreland is due to the meteorological conditions, and that, therefore, there has been a more active local erosion by glaciers (cirque glaciers) on the eastern side of the island than on the western side, cutting back the mountain slope.

It might seem most natural to explain the difference in steepness between the eastern and western sides of the mountains as an effect of a more vigorous marine erosion along the more exposed west coast. But in that case there should be a broader strandflat along the west coast. As will be mentioned later, there is a submerged platform along this coast, but not very broad, and the width of the submerged and emerged strandflat is not broader along the west coast than along the east coast of the island.

In its southern part the strandflat extends across the island, forming the Foreland Plain (or Foreland Laich), 4.5 to 9 kilometres broad from coast to coast, and 15 kilometres long between the slopes of Mount Methuen to the north (Fig. 137) and of Persis Crest (Fig. 140) of the Saddle Mountain to the south (Fig. 136).

According to Hoel [1914, pp. 25 f.] Mr. Koller of the Isachsen Expedition took the levels of this plain in 1909. It rises very gently landwards from both shores, but the highest point along his line of levelling, 16.3 metres above the sea, was 4.6 kilometres from the west coast and only 1.95 kilometres from the east coast, which may indicate that the western part of this plain has been slightly more denuded by the wave erosion. The width of the strandflat may otherwise vary between 1 and



and Mount Methuen, seen from Poole Point on July 23rd, 1912 [from Nansen 1920].

5 kilometres along the east coast, while along the west coast it is as a rule less than 2 kilometres and often less than 1 kilometre.

The strandflat of Prince Charles Foreland is cut in shales and limestones of the Hecla Hook system, which are easily disintegrated by the frost. In some places there are lenses and layers of quartzites forming quite low ridges, as pointed out by Hoel.

The bare rock is seen everywhere in the surface of this strandflat, or is covered by a thin layer of débris evidently disintegrated by frost, and in many places transformed into an argilaceous or muddy soil, with the characteristic network of stone-rings, which, according to my view, is due to the effect of the frost and thaw causing expansion and contraction of the water in the wet soil and in the patches of snow when freezing and melting [cf. Nansen, 1920 and 1921, Chap. VIII].

Wherever the rock is bare near the shore, there is a vertical shore cliff 4 to 8 metres high. At many places there is, however, a flat shore of sand, gravel, or pebbles, evidently to some extent consisting of waterworn moraine material (Fig. 138). In some places in the shore I noticed that this drift was stratified. It lies nearly at the same height as the real strandflat cut in solid rock, and rises to a few metres above high water level.

The wave-action, and perhaps also the sea-ice, have built up ridges which may often extend considerable distances along the shore, forming lagoons, which are common along the east coast of this island.

On July 25th, 1912, I observed that on the north side of Poole Point the storm of the previous day and night had entirely filled up and obliterated the entrance to the lagoon. Only two days earlier this entrance had been so deep that I could not easily wade across it.

The strandflat rises gently from the shore, or the shore cliff, to a general level, the altitude of which I estimated to be about 6 to 10 metres in the region of "Sandbukta", near the northern part of Saddle Mountain, south of the Foreland Plain.

Further inland there are a good many ridges rising to a higher and fairly uniform level extending to the foot of the mountain, which rises abruptly from the plane (cf. Figs. 139 and 140). I estimated the height of this level to be 20 to 30 metres above the sea, but I had no oportunity of measuring it by levelling. My estimate agrees, however, with Hoel's statement that the inner margin of the plain is 25 to 30 metres above sea-level. Peach's estimate of the height of the inner margin of the strandflat of the Foreland, 150 feet (or 46 metres), appears to be too high.

At the foot of the mountain, Persis Crest, there is a conspicuous ledge, to a great extent built up of loose stones. I observed indications of similar ledges at the foot of the mountain, on the south-eastern side of Saddle Mountain, and also on the south-east side of Mount Methuen (cf. Fig. 137). I found a similar conspicuous ledge in Lake Valley on the west side of Wijde Bay (see later).

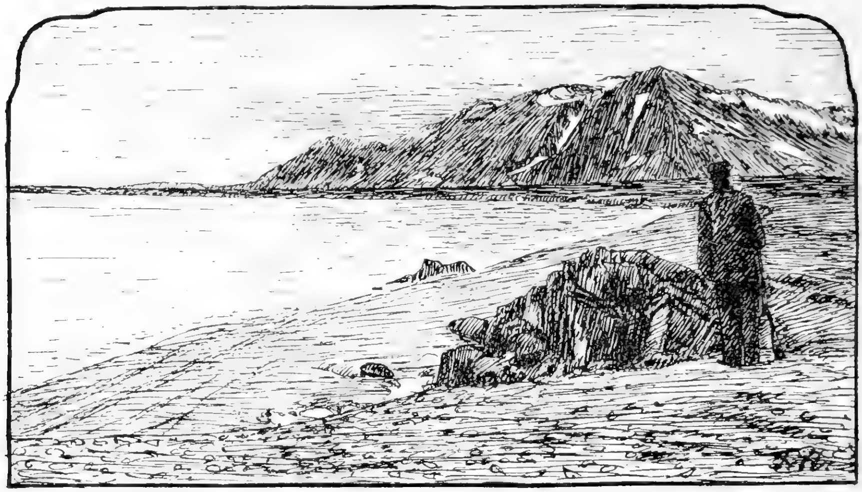


Fig. 138. The Sand Bay ("Sandbukta") with the southern part of Saddle Mountain and the strandflat on Prince Charles Foreland. July 22nd, 1912 [from Nansen 1920].

Hoel assumes that these stone-ledges have been formed by stones that have fallen down from above on to the surface of small glaciers along the mountain sides, and have gathered at the foot of these glaciers. But considering the evenness of their upper surface, situated very nearly in the same level as far as I could see from the distance, — I think that they indicate a raised shore-line, and they may have been formed to a great extent by stones that, owing to the regular shore-erosion, described pp. 30 ff., have continually been falling down from the mountain side above on to the accumulations of snow on the shore ledges, and have gathered on the beach and on the relatively steeply sloping sea-bottom outside the foot of these shore-accumulations of snow and ice. The stones that remained above water were soon disintegrated by the frost, while those below water were more protected.

The fact that the stones on these ledges are sharp-edged as a rule, and show no traces of having been worn by the surf, may be accounted

Fig. 139. Surface of the strandflat with 'stone-rings', on the east side of Saddle Mountain. July 22nd, 1912 [from Nansen 1920].

Fig. 140. The strandflat at the foot of Persis Crest, on the north-eastern side of Saddle Mountain. July 2nd, 1912 [from Nansen 1920].

for as an effect of the frost action, in a similar way as the fact that the rocks of the shore-ledges cut in solid rock are also sharp-edged, with very few traces of wave-erosion. Some stones have obviously also fallen down on these ledges after they were raised above sea-level.

It is striking that these ledges, wherever I have observed them, always occurred at the foot of very steep mountain sides, where stones may be expected to have been perpetually falling, especially when the shore erosion worked at the foot of the mountain. The probability is, however, that the inner part of these ledges are more or less cut in solid rock, but this is often difficult to examine, as their inner margin is generally covered by a talus (scree).

I had no opportunity of measuring the height of these stone-ledges on Prince Charles Foreland, but estimate it to be about 50 metres above sea-level.

At the foot of the ledges accumulations of snow are now eroding small cirques in their steep slope, oversteepening them (cf. Fig. 140).

Along a part of the east coast of Prince Charles Foreland, from J. Murray Point southwards, the strandflat is now covered by flat glaciers, Murray Glacier and Buchanan Glaciers (Fig. 9 and 10). The rocks of the strandflat project in several places along the outer edge of the glacier. I agree with Hoel, that the strandflat was obviously formed during periods when the glaciers had less extent than at present. They have afterwards extended over this flat plane, and form a nearly horizontal ice-sheet, to some small extent fed by the small glaciers of the mountain slopes behind.

The glaciers to the south, Geikie Glaciers, form thin sheets extending from the mountain slopes over the undulating lower land (Fig. 137).

The strandflat of Prince Charles Foreland is continued outside the shore in a *submerged strandflat* (see Fig. 133) the contours of which may be approximately traced along the east coast by the soundings of the Isachsen Expeditions of 1909—1910 in the Foreland Sound [cf. Isachsen, 1912, chart], and along the west coast by the soundings taken by the Hoel Expeditions in the years 1913 to 1921. By Hoel's kind permission I have been able to study the detailed charts with these soundings. In the map Figs. 133 & 134 is drawn the isobath for 30 metres below sea-level. The edge of the submerged strandflat seems to be very near this isobath at depths between 20 and 30 metres or often near 20 metres. In some places the edge seems to be quite sharply defined, whilst in other places the side slope of the submerged plateau is more gentle, making the edge less distinctly marked.

Along the northern part of the west coast of the island, north of Cape Cold, the submerged strandflat is mostly about 2 kilometres broad, the width decreasing north of Cape Cold to about 1 kilometre. Off Cape

Cold it is broader, nearly 5 kilometres, and along the coast to the south it is between 2 and 3 and 4 kilometres broad.

Along the east coast of the island the width of the submerged strandflat varies much, being mostly between 1 and 2 kilometres, but off the north-east coast it has a wide extent, 7 to 8 kilometres. The surface of this broad platform slopes gently from a depth of 10 metres near the shore, to about 27 to 30 metres near the edge, which seems to be very sharply defined towards the east and north-east, where the depths suddenly increase to 126 and 178 metres, while towards the north and north-west of Vogel Hook the sea-bottom slopes more gently outwards.

It is a striking contrast between this wide submerged plateau and the total absence of a submerged strandflat along the west coast of Brøgger Peninsula on the opposite side of Foreland Sound. As the north-east coast of Prince Charles Foreland is to some extent built up of Tertiary sandstone and conglomerate, the probability is that the wide submerged strandflat, being a continuation of the very broad emerged strandflat, has, to some extent at least, been cut in rocks of this system which have offered relatively little resistance to the shore erosion. On the opposite side of Foreland Sound the strandflat may, to some extent, have been cut away by the glacier formerly extending far towards the north-west from Comfortless Glacier. At the north-western end of Brøgger Peninsula, off Quade Hook, however, there is a submerged platform, which has not been cut away by the glaciers of Foreland Sound or King Bay.

Further south there is a Barrier ("Revet") across Foreland Sound, from John Murray Point to Michael Sars Point, which, however, seems to be built up of loose material, mostly sand, like the sand spit of Michael Sars Point.

Between this region and St. John Bay there is a submerged strandflat 2 to 3 kilometres broad. The rock of the shore is here Tertiary and it is the same on the opposite side of the sound on both sides of Ferrier Haven and at Poole Point where the submerged strandflat is also fairly broad.

Considering that the emerged strandflat is cut in solid rock, it seems probable that the rock surface continues more or less in the platforms under the sea surface. It is a striking fact that these platforms are especially broad where the shore is built up of Tertiary rocks, *viz.* off the north-east coast of Prince Charles Foreland, north and south of Michael Sars Point, at Ferrier Harbour, and at Poole Point. This seems to indicate that the platforms are not built up of loose material to any great extent. The Tertiary rocks have obviously been less resistant to the shore erosion than the rocks of the Hecla Hook system.

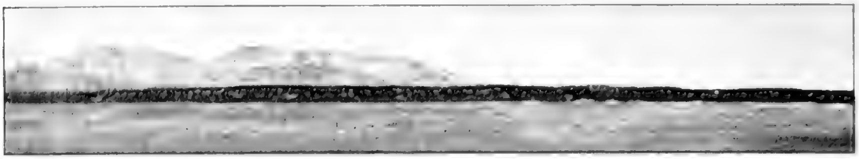


Fig. 141. Axel Island. August 31, 1912.

West Coast of Spitsbergen south of Ice Fjord.

Along the west coast between Ice Fjord and Bell Sound, there is a well developed emerged strandflat cut in rocks of the Hecla Hook system. The submerged strandflat is also broad in this region, as much as 11 kilometres, with depths between 10 and 20 metres and the sharply defined edge not much deeper than 20 metres. The breadth of the emerged and submerged strandflat together is about 14 kilometres. 16 to 25 kilometres outside this coast is the Sentinelle Bank, the highest part of which has depths less than 30 metres.

Axel Island in Bell Sound has a sharply defined level surface, less than 20 metres high, cut in rocks of the Carboniferous system (Fig. 141). On the north side of Lowe Sound there is an extensive low plain which to some extent is a real strandflat cut in solid rock, but a part of it is the floor of the wide Ondiepe Valley which has been filled up with sediment.

Along the coast southwards from Cape Lyell, in Bell Sound, there is a well developed emerged as well as a submerged strandflat. The latter is 3 to 5 kilometres broad, and off Torell Glacier even 9 kilometres broad. It is mostly less than 20 metres below sea-level.

On the north side of the entrance to Horn Sound there is practically no emerged strandflat because, as W. Werenskiold tells me, the coast is here built up of gabbro.

South of Horn Sound there is a well developed emerged strandflat which has been surveyed by A. Hoel and W. Werenskiold during their expeditions of recent years. This strandflat is especially extensive at the southern end of the land.

As the soundings taken by the Hoel Expeditions during the last years have shown, there is also a broad flat submerged strandflat outside the coast in this region. It is near sea-level with depths to a great extent less than 12 and 15 metres and carries many shoals and rocks. It is 9 to 10 kilometres broad, and at South Cape and east of it even 12 kilometres broad. The sea outside is not very deep and the sea-bottom slopes fairly gently, especially on the south-western side, to depths of 70 to 120 metres without any very distinct edge. On the south-eastern side the slope is somewhat steeper.

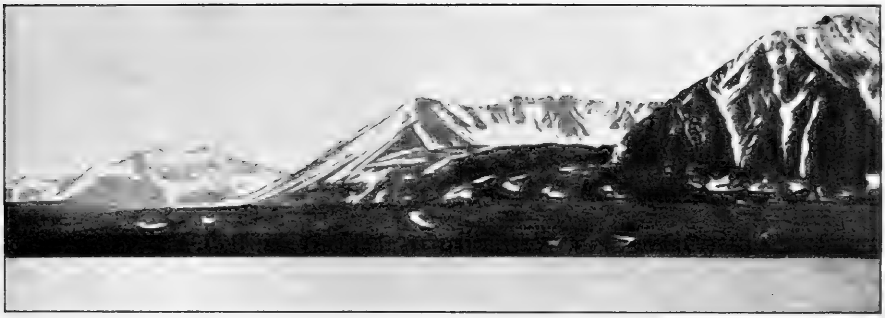


Fig. 142. Shore cliff and strandflat at Cape Guissez, with Mount Grimaldi. August 28, 1912.

Cape Guissez in Cross Bay.

Along the shore east of Mount Grimaldi, on the east side of the entrance to Cross Bay, northwards from Cape Guissez, there is a vertical cliff of solid rock (see Fig. 142) which, according to Hoel's statement [1914, p. 26], is about 20 metres high. The plain rises gently inland from the edge of this cliff to the foot of the mountain where, according to Hoel, it attains an altitude of about 35 metres above the sea. It is here covered by more recent terraces of gravel, and the surface of the strandflat, cut in solid rock, is lower. Hoel estimates it to be about 25 metres above the sea.

Outside this shore, north and south of Cape Guissez, there is a submerged platform, half a kilometre to one kilometre broad, or even more, with depths less than 20 metres [cf. Hoel, 1914, p. 40, Pl. XXV, 1].

Cape Mitre Peninsula and the North-western Part of Spitsbergen.

On the south and west side of Cape Mitre Peninsula, west of Cross Bay, there is a very flat and well developed emerged strandflat, the Dieset Plain ("Dieset Sletten", map Fig. 143), as has already been pointed out by Hoel. It is 2 to 4 kilometres broad, and rises very gently from the low shore to the base of the abruptly and steeply ascending mountains (Fig. 144), at about 25 to 30 metres above sea-level. There are a good many shallow lakes on this strandflat. Towards the south it is continued as a submerged platform, 3 to 4 kilometres broad and with depths less than 20 metres. As regards the occurrence of the emerged strandflat there is a striking difference between this peninsula and Prince Charles Foreland. Here the strandflat is well developed along the west coast, while there is no strandflat along the east coast of the peninsula, in Cross Bay, except near Ebeltoft Harbour ("Ebeltoft Havn", Fig. 143). The reason why there is no strandflat along the coast north of Ebeltoft Harbour is obviously that after the development of the strandflat, Lilliehöök Fjord

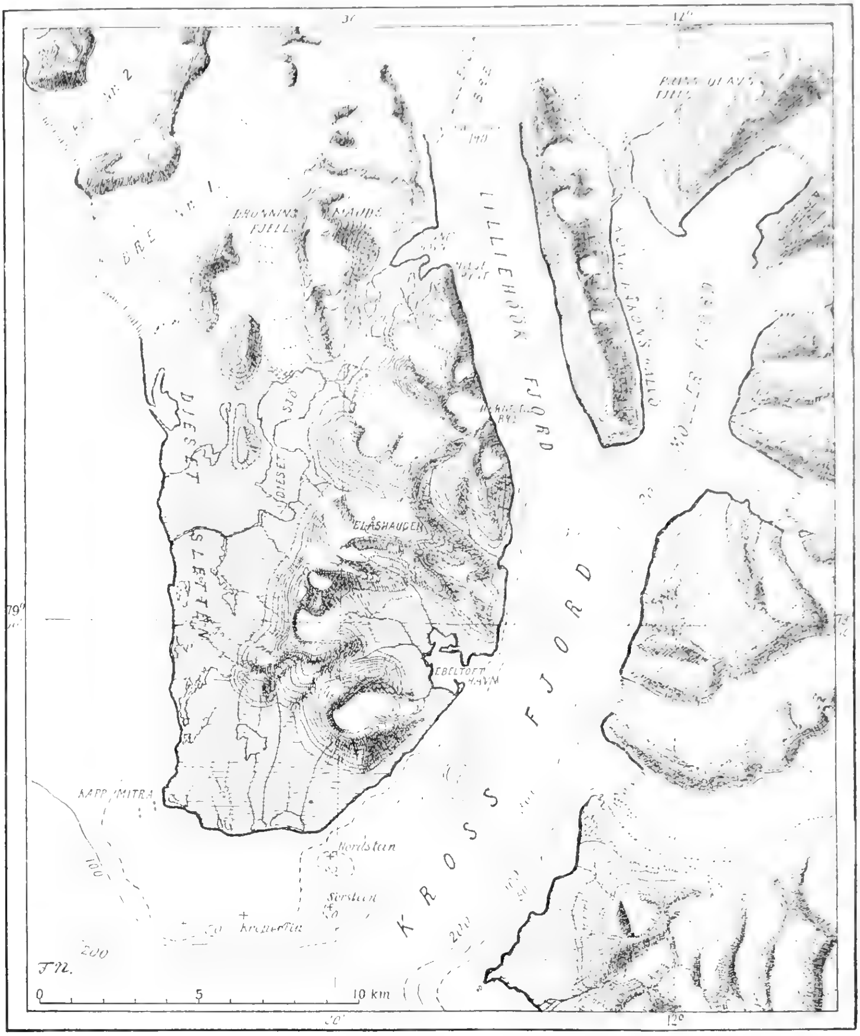


Fig. 143. Cross Bay and the Cape Mitre Peninsula, based on the maps by Gunnar Isachsen. The *horizontal hatching* indicates the strandflat. *Isobaths* are drawn for 50, 100, 200, and 300 metres of depth. The *contours* on land for every 50 metres. [From Nansen 1920].

and Cross Bay ("Kross Fjord") have been much deepened and excavated by glacial erosion, which has cut away the strandflat and steepened the mountain sides. It is, however, noteworthy that here too there may be observed a certain tendency towards formation of cirque glaciers on the eastern side of the mountain ridges which is especially conspicuous on King Håkon Peninsula ("Kong Håkon's Halvo", Fig. 143).

The strandflat of the Cape Mitre Peninsula is cut in schists of the Hecla Hook system, which are fairly easily disintegrated by frost. But to the north of this peninsula the coast is built up of very resistant granites

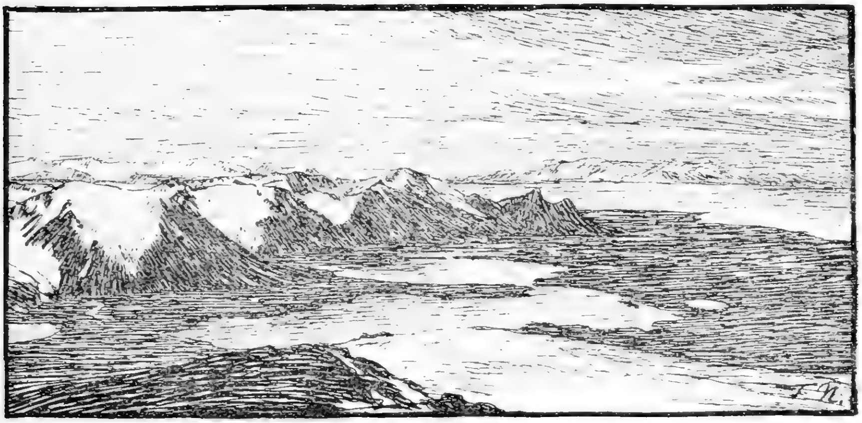


Fig. 144. Strandflat on the west side of the Cape Mitre Peninsula. The Dieset Plain (Dieset Sletten) and Dieset Lake (Dieset Sjo). [From Nansen 1920].

and gneiss-granites which fact causes an abrupt and striking change in the development of the strandflat, as has been pointed out by Hoel. In this granite region the emerged strandflat is, as a rule, hardly more than a hundred or a few hundred metres broad. On both sides of Hamburg Bay, south of Magdalena Bay, it is 300 to 400 metres broad. In some places in this region the emerged strandflat is missing altogether. The submerged strandflat also seems to be poorly developed along a great part of this coast, but there are too few soundings to trace its extent.

On Danes Island and Amsterdam Island, built up of granite, the emerged strandflat is also narrow or missing. Fig. 145 shows the strandflat along the north-east coast of Danes Island. It is in this region less even than in the region of the Hecla Hook rocks to the south, and it is more like the strandflat in the granite regions of Norway.

The low level plain, the Hollaender Ness, on the east side of Amsterdam Island (Fig. 146) is chiefly formed of loose material (sand and moraine material), but in its inner part near the foot of the mountain there is obviously rocky ground near the surface (Fig. 147).

Off these islands and also north of the islands Vogelsang, Cloven Cliff, and Norway Islands, there is a submerged strandflat with skerries and rocks and with depths of less than 30 metres. Its extent cannot be traced, as the soundings are too few. North of Norway Islands it seems

Fig. 145. The coast east of Virgo Harbour on north-eastern side of Danes Island. August 23, 1912.

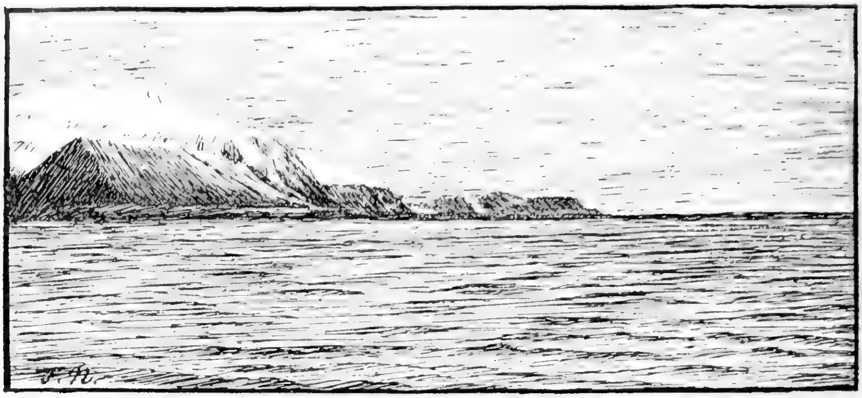


Fig. 146. The east side of Amsterdam Island, with the low Hollaender Ness. August 1, 1912. [From Nansen 1920].

to have a width of 9 kilometres. On the whole the sea-bottom seems to be uneven in this region, as we have generally found it in regions of granite and resistant igneous rocks.

Reindeer Land.

Almost the whole of Reindeer Land forms a very level strandflat which is about 18 kilometres across (Fig. 148). I have only been ashore on its east coast 5 or 6 kilometres north of its south-eastern corner. There were in some places low vertical shore cliffs, with a flat beach in front, while in other places the rocks sloped more gently down to the shore (see Fig. 149).

The general level of the flat gently undulating surface of the land (Figs. 150 and 151) is between 15 and 20 metres above the sea. Low ridges rise above this level to about 26 metres. The highest ridge inside our anchorage on the east coast, was 27.5 metres above sea-level. Most ridges seen inland had about the same height, but some ridges further in to the north of us, were higher, and may have attained altitudes of about 50 metres. Bare rock was seen in the surface in many places especially on the ridges.

Near the northern point of the peninsula, near Welcome Point, there is a solitary hill rising to 98 metres above the sea, as determined by the Isachsen Expedition 1909—1910.

The whole peninsula is built up of Devonian schists. In its south-western part there are higher mountains consisting of the same kind of rocks. According to what I was told by Hoel, the plain extends almost horizontally to the foot of these mountains, which rise abruptly, with a sharply defined line of demarkation between the plain and the mountain sides.

Fig. 147. The Hollaender Ness on the south-eastern side of Amsterdam Island. August 22, 1912. [From Nansen 1920].

The Peninsula between Liefde Bay and Wijde Bay.

On the east side of Liefde Bay, where I was ashore, perhaps 12 kilometres south of Grey Hook, there is a sloping platform cut in solid rock (see Fig. 152), but its upper level is very much higher than the strandflat of Reindeer Land. From a vertical shore-cliff, about 10 or 11 metres high, backing a flat beach, there is a relatively steep ascent to a sharply marked shore-line cut in solid rock 41 metres above sea-level. It is marked by a horizontal series of small accumulations of snow (see Fig. 152) and is backed by a vertical shore-cliff about 6 metres high. From the edge of this cliff, 47.25 metres above sea-level, there is again an ascent to 62.25 metres above the sea, where a relatively broad plateau extends southwards along the foot of the steep mountain side (see Fig. 153). The foot of the steep scree along the inner margin of this plateau stands about 4 to 8 metres higher, *i. e.* 66 to 70 metres above sea-level. On the plateau there were indications of a shore-line marked by a series of snow-accumulations (see Fig. 153, along the middle of the plain, towards the mountain slope).

The surface of this plain consisted of loose material. The highest level at which solid rock was observed was that of the shore-cliff at about 47 metres above the sea. This may be the actual height of the rock plateau, which may, however, rise gently to a few feet more under the layer of loose material at the foot of the mountain side.

To the north of this place, where we made our measurements, there was a lake (see Fig. 154) lying at a lower level. On the north side of

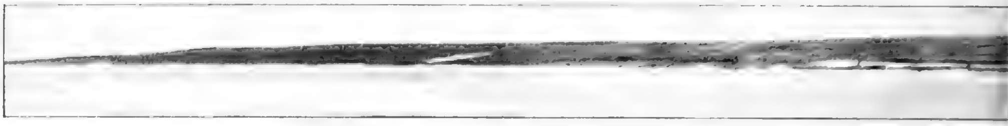


Fig. 148. Panoramic view of the east coast of Reindeer I

this lake and its outlet, the plain under the steep mountain-side, ascended to a higher level than that of our plateau, perhaps 30 metres higher, giving an altitude of about 90 metres above sea-level (see Fig. 154 to the right).

The river running out of the lake has formed a canyon through the broad moraine terrace which has dammed up the lake (see Fig. 154). This moraine has a considerable thickness as is proved by this canyon, and is built up of coarse material, with numerous boulders embedded in its mass, as is seen in the sides of the canyon. The surface of the moraine is levelled by the sea to form a horizontal terrace at about 16 metres above sea-level.

The well-marked coast-ledge of this region extends along the coast northwards to Grey Hook where there is a well-developed strandflat in front of the very steep mountain side (see Fig. 150). The coast-ledge continues from Grey Hook south-eastwards along the west coast of Wijde Bay.

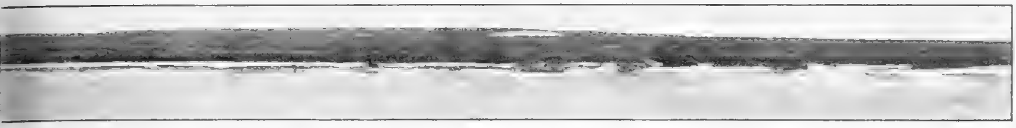
I was ashore in *Lake Valley*, on the west side of Wijde Bay. The lake in this valley is a big lagoon to which a narrow channel leads from the sea through the shore terrace built up of drift material. The channel leads first into a smaller lagoon, and then a longer distance into the big lagoon. Strong tidal currents run through this narrow channel like a river.

I took the height of the strandflat by levelling.

The ground rises from the plain near the shore (see Fig. 155) inland to a height of 46.8 metres where there is a well-marked shore-line partly cut in solid rock. Its exact level was difficult to determine as it was covered by too much gravel and loose material. This shore-line forms a conspicuous horizontal line, marked by accumulations of snow, along the coast southwards.

From this shore-line an extensive plain rises gently inland towards a terrace built up of stones at the foot of the much oversteepened mountain side (see Fig. 156). The base of the terrace is about 55.8 metres above the sea, and its upper level surface about 64.8 metres (Fig. 157). This stone ledge is obviously a formation similar to those observed on Prince Charles Foreland, and has been formed in the same manner. Similar terraces were seen northwards along the coast towards Grey Hook, approximately at the same height at the foot of the mountains, along the inner margin of the coast platform.

On the north side of the big lagoon of Lake Valley, the platform appeared to lie, to a great extent, at about the same level as the well-



from our anchorage in Liefde Bay. August 8, 1912.

marked shore-line described above, at about 47 metres above the sea. It rises gently inland towards the foot of the mountain.

Hence we may assume that the upper level of the platform cut in solid rock lies about 47 metres above the sea in the region of Lake Valley, and is probably a few metres higher at the foot of the mountain-side

This is exactly the height of the coast platform, which we found on the west side of this peninsula, on the east coast of Liefde Bay. But it is considerably higher than the observed heights of the strandflat on Reindeer Land, and on Prince Charles Foreland.

The question is then whether this coast platform may be considered as actually belonging to the strandflat, or whether it is rather a shore-ledge similar to the raised beaches and shore-lines, formed during some more temporary depression of the land. On the one hand it seems to be too high to be a part of the regular strandflat, on the other hand it seems difficult to assume that a platform as broad as this has been formed during temporary depressions of the land. Lately Hoel [1922] and Werenskiold [1920], however, have found some most remarkable broad ledges or plateaus, cut in solid rock, on the west coast near the

Fig. 149. East coast of Reindeer Land. August 8, 1912. [From Nansen, 1920].

Fig. 150. On the plain near the east coast of Reindeer Land, with the "Veslemøy" at anchor. The crows nest of the latter is 13 metres above the water. As it is very nearly level with the horizon, the plain at this place is about that height above sea-level. The land at Grey Hook with the strandflat outside is seen in the back ground. August 8, 1912.

southern end of Spitsbergen. They must have been formed during periods of temporary submergence of the land, for they are at various heights, the highest plateau being as much as 340 metres above sea-level. They are as much as some hundred metres broad, and must have been formed after the land was covered by glaciers at that place, for there were many pebbles and round shore boulders on the highest plateau.

This seems to prove that, owing to the vigorous shore-erosion in this region, fairly broad shore benches or shelves may be cut in relatively short time where the rock is not very resistant.

There is thus a possibility that these high platforms on the west and east coast of the peninsula between Liefde Bay and Wijde Bay, are raised coast platforms of the same nature as the raised beaches, and are not a part of the regular strandflat.

If this be correct, we may assume that the real strandflat on both sides of this peninsula has been more or less cut away by the big glaciers which filled Wijde Bay and Liefde Bay (and Wood Bay) and have deepened and excavated these fjords after the strandflat had been developed.

East Coast of Wijde Bay, and Verleegen Hook.

There is a well developed strandflat along the east coast of Wijde Bay, which was observed from the region of Aldert Dirkse's Bay and northward to Verleegen Hook (Figs. 158 and 160). I did not land on this coast, but as far as I could see from the sea, the strandflat is cut in

Fig. 151. The plain of Reindeer Land some kilometres from its east coast. August 8, 1912.

solid rock, and is to no considerable extent covered by drift or moraines. In many places the surface of the bare rock slopes gently down to the shore, while in other places there is a low shore-cliff, with accumulations of snow on the beach at its foot.

The rock consists here chiefly of crystalline schists (mica-schists, hornblende-schists, gneisses) and granites, and the strandflat once formed, has been relatively well preserved. The land on the west side of Wijde Bay is built up of sedimentary rocks of the Devonian system which have

Fig. 152. Platform on the east side of Liefde Bay. August 9, 1912. [From Nansen, 1920].

Fig. 153. The level upper surface of the platform of the east coast of Liefde Bay. August 9, 1912.

obviously less power of resistance to the frost erosion than the crystalline rocks of the east side of the fjord.

The only manner in which I can explain why, in spite of this, the strandflat is so much broader and lower on the east side, is that the glaciers have cut away the Devonian rocks more easily than the crystalline schists and granites, and that during the deepening of the fjord during late glacial periods, after the strandflat was formed more or less, the western side of the fjord has been more excavated than its eastern side.

I did not land at Grey Hook, but, seen from the sea, it looked as if the strandflat is wide and fairly low in that region, which has been less exposed to the erosion of the glaciers of Wijde Bay as well as of Liefde Bay.

On *Verleegen Hook* I was ashore. The strandflat is very wide and low, cut in mica-schist and hornblende-schist, its surface being to a great extent formed of bare rock which is in many places scoured and rounded by glacial erosion (Fig. 159). At the outer edge of this plane a cliff much disintegrated by frost was observed inside a flat somewhat raised beach, near the present shore (see Fig. 15).

Fig. 154. Panoramic view of the great terraces of moraine material outside the

The low rocky ridges of this flat plain attained an altitude of 16 metres above sea-level. Further inland there was a slightly lower plain covered with gravel and pebbles.

Near the shore, at an altitude of about 9 metres, was a broad flat plane in the rock, a raised shore-line several hundred metres long.

Small shore ridges of wave-washed pebbles were seen in several places up to the highest level of 16 metres.

The strandflat extended inland, rising slightly, to the foot of the oversteepened mountain sides (Fig. 160).

About 3 kilometres north of Verleegen Hook I found the depth to be only 30 metres, indicating that the strandflat continues as a submerged platform some distance seawards. About 5 kilometres north of the Hook I found a depth of 48 metres, but then it suddenly dropped to 152 metres and deeper further north.

North-west Coast of North East Land.

Great Stone Island, and Low Island outside, on the north-west side of North East Land, are low and seem to form a well-developed strandflat cut in rocks of the Hecla Hook system. I have not, however, landed in this region. From this coast a wide submerged platform extends about 27 kilometres (15 naut. miles) north-westwards, with depths chiefly about 15 to 25 metres. The outer edge may possibly be at a depth of about 25 or 30 metres, where the bottom begins to slope more steeply towards depths greater than 100 metres. In about 80° 25′ N. Lat., at a distance of about 35 kilometres from North East Land, I sounded 30 metres. This wide platform may probably be considered as a part of the strandflat.

The Fjords.

In the inner parts of the fjords of Spitsbergen, the strandflat is not so well developed as along the outer coasts, but there are nevertheless traces of a strandflat in many places, indicating that the shore erosion

ne east coast of Liefde Bay. The lake is seen to the right. August 9, 1912.

Fig. 155. Strandflat in Lake Valley, view southwards along the west coast of Wijde Bay. August 10, 1912.

has been at work there too, although not so effectively and perhaps during a shorter time than along the outer and more exposed coast.

On the north side of Lowe Sound (Van Mijen's Bay) there is an extensive flat plain corresponding to the strandflat as was mentioned above (p. 192).

In Ice Fjord there are obvious strandflats in a good many places, *e. g.* Cape Erdmann, Cape Boheman, Cape Woern, Cape Thordsen, Bjona Haven in Sassen Bay (according to Peach), Advent Point west of Advent Bay, &c.

As was pointed out by Bertil Hogbom [1914] there are also narrow submarine platforms outside the shore in several places in Ice Fjord, and they seem to be best developed where the coast is most exposed, *e. g.* west of Advent Bay, and off Cape Thordsen. West of Cape Boheman there is also a submarine platform with several rocks, the Twin Rocks &c.

The Age and Genesis of the Strandflat of Spitsbergen.

The strandflat of Spitsbergen is obviously a relatively young formation. As was previously mentioned (p. 179), and was already pointed out by Hoel [1914, p. 27], its present very level surface has not been exposed to the erosion of the glaciers of the Great Ice Age, or Ages, which covered the whole land and have deepened and excavated the fjords, and have sculptured the land surface. The present plane or planes of the strandflat have, therefore, been developed after that time.

On the other hand there has been a considerable advance of the glaciers after their formation, as is proved by the erratic blocks, mentioned by Hoel and Peach, and by the moraine material found on the surface

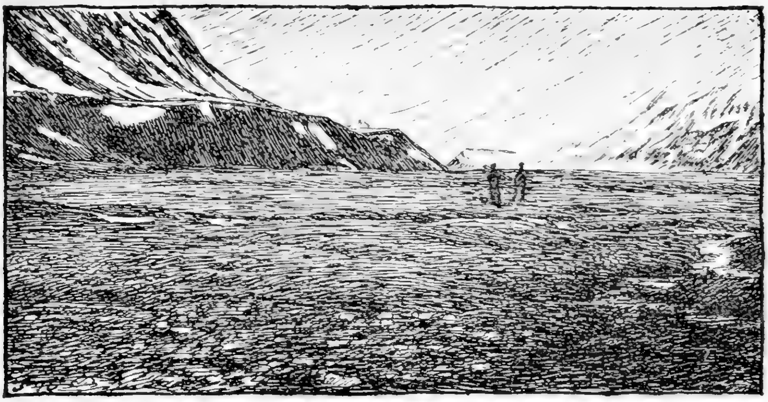


Fig. 156. The level surface of the platform in Lake Valley, with a terrace of big stones at the foot of the steep mountain. August 10, 1912. [From Nansen, 1920].

of the strandflat. Its rocks are also scoured and rounded, *e. g.* at Verleegen Hook, and striæ have been observed, as mentioned by Peach.

This strandflat must, therefore, have been planed to its present levels after the Great Ice Age, or Ages, and before the last great advance of the glaciers of Spitsbergen.

In Chapt. VI (pp. 47 f.) I have pointed out that the strandflat of Norway has obviously been developed during periods when the land crust had attained its natural level of equilibrium, and the shore-line remained stable during a long time, *i. e.* during periods when the land was not depressed by the weight of any ice-caps. At the same time there must have been a severe climate favouring the shore erosion by frost. I therefore consider it probable that the Norwegian strandflat has to a great extent been formed during periods with a severe climate preceding each glacial period, and before the land had been depressed by the inland ice.

In Spitsbergen the conditions are different. The land is still covered with glaciers to a very great extent, and we cannot say what the natural level of equilibrium of the crust may actually be. At the same time the climate of that region is so severe that probably, even during warmer interglacial periods, it was sufficiently cold for an active shore erosion by frost.

Nevertheless it is a striking fact that the emerged as well as the submerged strandflat of Spitsbergen have levels that are very similar to those of the Norwegian strandflat, and we may assume that they indicate levels of an approximate natural equilibrium of the crust in this region.

I imagine that the Spitsbergen strandflat was planed to its present levels during interglacial periods when the shores were not covered by glaciers and the ice covering of the land was similar to what it is now.

Fig. 157. Panoramic view of the coast platform from the top of the stone terra

Fig. 158. Panoramic view of the strandflat along the coast south of Mossel B

During some part of the time when the strandflat was formed the glaciers had less extent than at present. As pointed out by Hoel [1914, p. 27] this is especially proved by the Buchanan Glaciers and the Murray Glacier now extending over the strandflat on the east coast of Prince Charles Foreland.

It has been already mentioned, that two levels of the strandflat were probably observed on Prince Charles Foreland, one at about 6 to 10 metres and one at about 20 to 30 metres above the sea.

The lower level is probably the same as that of the low strandflat at Verleegen Hook, where it was between 10 and 16 metres above the sea.

The higher level of 20 to 30 metres is generally found on the strandflat along the whole west coast of Spitsbergen, and also predominates on Reindeer Land.

It was pointed out before (p. 200) that the higher shelves, at about 47 metres or more above the sea, observed on the west and east side of the peninsula between Liefde Bay and Wijde Bay cannot really belong to the strandflat, but must have been formed during some more temporary submergence of the coast. According to Peach the altitude of the rocky surface of the strandflat at the base of the mountains should be 150 feet (46 metres) above the sea, and he states it to be even 200 feet (61 metres) in some places (see above p. 184). His statements seem, however, to be rough estimates, and not based upon very accurate investigations.

·e Fig. 156) at the foot of the mountain side in Lake Valley. August 10, 1912.

;e land near Verleegen Hook is seen to the left. August 10, 1912.

Raised Shore-lines.

Raised shore-lines and beaches frequently occur along the coasts of Spitsbergen, and have been described especially by A. Hoel [1914, pp. 28 ff.] and Peach [1916, pp. 297 ff.]. They have obviously been formed after the strandflat and are relatively recent formations.

At the place where I landed on the east side of the entrance to Liefde Fjord (see above p. 107) I found shore-lines cut in solid rock at the following heights above sea-level:

Fig. 159. Strandflat cut in hornblende-schist and mica-schist on Verleegen Hook. August 12, 1912.

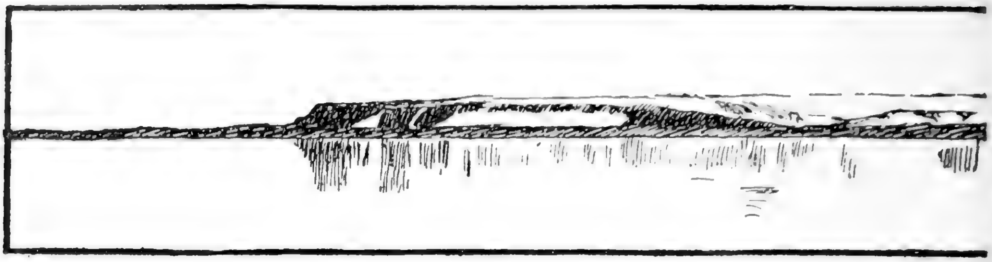


Fig. 160. The land north of Mossel Bay to Verleegen Hook, with the strandflat along the shore and

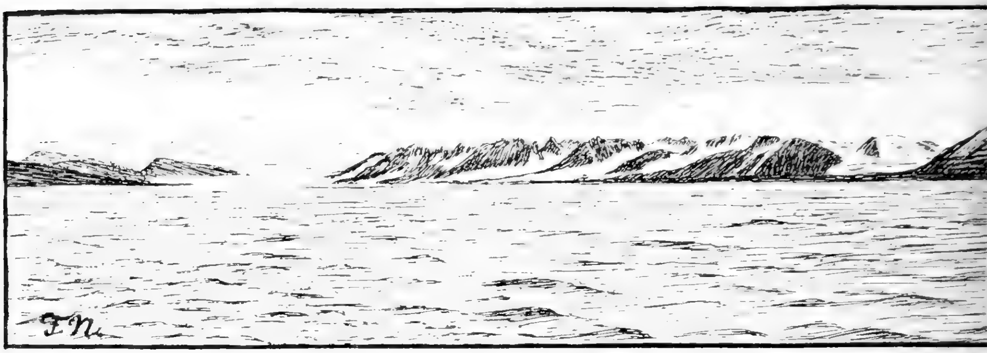


Fig. 161. The north side of Brøgger Peninsula, with the conspicuous flat platform (about 200 metre right, with the mountain on Prince Charles Forelan

11 metres. This shore-line continued northwards along the slope of the big moraine terrace in front of the lake mentioned p. 198.

27 metres. A fairly distinct shore-line in solid rock.

41 metres. A sharply defined shore-line marked by a horizontal row of small accumulations of snow, and backed by a vertical cliff.

47.25 metres. The upper horizontal edge of the above mentioned cliff.

In *Lake Valley*, on the west side of Wijde Bay, shore-lines were observed at the following heights:

11 metres — quite distinct.

24 metres — less distinct.

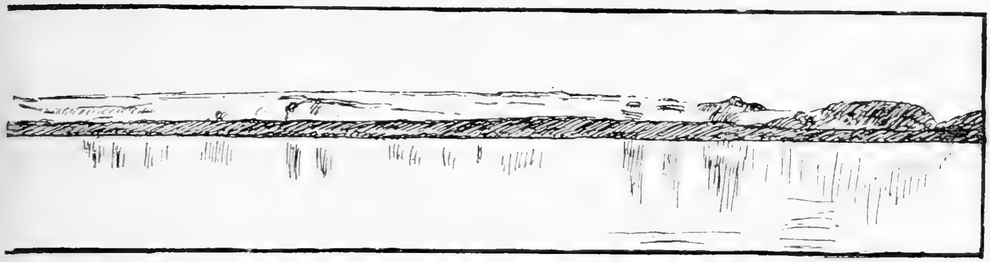
30.8 metres — sharply marked.

46.8 metres — partly in solid rock, very conspicuous along the coast as a horizontal line marked by accumulations of snow.

At *Verleegen Hook* a shore-line was observed at about 10 metres above sea-level.

Platforms at high Levels.

In several places along the coasts of Spitsbergen one may observe traces of horizontal planes at relatively high levels. Especially conspicuous is the remarkable, broad plane on the Brøgger Peninsula south-east of Quade Hook (Fig.161). It extends north-westwards from Mount Schetelig,



the old flat surface (peneplain) at the top of the mountains. August 10, 1912. [From Nansen, 1920].

above sea-level) in front of Schetelig Mountain. The low strandflat at Quade Hook is seen to the behind. July 31, 1912. [From Nansen 1920].

is nearly 2 kilometres wide and is bounded along its outer edge by a vertical cliff more than 150 metres high. According to Hoel's statements and the measurements of the Isachsen Expedition 1909—1910, this remarkably flat plane rises gently inland from the top of the cliff, at a height of about 200 metres above the sea, or somewhat less, and the plane attains a height of about 240 or 250 metres at the foot of the mountain, where the boundary between the plane and the steep mountain slope is to a great extent covered by a glacier.

As proved by O. Holtedahl's and A. Hoel's investigations this plane cuts the strata of the Carboniferous system of which the land is composed, and, as Hoel maintains, it is obviously a plane of marine denudation. It has been formed in a similar manner as the strandflat at lower levels, chiefly by shore-erosion by frost, assisted by the wave-action. It is hardly conceivable that this very level plane, giving the impression of being a quite recent formation, can have been exposed to any considerable glacial erosion, for in that case it could not have preserved its level surface. The probability is, therefore, that it has been formed at some period after the time when this region was covered by the inland-ice of the Great Ice Age. It has, however, been formed before the lower strandflat of between 10 and 30 metres above the sea. This younger strandflat has a fairly great width at Quade Hook and has obviously been cut in under the older and higher platform. Thus the high vertical cliff at the edge of the latter was formed.

Traces of a similar plain of marine denudation have also been observed by Hoel north of Ebeltoft Harbour in Cross Bay, but it was there lying at a lower level of about 150 metres above the sea.

On the east side of Amsterdam Island I observed indications of what may be an ancient platform which I estimated to lie at a level somewhat higher than 150 metres (Fig. 146). On the southern Norway Island there is also a plateau in a similar height (see Fig. 8). But as these platforms are cut in more resistant rocks (granite and gneiss-granite) they may be older.

Inside the low and level strandflat at Verleegen Hook the mountain rises to a very flat plane with a similar altitude. As, however, the inner margin of this plane is not marked by any declivity, and as there is a quite gradual transition from this plane to the general mountain plateau inland, without any marked difference, it may here most probably be a part of the raised ancient level mountain surface, that extends southward over all the land east of Wijde Bay.

As was mentioned above (p. 199) A. Hoel [1922] and W. Werenskiold [1920] have found several horizontal shelves or plateaus at various high levels along the coast in southern Spitsbergen near South Cape. There is one shelf at about 40 metres above sea-level, another at about 80 to 100 metres. This platform is especially well developed. It is in some places several hundred metres broad, and is widely extended along the south coast of the land, inside the low plain of the strandflat, which is there very broad (see Fig. 134). Farther north towards Horn Sound this platform is perhaps somewhat lower, about 70 metres.

There is one shelf, somewhat uneven, at 220 metres, and then a fairly broad and conspicuous one at 340 metres above the sea, on which Hoel observed many pebbles and shore boulders.

It is indeed strange that shore formation of so recent date, that the pebbles have not even been removed by glaciers, occur at such high altitudes so near the southern end of the land.

It shows on the one hand that there has been very great vertical movements of the crust in this region relatively recently, and on the other hand that the shore erosion must be so effective in this region, that in the rocks of little resistance broad shore platforms can be cut in relatively short time during temporary depressions of the land.

XIII. THE STRANDFLAT ALONG COASTS INSIDE AND OUTSIDE THE ARCTIC REGIONS.

The Coasts of Siberia, Greenland, and Alaska.

Along the north coast of Siberia there is a well-developed emerged strandflat, which I have previously described [1904, pp. 20 ff., Pl. III]. On the Eastern Taimur Peninsula and the Chelyuskin Peninsula, between the mouth of Taimur River and Chatanga Bay, it forms a very conspicuous level foreland backed by mountains rising abruptly above its plane [see 1904, Pl. III, Figs. 1—4]. Its height, near the coast, was estimated to be less than 30 metres above the sea, it has a considerable width, and forms a continuous level plain along most part of the coast, extending horizontally to the foot of the mountains. It is cut in solid rock, but is to a great extent covered with drift material, which may in some places attain considerable thickness. The coast between Taimur Bay (the Nordenskiöld Archipelago) and the mouth of Yenisei River is low, and as there are few mountains or hills near the sea, it is difficult to say whether the whole of this low land is actually a strandflat which has been cut horizontally by shore erosion. We must in that case assume that most initial hills surmounting the plane of this strandflat have been planed down. As this coast land and the islands outside are so very flat [cf. 1904, Pl. III, Figs. 7—10, Pl. IV, Fig. 1], and considering that there is a quite similar low coastland with low islands to the north forming a foreland or regular strandflat in front of the steep mountain sides, it seems to me to be probable that this land too has been levelled by shore erosion, and that it is actually a strandflat.

The sea along the north coast of Siberia is very shallow; often 30 or 40 kilometres or more from the coast, it has depths less than 40 and 50 metres. The soundings taken in this region are, however, much too few to make any study of the topography of the sea-bottom possible. It has to be considered that there is an exceptionally broad continental shelf, with depths less than 100 metres, extending a great distance north from the Siberian coast, in the region of the New Siberian Islands even as much as 600 or 700 kilometres, and that the whole of this sea is therefore very shallow. As it is especially shallow outside the mouths of the great rivers, Yenisei, Lena, &c., it seems probable that it is to some great extent filled up with river sediment. But on the other hand, as small rocky skerries rise above the sea in many places along the coast, and as I also observed sunken rocks near or in the water-surface, it is obvious that the sea-bottom consists of solid rock to a great extent, and it seems probable that there is a *submerged rocky strandflat* which is very widely extended in some places, and the plane of which lies at levels less than 30 metres below the sea-surface.

In the region of *Yugor Strait* and *Vaigach* the land is low and flat. The plain is to a great extent cut in solid rock as is especially clearly seen along the shores of the strait and on Vaigach [cf. Nansen, 1904, p. 22].

Along the coasts of *Novaya Zemlya* there is in many places an unusually well-developed strandflat forming a flat foreland in front of the steep mountain sides ascending abruptly above its plane. The low and flat Goose Land seems, for instance, to be a broad strandflat. On the Holtedahl Expedition to Novaya Zemlya in 1921 the emerged strandflat was studied and its levels taken in several places, and we may look forward to an interesting report on these investigations.

The soundings taken along the coasts of Novaya Zemlya indicate that there is a *submerged strandflat*, but they are too few to tell much about its topography and extent.

On the whole it is striking that along all these Arctic coasts, we find a well developed strandflat, which often, especially along the north coast of Siberia, forms extensive plains. It indicates that in these regions there has been a very vigorous shore erosion, obviously due to the cold climate in these northern latitudes, which has caused an active disintegration by frost of the rocks of the shores even during the warm interglacial periods.

Well developed strandflats obviously also occur along other coasts of the Arctic region.

Along the west coast of *Greenland* there is a strandflat very similar to the Norwegian one, with a belt outside the coast of numerous low islands and skerries [cf. Nansen, 1904, pp. 90 f.]. It does not seem, however, to be as well developed as along the coast of Norway.

Along the east coast of Greenland I have found no certain evidence of the existence of a strandflat near present sea-level. This is what might be expected, as Greenland is still covered by an ice-cap which extends to the outer coast along most part of the east coast south of 68° N. Lat. The probability is, therefore, that this coast is still much submerged by the weight of this ice-cap. If there is a strandflat it may be at some depth below sea-level.

Along the west coast of Greenland south of 68° N. Lat. the conditions are different. The margin of the inland ice is a great distance from the outer coast, and there is a broad coast land which is not covered by the ice-cap. It is therefore possible that the outer part of this coast land may have risen towards its natural level of equilibrium, and even that, by the pressure of the ice-cap over the inner land, the outer coast may have been upheaved above its natural isostatic level, although this is hardly probable.

These are interesting questions which have to be settled by special investigations on the spot.

On the islands of the *Arctic Archipelago* north of Canada, there is obviously also a strandflat.

On the islands along the coast of *Alaska*, there is a strandflat forming a flat foreland between the base of the steep mountains and the descent to deep water.

Gilbert [1904, pp. 130 ff. and 179] mentions this low foreland in several places and gives some very illustrative pictures of it (see his Figs. 64, 65, 85, and his Pl. XVII) showing that it is obviously of the same type as the Norwegian strandflat. Gilbert, however, explains it as a preglacial peneplain, or base-levelled plain, in the same manner as Ahlmann has lately adopted. This peneplain formed originally a more continuous foreland, which has afterwards been dissected by erosion, forming deep channels now separating the islands. These channels have to a great extent been formed even by fluvial erosion "at least 500 feet (150 metres), and probably 1,000 feet (300 metres) or more, below the present sea-surface" [1904, p. 136]. It seems to me difficult to understand how a plain of this kind could possibly have survived a fluvial and glacial erosion which has cut channels through it, now 1,500 to 1,700 feet (450 to 520 metres) deep. Gilbert has also to assume that "the glacial degradation must have been locally quite moderate, or the general plain character would not have survived" [1904, p. 131].

In my opinion there can be little doubt but that this low foreland in Alaska is a formation of the same nature as the Norwegian strandflat, and has been formed in the same manner by shore erosion, during cold interglacial periods, and during the beginning of glacial periods, before the land began to sink, and before the coasts were covered by glaciers.

The heights of the Alaskan strandflat seem to be similar to those of the Norwegian one. Gilbert states that on the islands along the coast of Kadiak "the height ranges from about 100 feet (30 metres) to sea-level" [1904, p. 179]. On the Annette Island, in the Alexander Archipelago, he says, however, that "there is a general and gradual ascent from the sea front to the mountain base, where the altitude may be three or four hundred feet" (90 or 120 metres). This description does not, however, agree with the impression given by his illustrations, which show a low fairly level plane, and I think, therefore, that this high altitude of the mountain base is not the general one.

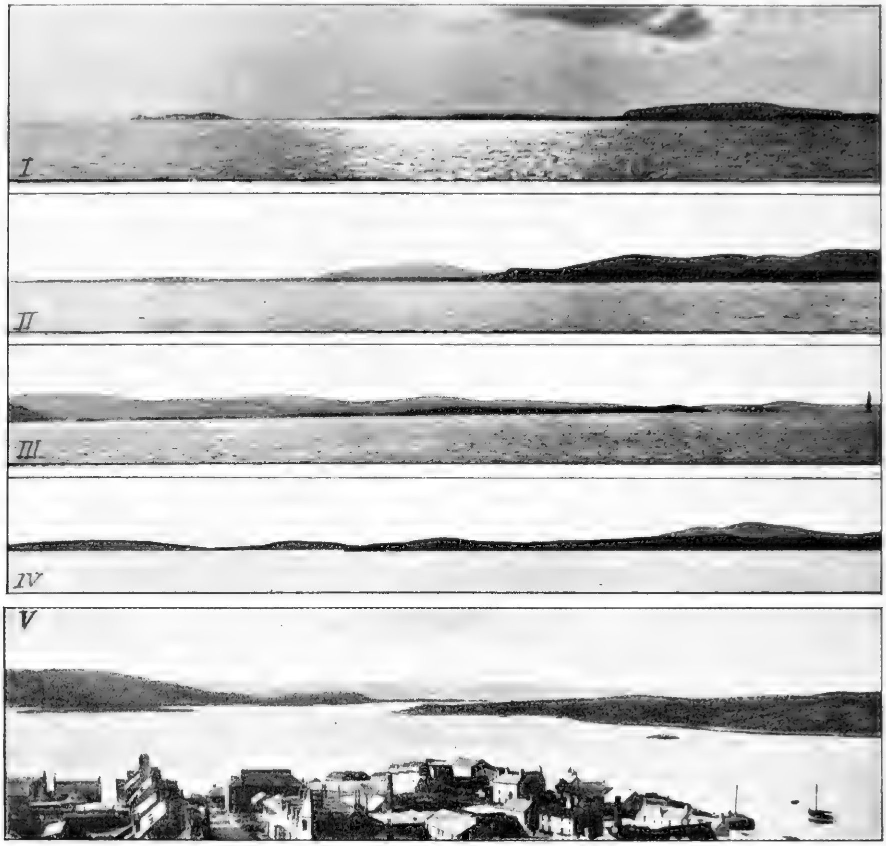


Fig. 162. Low land along the east coast of the southern portion of Mainland. I The coast northwards from Sumburgh Head, seen from the north-weast. II Southward view along the coast from the sea off Mousa. III View northwards along the coast from the sea off Mousa. IV View southwards along the coast from the sea off Helli Ness. V View northwards through Bressay Sound from Lerwick. August 23, 1911.

Shetland Islands.

As I considered it to be of interest to study the strandflat on an exposed island group far out in the ocean, I sailed across to Shetland for a few days in August 1911. The stay was, however, too short for a real survey, and I could only expect to get a general impression of the topography of the coast. I sailed along the whole east coast of Mainland and nearly to its north end, and I landed at several places. I also crossed the island from Lerwick to Weisdale Voe on the west coast.

The Shetland Islands have a very complicated geological structure. In the southern portion of Mainland the clay-slate series, with associated limestones and quartzites, prevails. Its eastern sea-board from Lerwick southwards is skirted by the lower Old Red Sandstone (Devonian). The north-western half of Mainland, as well as the islands Whalsey, Yell, and

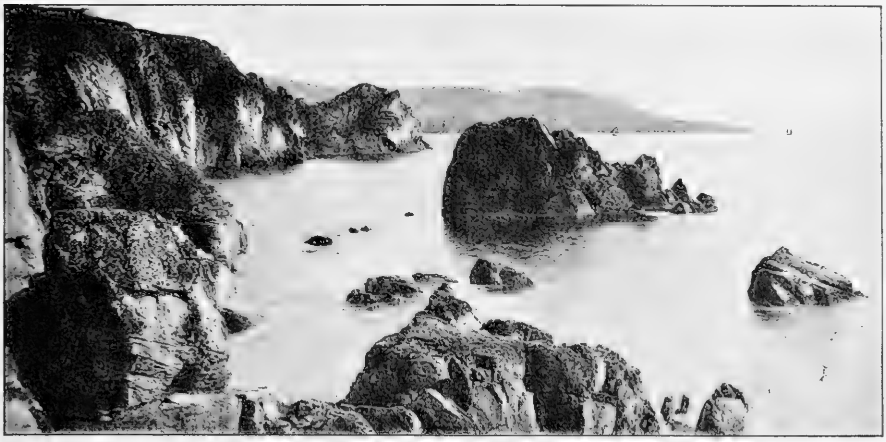


Fig. 163. The Nab south of Lerwick, the west side of Bressay in the background.

the western sea-board of Unst consist chiefly of micaceous and hornblendic gneiss with limestones and quartzites. In Unst and Fetlar, the north-eastern islands, there are large masses of serpentine and gabbro. In Delting and Northmavine, in the north-western portion of Mainland a large area is occupied by diorite. The islands Foula, far out to sea toward the south-west, and Bressay, east of Lerwick, are built up of the lower Old Red Sandstone, and so is the greater part of Walls, in the western portion of Mainland.

As these rocks, building up the islands, have to a great extent considerably less power of resistance to erosion than the rocks of the west coast of Norway in the same latitude, it is natural that the islands have an aspect very different from the Norwegian coast. They are on the whole low with rounded forms, while the shores are cut back by recent marine erosion, forming cliffs and many isolated vertical rocks, the so-called "drongs", in the sea outside.

But in spite of these conspicuous marks of a recent shore erosion, no quite convincing evidence of the existence of a real *emerged strandflat* could be discovered along the shores. Many low islands occur, and low flat plains extend inland from the shore in many places in Mainland. But nowhere did I observe a sharply defined boundary between the coastal plains and the hills rising above them.

It seems to me, however, to be probable that the low land, about 20 to 30 metres above sea-level, extending along the southern east coast of Mainland, northwards from Sumburgh Head (see Fig. 162, I—IV) is actually an old strandflat. Inside this low land the hills rise more steeply, but as a rule not abruptly with a sharply marked boundary. In some places especially on the points, there may be a more marked difference between the flat shore land and the rising hill side (cf. Fig. 161, V, the distant low point on the west side of the sound north of Lerwick, see also

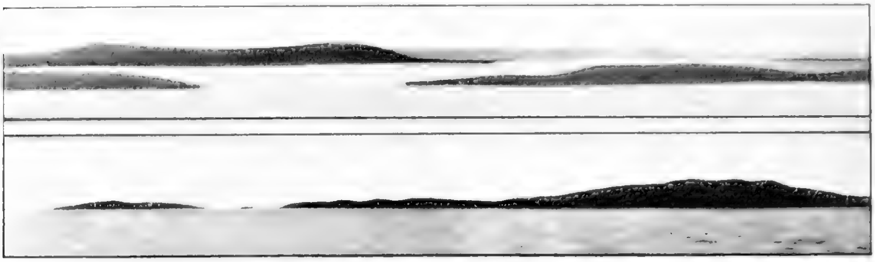


Fig. 164. I Lunna Holm and the Islands west of Lunna Ness. II Out Skerries with the Lighthouse. The height of the highest islands is 52 metres above the sea. August 26, 1911.

Fig. 163, the west side of Bressay in the background). On some of the islands similar formations are noticeable, a low outer border and higher ridges inside (see Fig. 164).

In Yell Sound at Ollaberry Bay, on the east coast of Northmavine (in the northernmost portion of Mainland), I found, by levelling, the plane of the supposed strandflat to be about 33 metres above the sea. The islands Bigga and Samphrey in the middle of the sound are 33 metres and 30 metres above sea-level.

If this low land may actually be considered to be a regular strandflat of the same kind as the Norwegian strandflat, it seems probable that the slopes of the hills inside have been much changed by subaërial denudation and perhaps by glacial erosion after the formation of the strandflat. During the periods when the strandflat was developed, the shore erosion by frost was probably not very effective in this region, so near the warm Atlantic Current, where the climate was probably not very cold. Hence the strandflat was not cut very broad, and as its formation took a long time, the surface of the land was at the same time to a comparatively large extent affected by the subaërial denudation.

There is no well-developed *submerged strandflat* along the shores of the Shetland Islands. Along a great part of the coast the sea-bottom slopes gradually from the shore down to depths of 100 metres and more, without any distinct break or well marked edge. At many places there are, however, indications of a submerged narrow platform, less than 15 or 20 metres below sea-level. They may be as much as 1 kilometre broad and are bounded by a somewhat steeper slope outside.

Considering the exposed situation of these islands to a stormy sea, and the comparatively small power of resistance of their rocks to erosion, it may seem remarkable that there is not a better developed emerged or submerged strandflat along their coasts.

It proves: — on the one hand, that the wave action alone has not much power to form a strandflat, and on the other hand, that there cannot have been much shore erosion by frost for its formation in this region.

XIV. THE LEVELS OF THE STRANDFLAT AND THEIR DEVELOPEMENT.

We now propose to discuss the possible changes in the level of the shore-line and the relation between the two similar formations, the strandflat standing at levels near or slightly above present sea-level, and the much broader continental shelf standing at levels one or two hundred metres below present sea-level. Let us first, however, summarize the conclusions on the nature of the strandflat to which our investigations have led us.

Summary of the Results of our Investigations of the Strandflat.

We have found:

On the one hand that, during the long periods required for the formation of the strandflat, the shore-line has maintained very uniform levels along the extensive coasts where a strandflat occurs, *i. e.* especially in Arctic and Subarctic regions.

On the other hand that after the formation of the now emerged strandflat began, there has been a negative shift of the shore-line caused either by an upheaval of the coasts or by a lowering of the sea-level. These changes of level have been very uniform over extensive areas.

On the whole, the strandflat creates the impression of having been formed during long periods when the earth's crust in those regions stood at its natural level of equilibrium; and since then there has been no appreciable tilting of this level on the whole, although there may have been small local changes in the course of time.

Our investigations show that there are probably several levels of the strandflat: the emerged strandflat has probably in most places two levels, and the submerged strandflat represents at least one level.

The results of our investigations as regards these levels may be summarized as follows:

The emerged Strandflat.

Along the west coast of southern Norway, in the regions of Stavanger, Karmøi, Hardanger Fjord, Sotra, Radoi, Lindås, and Sogne Fjord, the emerged strandflat seems to have two levels: *An upper level* at between 30 and 40 metres, or in some places perhaps between 26 and 35 metres above the sea — and *a lower level* at about 15 to 18 metres above the sea. In most places in these regions the upper level comprises the greater part of the area of the strandflat. The lower level extends near the shore, is more even, and is obviously of younger age than the upper level. In the region of Stavanger, this lower level is of comparatively wide extent, especially where the rocks are phyllite and chlorite schists, &c. which have comparatively little power of resistance to erosion.

In the region of Smølen, Hitteren, and Frøia (Fig. 107) the emerged strandflat has probably also two levels: an upper level about or higher than 30 metres above the sea, and a lower level lower than 20 metres above the sea. The lower level is here of a comparatively greater extent than in the above mentioned region of the west coast. It comprises the most part of Smølen, and a great part of Frøia, and is also widely extended along the north coast of Hitteren.

Along the coast of Helgeland the lower level of the emerged strandflat comprises the greater part of its area, especially in regions where rocks with comparatively little power of resistance to erosion prevail. On Dønna and Herøi it forms very even planes at altitudes of 8 to 10 meters above the sea, and in some parts of the islands even lower. This low plane of about 10 metres seems to be of very wide extent on the many islands of Helgeland.

The upper level at about 30 metres, or between 30 and 40 if it exists, is at any rate of very small extent in the region of Helgeland (cf. the maps Figs. 113 and 114).

On Lofoten and Vesterålen the emerged strandflat has probably also two levels, and the upper level, perhaps at about 30 metres, seems to be of a greater extent, *e. g.* on Hasseløi, than in Helgeland. The lower level is well marked on the small islands along the coast (see Figs. 1 and 2).

The submerged Strandflat of Norway.

Along the west coast of southern Norway south of Sogne Fjord there is not much of a submerged strandflat. There are numerous shoals sunken rocks here and there, at somewhat varying depth, but there are no well defined platforms with horizontal planes.

Along the coast between Sogne Fjord and Stat, there are more indications of a submerged strandflat in the shape of small submerged platforms and groups of shoals and sunken rocks often far out to sea. The soundings given in the charts of this coast are not sufficiently numerous for a study of the shape and topography of these platforms. Their depths seem to vary somewhat, but are to a great extent less than 10 metres below sea-level.

Along the Sondmor and Romsdal coast the submerged strandflat is considerably wider and more developed, forming platforms extending far out to sea. Outside the islands Fjertoft and Haroi, north-east of Ålesund, these platforms extend as much as 8 or 10 kilometres seawards from the outer coast of the islands, and have depths to a great extent less than 10 metres below sea-level. Their surface is somewhat uneven and dissected by channels and depressions, and their edges do not seem to be very sharply defined.

The submerged strandflat is similar outside the coast at Hustad. It is especially well developed in the region of Smolen, Froia, and the Froan Islands where it extends 12 to 20 kilometres, or more, seawards from the outer coast of the big islands, and has a level surface, less than 10 metres below sea-level, and well defined edges. It is, however, dissected by numerous channels. This strandflat is cut in pressed igneous rocks and granites, which, however, seem to have no very great power of resistance to erosion by frost. The submerged strandflat of this region has, on the whole, a greater area than the emerged strandflat.

Along the coast to the north-east the submerged strandflat is well developed, and its surface topography is largely similar to the one just described.

Along the coast of Helgeland the submerged strandflat is of exceptionally wide extent. The area of the emerged strandflat is quite small in comparison. The surface of this submerged strandflat is, as a rule, very level, almost perfectly horizontal, and less than 10 metres below the sea-surface, largely in fact between 2 and 6 metres. Its edges are to a great extent sharply defined with steeper side slopes. Where the rocks are mica-schist, limestone, and weak gneiss the surface of this submerged strandflat is more level and the edges more sharply defined, than where the rocks are granite or other fairly resistant igneous rocks.

In Lofoten and Vesterålen the submerged strandflat is not broad, obviously owing to the great power of resistance of the rocks to erosion, and also owing to the considerable initial height of the land. The submerged strandflat of this region has, however, as a rule a much greater width than the emerged strandflat. Its depth is as a rule greater than those of the submerged strandflat of Helgeland, its surface is less horizontal, and the edges less marked.

Along the coast to the north-east there is also a well developed submerged strandflat at about the same depth, as far as Ringvasoi and Kvaloi.

The three Levels of the Strandflat.

We may thus assume that the strandflat of Norway has at least three different levels: *An upper level* which in southern Norway is mostly between 30 and 40 metres above the sea (in some regions, as for instance on Stord, perhaps somewhat higher than in other regions). In northern Norway, especially in Helgeland, this level is perhaps somewhat lower, and is less conspicuous.

A lower level which in southern Norway is about 15 to 18 metres above the sea (in the inner part of Sogne Fjord about 10 and 12 metres) and in Helgeland in northern Norway is somewhat lower, about 8 to 10 metres (or even 5 metres), and is there of wide extent.

A submerged level which is not much developed along the coast of southern Norway, is much more developed along the coast of Søndmør, Romsdal, and Nordmør coast, and is of a very wide extent along the coast of Helgeland. Wherever this level is well developed it has a depth of only some few metres, and less than 10 metres, below present sea-level.

These different levels of the strandflat obviously indicate that the shore-line has stood at different levels during the long periods when the strandflat was developed. We must assume either that the land has risen or that the sea-level has been lowered.

The inner part of the emerged strandflat (at the upper level) has obviously been formed at some earlier period than the lower part of the strandflat (at the lower level). When the submerged level was formed is more difficult to decide. We have seen that in Helgeland where this level is especially well developed and is of very wide extent, it is only some few metres below the lower level of the emerged strandflat, and it might almost seem doubtful whether, in this region, it has not been formed more or less during the same long period as the latter.

In Spitsbergen we have found a well developed emerged strandflat with heights above sea-level very similar to those of the Norwegian strandflat, and there is also a distinct submerged strandflat with a depth of less than 20 metres.

On Bear Island there seems to be a wider range between the upper limit of the emerged strandflat and the level of the submerged strandflat, but this may be due to special reasons as has been previously mentioned. In other regions, especially Arctic, where there is a well developed strandflat, the investigations are not sufficiently detailed to give definite information about the heights of the levels, but they seem to be somewhat similar to the heights we have found in Norway and in Spitsbergen.

Causes of the Changes in the Level of the Strandflat.

It is, in my opinion, probable that the different levels of the strandflat in Norway indicate different interglacial periods of its formation, and mark the levels of equilibrium of the land crust during each of these periods.

Owing to the great quantities of rock and the débris of the interglacial erosion carried away from the land-surface into the sea by the big glaciers, the land has been somewhat raised by isostatic movement to the new level of equilibrium after the disappearance of the ice cap of each glacial period.

It is not known how many Pleistocene glacial periods there may have been in Norway. But considering that at least four different glacial periods are now established for Central Europe, it seems hardly probable that there should have been less in Scandinavia.

If the strandflat has two distinct levels it seems to indicate that there have been at least three glacial periods in Norway as was already assumed by Oxaal [1914, pp. 42 f., cf. above p. 48]. If there are actually three different levels, it may indicate four glacial periods.

If we assume that the changes of level are solely due to isostatic movements of the earth's crust, and in no degree to changes in the sea-level (caused by changes in the volume of the Ocean), it may seem difficult to understand why the heights of the raised strandflat are so very similar along the Norwegian coast and even on Spitsbergen, although the quantities of rock removed may probably have varied much in the divers regions of the coast.

If we assume that the upper limit of the strandflat is universally at some height between 30 and 40 metres above the sea, we would then have to assume that the quantity of rock material removed from the surface of the coast land corresponds to a continuous layer of rock with an average thickness of at least 36 to 48 metres, which has been removed after the upper level of the strandflat was first developed. This seems a great deal. Although much thicker layers of rock have obviously been excavated from the deepened valleys and fjords during this long period, the thickness of rock removed from the high land surface, between the deep valleys and fjords, has probably not been very considerable. It is also striking that the level surface of the strandflat itself cannot have been much denuded. On the other hand, if there have been at least two glacial periods, and probably three, after the upper level of the emerged strandflat was developed, it is not inconceivable that the weight of the rock material removed by the glacial erosion of the coast land during these periods may go some way towards explaining the elevation of the strandflat above present sea-level.

The submerged strandflat offers, however, another difficulty to this assumption. If, during some period before the last glacial epoch, this part of the strandflat was cut at a level actually lower, though slightly lower, than the present sea-level, the level of the land cannot have been permanently raised after that time, unless the general sea-level has also been raised.

To me it seems probable that, in addition to the isostatic upheaval of the land, there have been changes in the level of the sea.

There are several processes continually at work causing changes in the volume of the Ocean. The continual emission of water vapour from the volcanos adds new water to the Ocean, while on the other hand water is substracted from it by the alteration of rocks which binds water chemically. These processes are slow, however, and the one more or less checks the other. It is, therefore, hardly probable that, during the periods we are here considering, they have produced changes of sufficient importance to account for the observed shifts of the shore-line after the formation of the strandflat.

The displacement of sea-water caused by a volcanic eruption on the sea-floor would probably only cause a temporary rise of the general sea-level, as the effect would probably be more or less readjusted by the isostatic movements of the crust under the Ocean. Crustal movements changing the size or depth of the Ocean basin would naturally also cause changes in the general sea-level, but as these movements would be finally controled by isostasy, it is hardly probable that they can have produced appreciable changes during the periods we are discussing. The deposition of sediment on the sea-floor may gradually raise the general sea-level, as will be mentioned later; but this is also a slow process and is partly checked by crustal sinking.

Changes in the position of the poles would cause changes in sea-level. But if the lowering of sea-level since the first formation of the strandflat should be thus explained, we would have to assume, that the pole has come nearer to the regions of the strandflat, which would involve the probability that the climate has become more arctic since that time, which is exactly contrary to what might be expected. Changes in the earth's centre of gravity might also change the sea-level, but is probably so slow a process that it would not help much to explain the changes under consideration. The same is also the case with possible changes in the earth's rotation.

The subtraction of water from, and the addition of water to, the Ocean caused by the formation and melting of the great present and Pleistocene ice-caps have probably produced the most considerable changes in sea-level during comparatively short periods.

Much water is now accumulated in the extensive ice-caps of the Antarctic and of Greenland.

According to Hess, the area of the Antarctic ice-cap is about 13 millions square kilometres and that of Greenland 1.9 million sq. km. If we add to this the glaciers of the rest of the world, we get an ice-covered area of about 15,156,000 sq. km. altogether. We do not know what the average thickness of these ice-caps may be. The ice-caps of Greenland and the Antarctic with their general level surfaces standing at altitudes of 2,000 and 3,000 metres and more above the sea, must obviously have quite considerable thicknesses. If we assume the average thickness of the ice-caps to be 600 metres, the melting of them would increase the average depth of the Ocean by an amount of $\frac{15.156}{361.1} \times 600 \times 0.9 = 22.7$ metres, the area of the Ocean being about 361,100,000 sq. km. and the specific gravity of the glacial ice about 0.9.

If the average thickness of the ice-caps be 1,000 metres, the increase of the Ocean depth caused by their melting would be 37.8 metres.

The final rise of the general sea-level caused by this increase of the average depth of the Ocean, would be somewhat reduced by the gradual crustal sinking of the sea-floor under the increased weight of the oceanic water masses. If the specific gravity of the plastic rock or magma underlying the crust be 3, the depression (u) of the sea-floor will be

$$u = \frac{d}{3}$$

where d is the increase of the average depth of the Ocean. Hence, if the increase of the Ocean depth be 22.7 metres, the rise of sea-level will be 15.1 metres. It will be 25.2 metres if the increase of the Ocean depth be 37.8 metres. This is provided that the crustal sinking of the sea-floor is entirely compensated for by the upheaval of the areas which were covered by the ice-caps. If not, as will generally be the case, the sinking of the sea-floor will be somewhat reduced, as it will then have to be compensated for by the upheaval of the continents surrounding the Ocean (cf. pp. 235 ff.).

We see that the probable changes in the general sea-level caused by the reduction of the existing ice-caps would be quite sufficient to explain the negative shift of the shore-line after the first formation of the strandflat, if we add the probable isostatic upheaval of the land caused by the removal from its surface of glacial and interglacial waste.

The question is, however, whether we can assume that all ice-caps had disappeared when the strandflat was formed. The probability is that during long preglacial periods, there have been no ice-caps of significance, and that during those periods the Ocean had what we might call its normal average depth, which was somewhat greater than the present one.

During the warm interglacial periods it is also probable that the ice-caps of the earth may have been essentially smaller than they are now. The difficulty is, however, that the strandflat has obviously not been developed during these warm interglacial periods, but during periods with a cold climate favouring a vigorous shore erosion by frost. And these periods may have preceded the glacial periods, or have formed their beginning, before the crust was pressed down by the weight of the accumulating ice.

The development may also have continued some time after this subsidence of the land began, as the sea-level sank simultaneously because of the subtraction of water from the Ocean by the increasing accumulation of water in the ice-caps on land. But it should be noticed that this subsidence was not uniform, it being greater inland than nearer the coast, and in the outer coastal region there may probably have been an upheaval of the land during the first part of the subsidence of the inner land.

Hence it is not probable that the strandflat was developed to any large extent during this period when the land surface was warped, a characteristic feature of the strandflat being that its levels are practically horizontal.

However this may be, it seems probable that the general sea-level has sunk somewhat since the strandflat began to be developed, and it is possible that changes in the thickness and extent of existing ice-caps may at least to a large extent have caused these changes in the sea-level.

As long as there are ice-caps which during some periods increase and during others decrease, the average depth of the Ocean and the general sea-level will not remain quite stable.

It might then be possible that the present submerged strandflat was planed during some long period when the ice-caps of the earth were a good deal greater than now, and that although there has been an isostatic upheaval of the land since that time, the level of this lowest part of the strandflat has not been raised above the present level of the sea surface.

As will be mentioned in the next chapter there is, however, weighty evidence to show that the lower level of the emerged strandflat was formed just before the last glacial period. If therefore the plane of the submerged strandflat represents a different stage, we would in that case have to assume that it was formed before the lower level of the emerged strandflat, although this would be somewhat difficult to understand.

By the assumption that, during the long time which has elapsed since the strandflat began to be formed, the shore-line has been shifted partly by isostatic upheaval of the land and partly by changes in the general level of the sea, we obtain a simple explanation of the reason for there not being greater differences in the heights of the strandflat in the divers regions.

The explanation of the fact that the lower level of the emerged strandflat seems to stand somewhat lower along the coast of Helgeland and in the inner part of Sogne Fjord than along the outer west coast of southern Norway, in the region of Sogne Fjord and south of it, may then be, either that a smaller quantity of rock have been removed from the land surface in these regions after the formation of this level, — or that the isostatic upheaval of the land has not yet been quite completed in these regions.

The former explanation seems hardly probable, considering that the rocks of Helgeland are not on the whole very resistant. It seems less improbable that the upheaval of the land after the last glacial period is not yet finished in these regions which were considerably depressed during the last glacial epoch. The inner region of Sogne Fjord was depressed more than 100 metres and was probably covered by big glaciers comparatively recently, and the extensive Justedal glacier still remains, weighing down the land to some extent. In the region of Helgeland where the outer coast was depressed more than 75 metres, there may also have been a glacial covering comparatively recently, remnants of which still exist in the big "Svartisen" glacier.

Another fact which may also have retarded the upheaval of the crust in this region, is that the extensive submerged strandflat was covered during the depression by a layer of water as much as 75 metres deep or even more near its inner margin, and the weight of this water made the upheaval of the land slower. It may, therefore, not seem improbable that in Helgeland, as well as in inner Sogne Fjord, the upheaval of the land may still be a few metres short of its full completion, while it is long ago completed along the outer west coast of southern Norway as well as in Lofoten and Vesterålen where the late-glacial depression was very small or nothing at all, and where there was no extensive area of submerged sea-floor outside that should be elevated.

The Nature of the Rocks and the Topography of the Strandflat and the Continental Shelf.

Our investigations have shown that the shape and development of the strandflat vary to some extent with the nature of the rocks. This is especially conspicuous in the topography of the submerged strandflat of Norway.

Where the rocks possess comparatively less power of resistance to erosion, the submerged strandflat has a very level surface forming a nearly horizontal plane only some few metres below present sea-level, and its edges are sharply defined at about the same depth. Its side slopes are often steep descending to considerable depths on the continental shelf outside.

Where the rocks possess a comparatively great power of resistance to erosion, the surface of the submerged strandflat is considerably more uneven and irregular. It is generally sloping seawards, its edges are less sharply defined, and its depth may vary a great deal. Its outer side slopes are as a rule not steep, and the depth of the continental shelf outside not considerable.

If this be compared with the surface of the continental shelf of Norway outside the strandflat, we find a striking difference.

In regions of weaker rocks the continental shelf is broad, but is comparatively uneven and its surface is to a great extent lying at a considerable depth below present sea-level, while, as we have seen, the submerged strandflat is extremely level in those regions, and is standing comparatively high, being near present sea-level.

In the regions of more resistant rocks, *e. g.* outside the coasts of Søndmør, Romsdal, Nordmør, Lofoten, Vesterålen, Senjen, &c., the continental shelf is comparatively narrow, its surface fairly level, and its depth below present sea-level to a great extent less than 150 metres, and in some regions even less than 100 metres, while the submerged strandflat, as we have seen, is also narrow, but is comparatively uneven and irregular, sloping seawards, and lying deeper below present sea-level than in the regions of weaker rocks. There is often no very sharply defined boundary between the low strandflat and the high inner part of the continental shelf.

Although the submerged strandflat is very broad outside Helgeland, its outer side slopes seem to have been cut back more and to have been made steeper in the regions of weaker rocks than in those of more resistant ones. Its very level surface in the former regions seems therefore largely to be of a younger age than the more uneven surface of the latter regions.

Let us now leave the strandflat for a while and consider the formation of the continental shelf.

XV. THE CONTINENTAL SHELF AND ITS FORMATION.

In a previous treatise on the bathymetrical features of the northern seas [1904] I have described the continental shelf of Norway and of other northern regions and discussed its formation. There is this resemblance between the continental shelf and the strandflat, that both of them form fairly horizontal planes, in front of the coast which in Norway and several other countries is steep and ascends abruptly from the inner margin of the planes. Both formations as far as they are cut in solid rock, may most naturally be assumed to have been planed largely by marine denudation of some kind. There is, however, this striking difference between them, that the typical strandflat is largely confined to cold regions, where there has been severe climates favouring shore erosion by frost, and it is only exceptional that strandflats occur outside such regions, in places where there have been special climatic conditions, as for instance along the south-east coast of India — while the continental shelf has a universal distribution along most old coasts in all latitudes.

The continental shelf is obviously to a large extent built up of waste from the land carried into the sea during long geological periods and deposited outside the coasts. But as I previously pointed out [1904] it is also to some extent cut in solid rock. It would, for instance, be extremely difficult to explain in any other way the striking fact that outside the Norwegian coast its shape and the height of its level is obviously to some extent dependent on the nature of the rocks of the coast. It is especially narrow and high where the rocks possess a comparatively great power of resistance to erosion, as along the Romsdal, Søndmør coast and the coast of Lofoten, Vesterålen and Senjen, while it is very broad and lies comparatively deep below sea-level outside Helgeland where the rocks on the whole possess much less power of resistance to erosion.

The submerged fjords on the continental shelf, *e. g.* outside Søndmør, and outside Helgeland, and the coast north of Trondhjem, also indicate the rocky nature of the shelf. These fjords, which to a large extent follow the same direction as the valleys of the great Caledonian mountain folding on land, are obviously sculptured in solid rock [cf. Nansen, 1904, p. 151].

As a whole the continental shelf is obviously a very old formation developed during long geological periods, to a great extent preglacial, while the strandflat has been developed after the first Great Ice Age.

A few points may be specially mentioned.

Our investigations of the Norwegian strandflat and the late-glacial submergence of the land (see next chapter) prove the almost perfect isostacy of the crust.

It seems then improbable that the initial land in the region of the continental shelf can on the average have been very high.

Outside Helgeland this shelf has a width of 250 kilometres, very nearly equal to the distance from the coast eastwards to the central region of Fenno-Scandia where the land had its greatest late-glacial submergence of 300 metres or more. This shelf is consequently so broad that the crust in that region must stand very nearly at its level of equilibrium.

If the average specific gravity at the eroded surface rocks be 2.6, that of the underlying plastic rock or magma, displacing the upheaval (u) of the crust, be 3, the thickness of rock eroded be h, and the permanent lowering by erosion of the level of the land surface be l, we have:

$$u \times 3 = h \times 2.6$$

$$l = h - u$$

$$h = \frac{3 \times l}{3 - 2.6} = 7.5 \times l$$

Hence in order to lower the average level of the land surface 100 metres it would be necessary to remove a layer of rock having an average thickness of 750 metres. If the specific gravity of the underlying magma be higher, the thickness of the layer of rock which had to be removed would be smaller, *e. g.* with a specific gravity of the magma of 3.5, it would be only 389 metres.

As the planing of a shelf in solid rock by the joint action of subaërial denudation and marine denudation is obviously a very slow process, especially if it is not vigorously assisted by frost disintegration, and as the continental shelf of Norway cannot be assumed to be of sufficiently old age to make a vertical denudation of very great dimensions probable, we may assume that the initial land in the region of the present continental shelf was fairly low.

It may, however, have been much more uneven, and there may have been isolated parts or mountains rising to greater heights. The submerged lower parts, the depressions and valleys, of this initial land, may then in the course of time have been filled up with waste from the land, and the crust may thus have been depressed to a certain degree.

There is also the possibility that in the outer part of the shelf there is only a small amount of rocky ground, and that this part is chiefly built up of waste. This accumulation of waste will have pressed the crust down to some great extent. On the deeper sea-floor outside there may probably also have been formed thick layers of deposits, weighing down the crust. But why is there such a comparatively steep and sudden descent from the outer edge of the shelf on to the flatter sea-floor if the shelf and the sea-floor are built up of the same kind of material?

There is also another difficulty with which we are faced. The level surface of the continental shelf, whether cut in solid rock or built up of loose material, indicates an earlier sea-level or rather sea-levels, when either the land stood so much higher than now or the sea-level so much lower.

In Norway there is furthermore this difficulty that the height of the level of the shelf varies a great deal as was previously mentioned. Outside Romsdal and Sondmor as well as outside Lofoten the level of the continental shelf stands at a depth of 100 to 150 metres below sea-level, and outside Vesterålen and Senjen the depth below sea-level of the very flat shelf is even less than 100 metres. Outside Helgeland the surface of the continental shelf sinks down to 300 and 400 metres below sea-level.

Considering the nearly perfect isostasy of the earth's crust, which the crustal movements of Fenno-Scandia indicate, it seems extremely difficult to understand that, during the long period when the shelf was formed, the land as a whole can have stood so much higher as the depth below sea-level of the continental shelf; and when we consider that the other coasts of the globe must in that case also have been similarly elevated, the idea becomes quite impossible.

If the continental shelves of the world actually indicate one or more earlier sea-levels we would therefore be bound to assume that there have been considerable fluctuations in the level of the Ocean, and that during the periods when the continental shelves were developed it stood perhaps 100 to 150 metres lower than now [cf. Nansen, 1904, pp. 200, 211 f.].

Fluctuations in Sea-Level caused by the Formation of Ice-Caps.

During the Ice Ages great quantities of water were accumulated in the extensive ice-caps of the northern and southern hemispheres. Penck [1881, p. 76, 1894, II pp. 528, 660] estimated that the abstraction of water from the Ocean caused by the glaciation of the northern hemisphere alone sank the general sea surface 67 to 71 metres. Assuming that the glaciations of the northern and southern hemispheres were simultaneous, Drygalski [1887, p. 274] calculated that the lowering of the general sea-level thus caused was about 150 metres. The present writer pointed out [1904, pp. 211 f.] that the ice-caps of the northern hemisphere may probably during their widest extent have had a considerably greater area than assumed by Penck and the general sea-level may possibly have been sunk as much as 100 metres by their formation. If it be assumed that simultaneously there was a great extension of ice-caps in the southern hemisphere, and the antarctic ice-cap had a greater thickness, I thought it "conceivable that the level of the Ocean was at times lowered as much as 200 metres or even more".

Reginald A. Daly [1910, 1915, p. 173] has estimated that by the melting of the Pleistocene ice-caps since their maximum development "the general sea-level has been raised by an amount ranging between 23 and 129 metres". He thinks that this minimum estimate is likely to be too small, while the maximum estimate is too large. He thinks a rise of sea-level of the order of 50 to 60 metres to be most probable.

I think Daly's estimate is too low. It seems to me to be probable that during their maximum development the Pleistocene ice-caps had a greater average thickness and a greater extent than assumed even by Drygalski and Penck.

The Thickness of the Ice-caps.

During the last glacial epoch Fenno-Scandia was depressed by the weight of the ice-cap probably about 350 metres in its central region about Bottenviken (the Gulf of Bothnia). If the specific gravity of the plastic magma underlying the rigid crust be 3, the specific gravity of the ice 0.9, and the thickness of the ice-cap H, we have:

$$H \times 0.9 = 350 \times 3 + M$$

where M is a certain quantity due to the pressure counteracting the depression created by the upheaval of the peripheral areas surrounding the ice-caps, as will be mentioned below. If for the moment we leave this quantity out of consideration we have:

$$H = \frac{350 \times 3}{0.9} = 1167 \text{ metres.}$$

This is, however, a minimum value. First, it is improbable that the land had been depressed to the full extent corresponding to the weight of the ice-cap before the latter began to decrease.

Secondly, there is considerable evidence to prove that the depression of the areas covered by the ice-caps caused an upheaval of the regions surrounding the ice-caps. This upheaval will gradually spread outwards from the ice-caps over wider and wider areas, and the elevation will thus be reduced again very slowly. It is, however, obvious that as long as it lasts, the weight of the elevated magma under these upheaved regions will counteract to some extent the depression of the ice-caps, and will reduce accordingly the depth to which the underlying crust can be depressed by their weight. The wave of upheaval surrounding a depressed area will as it were temporarily raise the level of equilibrium of this area by the height of the wave. It is, however, extremely difficult to determine what the height of this upheaval may have been at the time when the ice-caps began to decrease, or, more correctly, when the sinking of the depressed areas ceased. A great part of these surrounding areas are now under water. The probability is, however, that owing to the upheaval of these areas we have to add a considerable amount to the thickness of the ice-cap computed from the late-glacial submergence of the land below its present level.

If the volume of the underlying magma be not altered by any chemical changes, it is obvious that the total volume of upheaval must be equal to the total volume of depression, without taking into consideration the elastic compression which in this connection is insignificant. If we assume that the area of the depressed land under an ice-cap is equal to one fourth of the area of the upheaved region surrounding the ice-cap, the average height (u) of upheaval must therefore be equal to one fourth of the average height (h) of depression. As, in the case of equilibrium inside these regions, the pressure should be uniform at a certain level below the earth's surface, this means that

$$u \times 3 = d \times 0.9 - h \times 3$$

where d is the average thickness of the ice-cap, 3 the specific gravity of the magma displaced by the depression, and 0.9 the specific gravity of the ice. As

$$u = 0.25 \times h$$

we have

$$d = \frac{3.75}{0.9} h = 4.17 h.$$

If for instance the average height (h) of the depression in the whole depressed area were 200 metres, the average thickness of the ice-cap would be 834 metres. If, however, the upheaved area were greater in proportion to the depressed area the thickness of the ice-cap would be less.

Thirdly, there is a probability that the specific gravity of the rock or magma underlying the rigid crust, at depths of perhaps 120 kilometres below the earth's surface, is somewhat higher than 3. In that case the thickness of an ice-cap computed from its depression of the crust would have to be increased accordingly.

According to what has been just pointed out, the probability is therefore that the thickness of the ice-cap was a good deal greater than the amount computed from the submergence of the land.

In the Christiania region, with a lateglacial submergence of 218 metres, the corresponding minimum thickness of the ice-cap, computed as on p. 230, would be 727 metres, and in the Trondhjem region, with a submergence of about 200 metres it would be 667 metres.

The Trondhjem region was very near to the outer margin of the Fenno-Scandian ice-cap. In its eastern, south-eastern, and southern portions the ice-cap probably thinned off much more gradually. In the region of Gotland its average thickness may have been about 250 metres as a minimum, but was probably much more.

If we estimate the average thickness of the Fenno-Scandian ice-cap at its maximum development during the last glacial period to have been at least 600 metres, we are certainly on the safe side. Probably it was a good deal more.

This ice-cap was, however, very small when compared with the north European ice-cap of the Great Ice Age during its maximum development, and the average thickness of that ice-cap was probably much greater.

Near South Cape on Spitsbergen A. Hoel and W. Werenskiold have recently found raised strand-lines and beaches at a height of as much as 340 metres above present sea-level. A submergence of this magnitude would correspond to the weight of an ice-cap which was at least 1130 metres thicker than the present inland-ice of Spitsbergen and probably much more. The formula p. 231 gives 1418 metres. As this raised beach was observed near the southern end of the land, it means an enormous increase of its glaciation.

On the top of Cape Flora, on the south coast of Franz Josef Land, at a height of about 330 metres above the sea, Dr. Reginald Koettlitz [1898] found water-worn pebbles which seemed to indicate a beach. A submergence of this height might indicate that this part of Franz Josef Land has recently been covered by an ice-cap which was at least 1100 metres (or 1376 metres according to the formula p. 231) thicker than its present glacial covering.

In Greenland and in Grinnell and Grant Land there are also numerous raised beaches and strand-lines proving a recent upheaval of the land and indicating that during the last glacial period the ice-cap has been considerably thicker than now; and it was more widely extended over the whole now bare land of the west coast of Greenland, as well as of its northern east coast.

During the maximum development of the ice-caps of the Great Ice Age, they were much more widely extended in Europe as well as in America and Greenland, &c., and also covered the broad continental shelves surrounding the coasts. For instance the whole of the shallow Barents Sea between Norway, Russia, Novaya Zemlya, Franz Josef Land, and Spitsbergen was probably covered by a thick ice-cap. The mean depth of this sea is perhaps 200 metres. I have moreover found indications of a glaciation in northern Siberia, and have also observed raised strand-lines on islands outside that coast, probably indicating a considerable lateglacial submergence of the coast land of those regions.

In North America the lateglacial submergence was at least 500 metres, probably a great deal more. Computed in the same manner as above (by the formula p. 231) this would correspond to a thickness of the ice-cap of about 2085 metres. If, however, we do not take into account the upheaval of the zone peripheral to the ice-cap, we find according to the formula p. 230 that the thickness of the ice-cap may have been 1667 metres only. But this is a minimum value, and it was probably a great deal thicker.

If we assume that the area of all Pleistocene ice-caps in the northern and southern hemisphere, during their maximum development was at least 50 millions square kilometres, that their average thickness above sea-level was 1000 metres, and that the average thickness of the extended Antarctic and Greenland ice-caps were increased by a similar amount; if we furthermore assume that the area of the Ocean be reduced by 4 per cent by the ice-caps covering some parts of the continental shelves, and by the sinking of sea-level, we find that, by the formation of the Pleistocene ice-caps, the average depth of the Ocean was decreased by an amount of about

$$\frac{50}{346} \times 1000 \times 0.9 = 130 \text{ metres.}$$

I consider this to be a minimum value, for the average thickness of the greater part of the ice-caps during their maximum development was probably more than 1000 metres. It is also probable that the total area of all Pleistocene ice-caps during their maximum development was more than 50 millions sq. km. Drygalsky [1887] and Penck [1894 II, pp. 528 and 660] have estimated the reduction of the Ocean by the formation of the Pleistocene ice-caps to have been equal to a water layer 150 metres thick.

Shifts of Sea-level and Shore-line caused by Changes in the Volume of the Ocean.

We thus see that there must have been an appreciable reduction of the volume of the Ocean during the maximum development of the Pleistocene ice-caps, which would cause an immediate sinking of the general sea-level.

By this shifting of water-masses, however, the equilibrium of the earth's crust is disturbed. What will be the result? In the course of time there will be a gradual and very slow readjustment. If perfect equilibrium be restored, the crust under the ice-caps will be depressed to an extent corresponding to the weight of the ice-caps, and the floor of the Ocean will be upheaved to an extent corresponding to the weight of the reduction of the volume of the Ocean.

If the specific gravity of the plastic rock or magma underlying the rigid crust be 3, the upheaval (u) of the general sea-floor, caused by a reduction (d) of the average depth of the Ocean, would be:

$$u = \frac{d}{3}$$

The final lowering of the general sea-level would in that case be about two thirds of the amount by which the average depth of the Ocean was reduced.

The above formula for u will only be valid if perfect equilibrium of the entire crust of the earth be restored. In that case the depression of the crust in the regions of the ice-caps would be entirely compensated for by the upheaval of the general sea-floor, and no permanent changes in the general level of the continents would then be caused.

As, however, the shifting of the plastic rock or magma underlying the rigid crust is an extremely slow process, this state of perfect equilibrium is hardly ever attained. What would actually happen may, perhaps, be as follows:

The immediate effect of the accumulation of water in the ice-caps will be a sinking of the general sea-level to the full amount by which the average depth of the Ocean was reduced. Then the isostatic readjustment of the crust would gradually begin.

The crust under the ice-caps would be depressed by the increase of the weight of the ice-caps. This depression would cause a corresponding upheaval of the crust in the areas surrounding the ice-caps. If these areas consist more or less of sea-floor, their upheaval will reduce the sinking of the general sea-level accordingly.

The reduction of the depth of the water in the other parts of the Ocean will gradually cause an upheaval (u) of the sea-floor. This upheaval, which is not compensated for by the depression of the crust in the regions of the ice-caps, has to be compensated for by the sinking of the continents surrounding the Ocean. The upheaval u of the general sea-floor will then be:

$$u = \frac{d}{3} - M$$

where M is a quantity determined by the reduction of pressure at a certain level under the continents due to their sinking.

The following consideration may help to make this clear.

If the globe were covered entirely by an Ocean, the increase or decrease of the volume (*i. e.* the depth) of this Ocean would have no effect upon the level of the sea-floor. If, however, continents emerge above the surface of the Ocean, the conditions are entirely altered. An increase of the volume of the Ocean will then press down the Ocean floor and press up the continents accordingly.

If the average depth of the depression of the Ocean floor be u, the average height of the upheaval of the continents be h, the area of the

Ocean being about 361.1 millions square kilometres, and the area of the land surface of the earth being about 148.8 millions sq. km., we have:

$$u \times 361.1 = h \times 148.8$$

$$h = 2.43\, u.$$

To give room for a universal depression of the Ocean floor the continents have consequently to be elevated on the average 2.4 times the average amount of this depression. This reduces substantially the depth to which the Ocean floor can be depressed by a certain additional weight. If perfect equilibrium be established, the pressure at a certain level below the earth's surface should be uniform in all regions. Hence the increase of pressure at this level created by the increase of the depth of the Ocean must be equal to the increase of pressure caused by the upheaval of the continents. Hence

$$d \times 1 - u \times 3 = h \times 3 = 2.43 \times u \times 3$$

$$u = \frac{d}{3 + 2.43 \times 3} = d \times 0.097$$

where d is the increase of the depth of the Ocean. If this increase be 100 metres, we find that the depression of the Ocean floor thereby caused can be no more than 9.7 metres, while the average upheaval of the continents would be 23.6 metres.

To simplify our computation we have here assumed that the volume of the Ocean was increased by water coming from outside the globe. In reality the water is removed from the continents to the Ocean, which complicates the matter. This removal causes an upheaval of the land in the region of the ice-caps, and a sinking of the crust in the surrounding regions, which will gradually extend over wider areas, but will only reach a certain part of the Ocean floor.

In this manner the universal upheaval of the continents caused by the shift of the water from the ice-caps to the Ocean will be reduced, and the possible depression of the Ocean floor may be increased accordingly.

On the other hand it would take an extremely long time before the depression of the Ocean floor could effect a universal and equal upheaval of the whole area of the continents. It would begin by pressing up the coasts surrounding the Ocean, and the upheaval would only very slowly extend landwards over the continents. Thus the depression of the sea-floor would also be much checked.

The whole process is thus seen to be a very complicated one, and as so many important factors are unknown, it would be useless to try to form any accurate estimate of the depression of the Ocean floor and of the upheaval of the continental coasts.

We have here considered the case where there was an addition of water to the sea by the melting of the ice-caps on land. In the opposite case of an abstraction of water from the sea by the formation of ice-caps on land, the same computation can be made, only in the inverse direction.

It has to be noticed that as the continental coasts are to some extent raised or sunk by the crustal movements, the negative or positive shifts of shore-line will not correspond to the changes of the general sea-level, but will as a rule be somewhat smaller.

For instance, by a decrease of the average depth of the Ocean, the sea-floor will be raised, which will reduce the sinking of the general sea-level accordingly; but the continental coasts will sink somewhat, which will reduce the negative shift of the shore-line caused by the sinking of the general sea-level.

These reductions, however, will not be considerable.

Let us take an example; let us assume that the thickness of the Antarctic ice-cap is increased on the average 1000 metres. As the area of the ice-cap is about 13 millions square kilometres, this would mean a reduction of the average depth of the Ocean by $\frac{13}{361} \times 1000 = 36$ metres.

Let us furthermore assume that the depression of the crust caused by this increase of the ice-cap is compensated for by an upheaval of the sea-floor in a surrounding area which is four times the depressed area under the ice-cap. According to the formula given on p. 231 we have then the average upheaval (U) of the sea-floor in this area

$$U = \frac{1000 \times 0.9}{3 + 3/0.25} = \frac{900}{15} = 60 \text{ metres.}$$

As the area of upheaval is 52 millions square kilometres, this would mean a reduction (r) of the sinking of the general sea-level by

$$r = \frac{52}{361} \times 60 = 8.5 \text{ metres.}$$

Hence the general sea-level would be lowered $36 - 8.6 = 27.4$ metres.

This reduction of the depth of the water of the rest of the Ocean, with an area of $361 - 52 = 309$ millions square kilometres, would cause an upheaval of the sea-floor and a sinking of the continents. In order to simplify our computation we will now leave the upheaved part of the Ocean round the Antarctic out of consideration as we well may in this rough estimate. If we assume that the area of the lowered continents be $149 - 13 = 136$ millions square kilometres the upheaval (u) of the sea-floor would be

$$u = \frac{27.4}{3 + \frac{309}{136} \times 3} = 2.85 \text{ metres}$$

and the average subsidence (h) of the continents would be

$$h = \frac{309}{136} \times 2.85 = 6.5 \text{ metres.}$$

Hence the general sea-level would be lowered about 24.5 metres instead of 27.4 metres and the negative shift of the continental shore-line would be 18 metres, provided that the coast would sink as much as the average subsidence of the continents, which, however, is not probable.

The values of the upheaval of the sea-floor and sinking of the continents found above are, however, maximum values. It would probably be a very long time before the whole area of the continents were sunk. For all practical purposes we may assume that only some parts of them near the coasts would sink and this would substantially reduce the amounts of the upheaval of the sea-floor and the subsidence of the continental coasts.

We may assume that the sinking of the general sea-level caused by the formations of ice-caps will at least be 70 per cent of the amount by which the average depth of the Ocean is thus reduced, and the negative shift of the general continental shore-line, outside the regions depressed and raised by the weight of the ice-caps, will be at least 53 per cent of the amount by which the Ocean depth is reduced, but as rule much more.

The preceding computations are only rough estimates. They prove, however, on the one hand that quite considerable changes in the average depth of the Ocean may have been caused by the formation of the Pleistocene ice-caps and by their melting, and on the other hand that the shifts of the general sea-level and the general continental shore-line have been at least 70 and 53 per cent of the amounts by which the depth of the Ocean was changed.

It is quite possible that during the maximum development of the Pleistocene ice-caps the general depth of the Ocean was reduced by 150 metres. In that case the general sea-level would sink at least 105 metres, and the negative shift of the general shore-line would be at least 80 metres.

The Lowering of Sea-Level during the Glacial Periods and the Surface of the Continental Shelf.

The question is now, whether this lowering of the general sea-level during the glacial periods can help us to explain the formation of the continental shelves? My view is that, although the great glacial periods may have lasted a very long time, the time would nevertheless not be sufficient for the development of such broad formations as the floor of the North Sea, the continental shelf west and south of Great Britain and Ireland, &c., not to speak of the continental shelf of Norway, Iceland, Greenland, and the coasts of the North Polar Sea. It must also be remembered that during the maximum development of the Pleistocene ice-caps these northern shelves were to a great extent covered by ice, and were more or less depressed.

The sinking of sea-level during the glacial periods may, however, help to explain certain features of the continental shelves which seem to indicate that they have been recently emerged, *e. g.* the occurrence at depths of 100 to 150 metres of numerous water-worn shore pebbles and shells of littoral molluscs, lying on or just beneath the surface of the continental shelf and hardly covered by later deposits. A great many river channels and valleys traversing the continental shelves also indicate that their surfaces must have been emerged during some recent period, when these channels were either formed or reopened.

In regions where the land was covered by Pleistocene ice-caps the continental shelves outside the coasts may also have been upheaved to some limited extent when the land inside was depressed by the weight of the ice-caps [cf. H. Munthe, 1910, p. 1206].

It is hardly possible to compute the magnitude of this peripheral upheaval. It seems probable that it reached its greatest heights during the first period of the depression of the ice-covered region, when only a comparatively narrow peripheral belt was pressed up by the underlying magma displaced by the depression. The height of this upheaved wave gradually decreased again as the wave slowly extended its area outwards. We have previously found that in the case of local equilibrium

$$u \times 3 = d \times 0.9 - h \times 3$$

where u is the average height of upheaval in the peripheral belt, d the average thickness of the ice-cap, and h the average height of the depression under the ice-cap. This means that as the depression (h) gradually increases the height of upheaval (u) will decrease, and when h has reached its full extent and

$$h \times 3 = d \times 0.9$$

the upheaval u will be zero, which will not happen before the whole crust of the earth has regained its level of perfect equilibrium. In that case the upheaval of the crust compensating for its depression under the ice-caps will have been entirely transferred to the floor of the Ocean the volume of which was reduced by the formation of the ice-caps.

In the case of the continental shelves of Norway and other glaciated regions the development may have been the following:

By the reduction of the volume of the Ocean there has been an immediate sinking of the general sea-level, which during the maximum development of the ice-caps may have amounted to 100 metres at least, and perhaps to as much as 150 metres. By the gradual depression of the interior areas of the land under the weight of the ice-cap the outer coast and the region of the continental shelf have been upheaved. If this upheaval was as much as 50 metres, there may have been a negative shift of the shore-line of as much as 150 or 200 metres.

This stage may have lasted for some time and during that period the surface of the continental shelf was to a large extent above sea-level and was exposed to subaërial denudation, fluvial erosion, and to a vigorous shore erosion by frost, which have left their marks on this surface.

I have previously [cf. 1904, pp. 151 f.] pointed out that the longitudinal arrangement of submerged valleys and fjords in the inner regions of the continental shelf of Norway must stand "in genetic relation to the tectonic structure of the underlying rocks", and that this fact is "conclusive evidence that the underlying ground of at least the innermost part of the shelf is solid rock at no great depth below the surface". And I furthermore pointed out [cf. 1904, pp. 57 f.] that these longitudinal valleys, following directions parallel to the coast and to the direction of the Caledonian mountain folding, "must owe their prime origin to the subaërial erosion of running water", because it is hardly conceivable that the glacial erosion alone would excavate such valleys at right angles to the direction of the general glacial movement, unless the glaciers were to some extent guided by initial fluvial valleys.

This means, however, that the least the inner part of the continental shelf must have been above water when these initial fluvial valleys were developed. This may to some great extent have occurred during preglacial periods; but it is also probable that by the emergence of the shelf during the glacial periods, there has been some fluvial erosion of these valleys.

When the ice-caps increased and extended outwards, the shelves were gradually more or less covered by the ice. They were then depressed instead of being upheaved, and the peripheral belt of upheaval was gradually shifted outwards. During the last glacial period this was obviously the case in the inner part of the broad continental shelf outside the coast of Helgeland and the Trondhjem region and also to some small extent outside the coast of the Nordmor and Romsdal region.

During the maximum development of the Pleistocene ice-caps the whole of these shelves were obviously covered by ice, and they were then much depressed, and were probably also much eroded by the glaciers, at least in some regions, *e. g.* outside Helgeland and the Trondhjem region, where the surface of the shelf was thus much lowered.

The Deposition of Sediment has gradually raised the general Sea-Level.

If the continental shelves of the world cannot have been initially formed and developed to their great width, and if their rocky planes cannot have been cut in solid rock during the comparatively short periods when the general sea-level was lowered by the formation of the Pleistocene ice-caps, the question still remains open how and when were they formed.

Is it probable that the general level of the Ocean has been as much lower as the development of these shelves near sea-level would necessitate, and that this low level has remained during such long preglacial periods as would be required for the planing of the broad shelves, provided that they are formed chiefly by marine and subaërial denudation and by sedimentation?

The following considerations may perhaps help to find an explanation.

The continual deposition of sediments on the sea bottom has a tendency to raise the general sea-level. The rise of level thus caused is to some extent compensated for by the gradual subsidence of the sea-floor under the weight of the sediment. If the specific gravity of the sediment be 2.5, that of the magma underlying the rigid crust 3, the subsidence (u) of the sea-floor caused by a layer of sediment with the average thickness of 100 metres will be:

$$u = \frac{100 \times 2.5}{3} = 83 \text{ metres.}$$

As the sediment came from the continents, these would be raised by an average height (h) of (cf. p. 235)

$$h = 2.43 \times 83 = 202 \text{ metres.}$$

Hence, although the general sea-level would be raised 17 metres, there would be a negative shift of the shore-line. If we assume that the amount of the upheaval of the coast is as much as 60 metres or midway between the upheaval of the continents inside and the subsidence of the sea-floor outside, the negative shift of the shore-line would be 43 metres.

These calculations are very rough. On the one hand, we do not know the specific gravity of the plastic magma underlying the rigid crust, nor do we know the exact specific gravity of the sediment on the sea-floor. The oceanic water contained in this sediment has to be left out of our calculation, as it was in the Ocean before the sediment was deposited. What we wish to know is the specific gravity and thickness of the sediment without the water.

On the other hand the processes that actually take place are of course much more complicated than here assumed. The deposit of sediments is distributed very unevenly over the Ocean floor. The deposition of terrigenous matter is largely limited to the regions near the coasts and the deposition of calcareous and silicious sediments (of organic origin) is limited to the regions of the sea-floor which have moderate depths, while there is extremely little deposition going on in the deepest areas of the sea-floor. This means that the depression of the sea-floor caused by the comparatively rapid deposition of sediment in certain areas is largely compensated for by the upheaval of the sea-floor in adjoining regions where the deposition is much less. In that case the rise of the general sea-level caused by the deposition of sediment will naturally be considerably more than found by our computation above.

It thus seems probable that the continual deposition of sediment on the sea-floor has in the course of time actually caused an appreciable rise of the general sea-level. At the same time there has been a gradual subsidence of the sea-floor and an upheaval of the continents.

If we imagine that, to begin with, the outer border of the continental surface was low and to some extent submerged below sea-level, then the emerged parts of this continental border would be exposed to marine abrasion as well as to subaërial denudation. By the joint action of these two agencies the emerged portions of the land surface would after a long time be planed down towards sea-level, while the depressions of the submerged surface would be more or less filled up with the waste from these emerged parts and from the continental surface inland. At the same time there would be a continual deposition of sediment on the continental slope, outside the submerged outer border of the flat continental surface.

In the course of time the result of these processes would be that the sea-floor of the continental slope would be gradually depressed under the heavy weight of the increasing layers of sediment. On the submerged continental border there has been a deposition of waste from the inner part of the continent in addition to the waste formed by the denudation of the emerged portions of the coast. This border will consequently also be pressed down to some extent. The emerged continental coast land inside this submerged border, however, has been denuded by subaërial erosion and will be upheaved. At the same time the general sea-level will be somewhat raised by the general deposition of sediment on the Ocean floor, and the submerged continental border will be still more submerged.

As the coasts would be continually exposed to the joint action of subaërial denudation and marine abrasion they would gradually be cut back; but this process would be extremely slow, as, owing to the general subaërial denudation of the continental surface, the denudation of the coastal land would be largely compensated for by its isostatic upheaval, and it would therefore be chiefly the marine abrasion which would cut back the coast, as this denudation is limited to the shore and would therefore create no appreciable upheaval of the land.

Although weighty objections may certainly be raised against many details of this theory, still I think it possible that on the whole it may give a fairly feasible explanation of the formation of the continental shelves.

It would be easy to understand that along coasts where there was no initial submerged border of the continental surface, the formation of a continental shelf will be a difficult and extremely slow process. We therefore find that the continental shelf is often very narrow outside such high coasts, while it is, as a rule, broad outside coasts where the continental surface is low and slopes gently towards the sea.

As the shore erosion by frost will largely increase the rate of the marine abrasion, the continental shelf may be expected to be very broad in the cold regions of the globe, where the climate may have favoured this erosion also during preglacial periods. The fact is that the continental shelf is exceptionally well developed in the Arctic regions, and especially outside the coasts round the North Polar Sea.

It might be objected that by the great amount of waste carried from the land on to the surface of the continental shelf formed in this manner, its level would be built up towards sea-level faster than the general sea-level could be raised by the deposition of sediment on the floor of the Ocean. Owing to the considerable movements of the water, however, especially those caused by tidal-currents and wind-currents over the continental shelf, as a rule comparatively little sediment can be deposited on its level parts or higher parts. The sediment is therefore chiefly deposited in the hollows and depressions or is gradually moved beyond the shelf, and is deposited on the continental slope outside.

Hence there will not as a rule be much deposition of sediment on the continental shelf after its depressions and hollows have been filled up, and it will not be much depressed by the weight of the sediment after it has been once fully developed. The probability is therefore that its level will remain fairly stable, while there is a slow upheaval of the emerged land inside to compensate for its denudation by subaërial erosion, and a slow subsidence of the sea-floor outside caused by the deposition of sediment. As the general sea-level gradually rises and the depth of water over the continental shelf increases, it will be slightly depressed by the increasing weight of this water.

If the submerged shelf of the continents has been developed in a manner somewhat similar to what has been indicated above, it is also fairly easy to understand how it is possible that there are two widely extended formations, which seem to indicate two distinctly different levels at which the shore-line of the Ocean has remained for very long periods. The one formation is the low continental plains, which rise gently inland from present sea-level, and the development of which would be extremely difficult to understand unless we assume that the general sea-level has remained more or less the same as now during long geological ages. The other is the continental shelf which also indicates a sea-level and which must have required a very long time for its development. The levels of these two planes are as a rule distinctly different, and the difference between them is often marked by a comparatively steep descent from the coast, or in Norway from the edge of the strandflat, down to the inner surface of the continental shelf.

Both plains have been formed at about present sea-level more or less, but while the continental shelf has been somewhat depressed and is more and more submerged by the slow rise of the general sea-level, the continental plains keep to a certain degree their levels, owing to the upheaval of the land compensating for the denudation. The denudation is, however, quite insignificant in the lowest parts of the plains, the outer borders of which will gradually be submerged by the rising sea.

The difference between the level of the continental shelf and the levels of the coastal continental plains as well as of the strandflat, may have been accentuated during the glacial periods when the general sea-level was lowered more or less by the formation of ice-caps on land.

By a negative shift of the shore-line to an amount of say 40 to 60 metres, or more, the inner parts of the continental shelf may have been more or less planed down by marine abrasion (shore erosion), and the slope from the present coast, or from the edge of the submerged strandflat, may have been cut back, and has become steeper.

In the manner explained in this chapter it may be possible to understand the development of the continental shelf without being obliged to assume considerable changes in the general sea-level. There are, however, certain bathymetrical features of the northern seas, which might seem to indicate much greater changes in the sea-level. I may especially mention the great similarity of the depths of 400 to 500 metres of the submerged ridges between Scotland, The Færoes, Iceland, Greenland, and Baffin Land [cf. Nansen, 1904, pp. 73, 83 f., 89, 173 f.].

It seems somewhat difficult to assume that the uniformity of the lowest levels of these ridges can merely be due to an accidental coincidence. It may also be mentioned that the floor of the wide outer part of the large submerged valley of the Barents Sea, south of Bear Island, which I have called the submerged Bear Island Channel [1904, p. 30], also seems to have a level similar to that of the above mentioned ridges. The mouths of several other submerged fjords (*e. g.* the Vest Fjord) also seem to have similar depths.

If these ridges and mouths of submarine fjords have actually been lowered to some ancient base level, indicated by their present depth, this would probably mean a lowering of the general sea-level, so great that it could hardly be explained by the shifts of sea-level discussed in this chapter, and it seems extremely difficult to find a satisfactory explanation of changes in the sea-level of this order.

There is another possibility that these depths may indicate a certain lower limit of the depth to which the Pleistocene ice-caps reached down during their maximum development. A depth below water of 400 to 500 metres reached by an ice-sheet would correspond to a thickness of the ice of about 440 to 550 metres, which does not seem excessive, even near the edges of the ice-caps. Besides it has to be remembered, that during the maximum development of the ice-caps the sea-level probably was considerably lower than now.

Hence we may well assume that the ice-caps reached down to these depths. The depths may then indicate a kind of base level to which the underlying ground was eroded by the glaciers. It was previously (p. 23) mentioned that the erosive power of a glacier, moving at a certain rate, remains the same below water as above it, as long as it rests on the ground and does not float.

XVI. THE STRANDFLAT AND THE LATEGLACIAL AND POSTGLACIAL SUBMERGENCE OF FENNO-SCANDIA.

As was pointed out already years ago by J. H. L. Vogt [1907, pp. 38 ff.] and by the present writer [1904, pp. 126 ff. and 200 ff.], there is a striking difference between the fairly uniform, nearly horizontal level of the Norwegian strandflat and the varying, generally much higher levels of the raised beaches and shore-lines which slope seawards from the inner land. This relation between the strandflat and the raised shore-lines, formed later, was held by the writer to be convincing evidence of the isostasy of the earth's crust.

The important fact that the raised lateglacial and postglacial shore-lines slope from the inner land towards the outer coast has been established for Norway as well as for Sweden, Finland, and the Kola Peninsula by the investigations of a great many authors. The following may be especially mentioned: Bravais [1838], R. Chambers [1850], Gerard de Geer [1890, 1898], Andr. M. Hansen [1891], H. Munthe [1892, 1900], A. G. Hogbom [1896, 1899, 1904], Amund Helland [1900], J. Rekstad and J. H. L. Vogt [Vogt 1900], W. C. Brøgger [1900], W. Ramsay [1898], J. Rekstad [1905—07, 1910], V. Tanner [1906, 1907], A. Hoel [1907], J. H. L. Vogt [1907], P. A. Øyen [several papers], Kaldhol [1912], Danielsen [1905, 1906, 1909, 1912], Gronlie [1913—14, 1918].

A great many American geologists after Gilbert [1882, 1890], Russell [1885], Warren Upham [1887], and others have found that the raised shore-lines of North America are tilted, and that the lateglacial and post-glacial shore-lines have a distinct inclination outwards from the central areas of the regions which were covered by an inland ice during the last glacial period; other quite local shore-lines were also found tilting outwards from the centre of a region formerly covered by the water masses of a great lake (Lake Bonneville).

The postglacial upheaval of the land has also there been greatest in the central parts of the ice-covered regions, diminishing outwards to nil near its outskirts. The details, however, of this upheaval have not yet been studied in so much detail as in Fenno-Scandia.

The Lateglacial and Postglacial Upheaval of Sogne Fjord.

Let us compare the heights of the Norwegian strandflat with those of the raised lateglacial and postglacial shore-lines.

In Sogne Fjord the following altitudes of the lower level of the emerged strandflat were found:

Locality	Distance from the outer skerries (Utvær outside Sogne Fjord) outside the coast	Height of Strandflat above mean sea-level
Sogndal and Norum Fjord	136 kilometres	about 10 metres
Leikanger	127 »	10 to 12 „
Tjugum and Balestrand	115 »	about 12 „
Tangen opposite Høyang Fjord	80 »	17 »
Matsnes east of Eike Fjord	63 »	17 »
Rutletangene	36 »	16 »
Dingenes	28 »	11.3 »
Northern Lindås Peninsula	16 »	17 »
Hellisø Lighthouse	2 »	17 »

The measured altitudes of the upper level of the emerged strandflat may indicate a similar rise of altitude from the inner parts of Sogne Fjord towards the outer coast. We found it to be about 25 metres on Vegarnes, 26 metres on Vangsnes, on Matsnes, and possibly on Rutletangene, 33 to 40 metres on Radøi (according to Ahlmann), &c.

Provided that these observations be correct, and that the difference be not due to glacial erosion, the strandflat has consequently been somewhat more raised near the outer coast than further inland, as was previously mentioned.

The upper limit of the lateglacial and postglacial submergence (or upper marine limit) in the region of Sogne Fjord can only be traced by the highest raised terraces. J. Rekstad [1905, 1906, 1907, 1910] has found the following heights:

Locality	Distance from the outer skerries, Utvær	Height above sea-level of upper limit of lateglacial submergence
Vadheim	72 kilometres	77 metres
Ortnevik, Fitje	88 »	87 »
Vik	112 »	115 »
Hovland, Årdal Fjord	170 »	137 »

Let us assume that the *isobase* (*i. e.* line of equal postglacial upheaval) for *17 metres* (*i. e.* the height above sea-level of the lower level of the emerged strandflat near the outer coast) passes across the middle of

Yttre Sulen, across the outer part of Atleoi to Rugsund near the mouth of Nord Fjord. Let us furthermore assume that the isobases for greater elevations further inland follow directions parallel to this line.

In the following table are given: 1) the direct distance of each locality mentioned from the isobase for 17 metres, 2) the height of the upper limit of lateglacial submergence above the lower level of the emerged strandflat (as given in the table on p. 246), 3) the gradient of the postglacial elevation (minus the height of the strandflat) a) between the isobase for 17 metres and the locality, and b) between each locality.

Locality	Distance from the isobase for 17 metres	Height of upper marine limit above lower level of strandflat	Gradient of Elevation	
			from isobase for 17 metres	between the localities
Vadheim	52 kilometres	60 metres	1.15 per mille	} 0.53 per mille
Ortnevik	71 »	70 »	0.99 » »	} 1.37 »
Vik	95 »	103 »	1.08 » »	} 0.52 »
Hovland	143 »	128 »	0.89 » »	

The gradients between Vadheim and Ortnevik and between Ortnevik and Vik differ much from each other and from the gradient between Vadheim and the isobase for 17 metres. If we assume that the terrace measured at Ortnevik does not actually give the upper limit of submergence, and if we take the gradient between Vadheim and Vik, we find it to be 1.00 per mille, which is slightly lower than the gradient 1.15 per mille between Vadheim and the isobase for 17 metres.

The gradient in the inner part of the fjord, between Vik and Hovland in Årdals Fjord, is very low, 0.52 per mille. The difference between this gradient and the gradient in the outer part of the fjord is much too great to be explained by the regular decrease of the gradient of elevation inland towards the central region of the depressed area. Rekstad is obviously right in assuming that the highest terraces at Hovland do not mark the upper limit of submergence, because the inner part of the fjord was filled with glaciers during the time of greatest submergence, and when the glaciers retreated and the terraces could be deposited, the land had already begun to rise.

The probability of this explanation is confirmed by Rekstad's measurements of the upper marine limit in the inner part of Hardanger Fjord and by H. Kaldhol's measurements of the raised terraces in Nord Fjord.

The observations made in *Nord Fjord* are of special interest to us here in another respect.

The Lateglacial and Postglacial Upheaval in the Region of Nord Fjord.

Rekstad found [1905] that the gradient of postglacial upheaval is much smaller in the outermost part of Nord Fjord than farther in. Kaldhol's numerous measurements (by levelling) of the upper heights of the raised terraces in this region, at about hundred different places, have shown this still more clearly [Kaldhol, 1912a].

At twenty different places in the outer coast zone, between the north coast of the Stat Peninsula and the south coast of Bremanger Land (and Froien Island), Kaldhol's measurements of the upper limit of submergence give heights between 15.2 and 17.7 metres above present sea-level (see map Fig. 165). In most cases it is between 16 and 17 metres. At two places, Revik on Vågsoi and Forde on Bremanger Land, he found the height to be 14.9 and 13.8 metres, but these values seem to be too low, for at Vedvik, 2 kilometres north of Revik, the height was found to be 15.8 metres, and at Tysketveit close by, also on Vågsoi, it was 16 metres (cf. Fig. 165). At Kalvåg on Froien Island, 10 kilometres south-west of Forde and more seawards, the height was 16.6 metres, and at Steinset on the outer side of the same island it was 17.3 metres.

These heights about 16 and 17 metres and less than 17.7 metres are found inland as far as Rugsund, inside the mouth of Nord Fjord, and about 23 kilometres from the outer coast-line (cf. Fig. 165)[1].

Kaldhol points out that the gradient of elevation is very gentle in this outer region. Even if the height of 13.8 metres at Forde (Bremangerpollen) be used, and heights found farther seawards be considered too high, the gradient will be no more than 0.26 per mille. It seems to me, however, to be much more probable, that the exceptional heights found at Forde and Revik are a little too low. Kaldhol's observations give then practically no gradient of elevation in this coastal zone. *The land has here been elevated about 16 or 17 metres, keeping its horizontal level, or at least without any appreciable tilting.*

It is striking what a perfect accordance there is between the height of this horizontal upheaval and the height of the strandflat in the outer part of Sogne Fjord and in the coastal region outside, which I also found to be about 16 and 17 metres. It is hardly probable that such a coincidence is merely accidental.

This seems in an unexpected manner to prove the correctness of our assumption that this level of the strandflat represents the level which the shore-line had in this region before the last glacial period and before the last submergence of the land.

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[1] If the observations of 28.9 and 23.9 m. at Sandvik and Hammersvik, in the inner portion of the Stat Peninsula, be correct, the border with the upper shore-line at heights less than 17.7 m. may be somewhat narrower in that region.

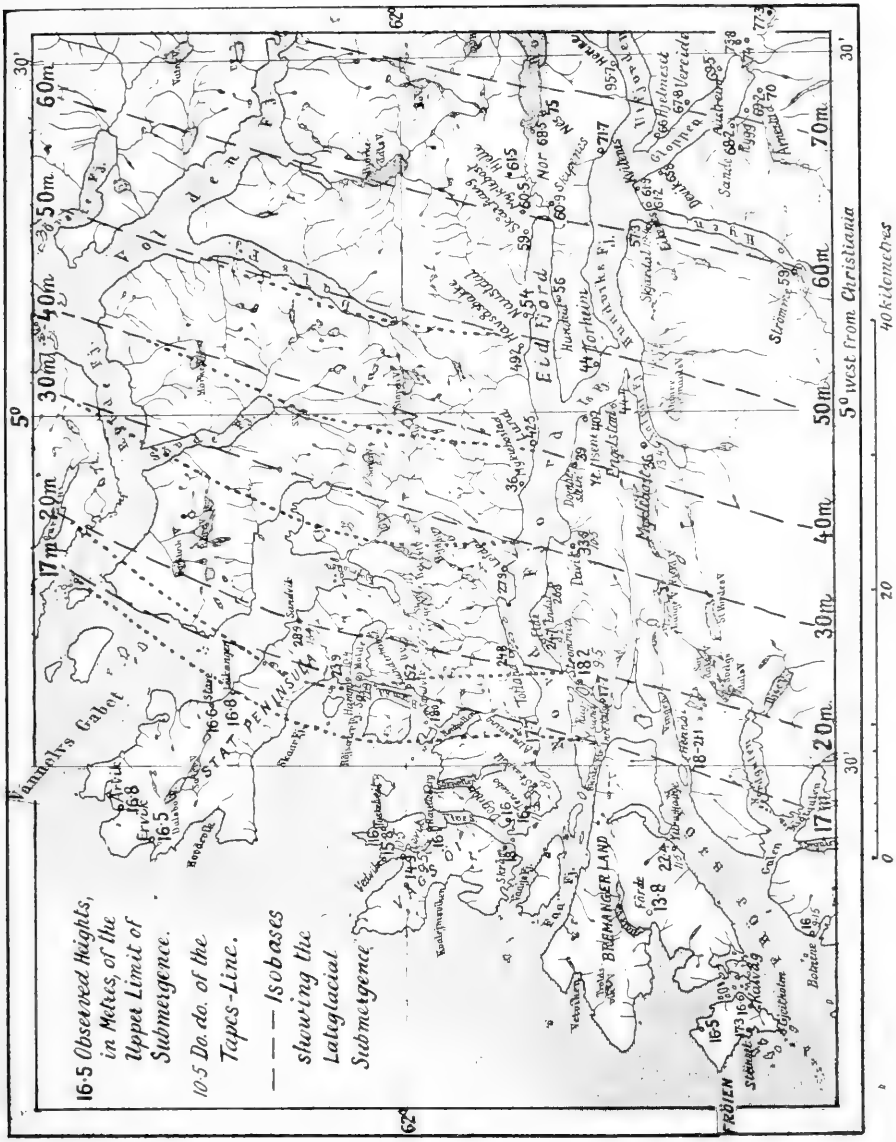


Fig. 165. Map of the Region of Stat, Bremanger, and outer part of Nord Fjord, showing Kaldhol's heights of the upper Limit of Lateglacial Submergence. If the values for the upper limit of submergence found at Sandvik on Stat Peninsula (28.9 m.) and at Hammersvik (23.9) and Salt (22.9), about 6 kilometres to the south-west are correct, the isobaths may have to be drawn along the dotted lines.

The land has consequently not been depressed during the last glacial period in this coastal zone, 25 kilometres broad, in the region of Nord Fjord, Bremanger, and Stat, although there has been a postglacial change of 16 to 17 metres in the level of the shore-line. The depression has only occurred in the region inside Rugsund, whence the upper limit of submergence suddenly begins to rise inland, as is clearly demonstrated by Kaldhol's profile.

The gradient of elevation is 1.20 per mille between Rugsund (Strømmen, height = 18.2 metres) and Eikenes in Hyen Fjord (height = 61.2 metres), a distance of about 35.7 kilometres if measured at right angles to the direction of the isobases (if we take Strommen in Hyen Fjord, height 59 metres, the distance is 33 kilometres and the gradient 1.24, cf. Fig. 165) — while it is on the average 2.00 per mille in the inner 32 kilometres of the fjord, between Hyen Fjord (Eikenes) and Indvik in Indvik Fjord (height = 125.3 metres), provided that Kaldhol's determinations of the upper limit are correct in this region. They give gradients which vary much in value. Between Lote (71.7 metres, see Fig. 165) and Henne (95.7 metres, see Fig. 165), a distance of 6.7 kilometres, his values give a gradient even of 3.6 per mille. It seems to me to be probable that the highest terraces, found by Kaldhol in this region of the fjord, are not marine.

We may, however, expect some irregularities here, as the region of Nord Fjord is perhaps the most prominent centre of seismic activity along the Norwegian coast [cf. Kolderup, 1914, map p. 111].

In the innermost region of Nord Fjord, inside Indvik, in Stryn, Olden, and Loen, Kaldhol's measurements of the heights of the highest terraces give suddenly much lower values than in the region west of Indvik. The explanation may be either that the formation of terraces was prevented by glaciers filling the valleys and innermost parts of the fjords during the time of the deepest submergence of the land, or, as suggested by Kaldhol, that a later advance of the glaciers has destroyed the highest terraces in that region.

Kaldhol's detailed investigations of the lateglacial and postglacial terraces in the region of Nord Fjord give most valuable information about the submergence and emergence of the land during this period, and his height measurements support, as we have seen above, the correctness of my view of the relation between the horizontal level of the strandflat — indicating the level of the shore-line before the last great submergence — and the tilted planes of the raised terraces and beaches — indicating the submergence and the upheaval of the land.

There is unfortunately no other region of our coast, which has been subjected to similarly detailed investigations, as far as I am aware, at least not in the outer coastal region. But several scattered observations in various localities indicate that along those parts of the outer coast, where the upper limit of submergence lies no higher than the strandflat, more detailed investigations would probably demonstrate a horizontal upheaval of the outer coastal region, and a tilted upheaval of the land inside, in quite a similar manner as we have found in the region of Nord Fjord.

Gradient of the Lateglacial and Postglaciel Upheaval of the West and North Coast of Fenno-Scandia.

A general impression of the postglacial upheaval of the land may be obtained by comparing the gradients of this upheaval in the different regions of the coast of Norway and of the Kola Peninsula as given in the following table. The values of the gradients are computed from the heights of the highest terraces and raised beaches which are supposed to indicate the upper limit of lateglacial submergence. The heights were measured by the authors given in the last column. The heights of the lower level of the strandflat have not been deducted from the figures used for the computation of these values.

In several regions it is difficult to decide which raised terraces and beaches actually indicate the upper limit of lateglacial submergence. In the outer coastal regions of Finmark Tanner [1906, 1907] has found raised shore-lines and terraces situated considerably higher than those which have been used for the computation of the gradients in our table. Similar higher shore-lines have also been found at several levels by Grønlie [1914] in the Tromsø distrikt and by W. Ramsay [1898] on the Kola Peninsula. These shore-lines, however, are less distinct than the lower shore-lines and have a much older appearance. They do not seem to correspond to the shore-lines which are supposed to mark the upper marine limit (the upper limit of lateglacial submergence) further south in Norway, and it is difficult to understand that they can have been formed during the last glacial period. They may more probably be survivals from a previous period of submergence, as is assumed by Ramsay and Grønlie.

For my computations I have therefore used the heights of the shore-lines and terraces belonging to the level which Tanner calls *Iε*, as this level seems to correspond to the upper level of the two conspicuous raised shore-lines of the Tromsø—Hammerfest region and Vesterålen, and to the generally accepted upper limit of the lateglacial submergence farther south in Norway.

These gradients given in the table differ so much locally that one might doubt their correctness; but on the whole there seems to be a certain system in their variations. If they be introduced in a map of the Norwegian coast where the submerged continental shelf is also outlined [cf.

Locality	Gradient of Elevation in *per mille*	Observer
Northern Österdal	0.7 - 1.6	G. Holmsen [1917]
Christiania Fjord	ca. 0.7	Øyen
Coast between Larvik and Christiansand	0.68	Danielsen [1912]
Hardanger Fjord, outer part	ca. 0.78	Rekstad [1906]
— — central part	0.68	— —
— — Halsenoi to Rosendal	0.94	— —
Sogne Fjord, between Vik and Vadheim	1.0	— [1910]
Sond Fjord, outer part	1.0	— [1906]
— inner part	0.9	— —
Nord Fjord, coastal zone 25 km.	0.0	Kaldhol [1912]
— middle 36 kilometres	1.2	— —
— inner 32 —	2.0 (?)	— —
Sondmor, Hardeidland	1.2	Rekstad [1905]
Coastal region northeast of Ålesund	1.1	— [1906]
Nordmor, Reinsvik (Christiansund) to Tingvoll	1.48	Kaldhol [1913]
— Reinsvik—Vågbo (Halsa Fjord)	2.00	— —
— Reinsvik—Bruset (Todal)	1.32	— —
— Tingvoll—Bruset	1.23	— —
— Henden (Arisvik Fjord)—Valsoibotten	1.87	— —
Southern Helgeland, average	0.73	Rekstad [Vogt 1900]
— — region of Donna	0.67	— [1904]
Dunderland Valley to Træna	0.91	— [Vogt 1907]
Mainland to Lofoten	0.76	J. H. L. Vogt [1907]
Ofoten to Kvæ Fjord	0.71	Vogt [Rekstad 1905]
Region between Andoi and Senjen	0.90	Helland [1900] [1]
Region of Senjen	1.22	— —
— between Senjen and Ringvasoi	0.85	— —
— — Ringvasoi and Skjervoi	0.90	— —
Fjord south of Hammerfest	0.67	R. Chambers [1850]
Porsanger Fjord	0.60	Tanner [1907]
Lakse Fjord	0.48	— —
Tana Fjord	0.58	— [1906]
Varanger Peninsula	0.51	— —
Region south of Varanger Fjord	0.60	— — [2]
Region of Ribachi (Fisker) Peninsula	0.53	Ramsay [1898]
— » Kildin	0.65	— —
— » Woronye River, Kola Penins.	0.72	— —
Southeastern coast of Kola Penins.	0.32	— —

[1] O. T. Gronlie gives in his text [1914, p. 224] values (between 1.35 and 1.77 per mille) of these gradients for the region between Andoi and Skjervoi, which are much higher than those computed from Helland's observations; but as far as I can see Gronlie must have made some strange mistakes in his distances. His map of the isobases gives much the same gradients as Helland's observations.

[2] As will be mentioned later (p. 263) it seems to me that Tanner has probably mistaken his level *Iε* in this region, and I have used his highest terraces for the computation of the gradient.

Nansen, 1904, Pl. XI], it is seen that, as a rule, the steepest gradients occur in those regions where the edge of the continental shelf is nearest to the outer coast of the land, *e. g.* in the region of Senjen and along the coast from Nordmor to Nord Fjord (cf. Fig. 166). In Sond Fjord it is also steep (1.0 per mille) although this region is farther away from the edge of the continental shelf. But here the deep outer part of the submeged Norwegian channel is very near the outer coast, while this channel is shallower outside the region of Hardanger Fjord where the gradient is less steep (0.7—0.8 per mille).

The lowest gradients occur along the south-east coast of Norway (0.68 per mille), in Helgeland (0.67—0.73 per mille), in the region from Hammerfest to the Varanger Peninsula (0.48—0.60 per mille), and on the Kola Peninsula. These regions are farthest away from the outer edge of the submerged continental shelf.

It is also noteworthy that the gradient seems to increase somewhat towards regions where there are deep submerged fjords on the continental shelf outside the coast, *e. g.* outside Træna [cf. Nansen, 1904, Pl. XI], where the gradient was found to be 0.9 per mille, while it was 0.67 and 0.73 per mille[1] in the region of Donna and Vega to the south, where the shelf outside is broader and less dissected.

As A. G. Hogbom has pointed out to me in a letter, the investigations of several geologists obviously show that there may be appreciable local variations in the upheaval of the land.

By careful levelling of a very distinct raised beach (from the Tapes period), formed of boulders, along the coast of Lake Venern in Sweden, R. Sandegren [1916] has found that along a distance of about 11 kilometres, from the region of Kleven (height 65.2 metres above the sea) to the region north of Otterbäcken (70 metres above the sea), the gradient of upheaval is 0.44 per mille, and along the next 19.5 kilometres to the NNE, between the region north of Otterbäcken to the region east of Vall in Visnum (height 92.1 metres above the sea), the gradient is 1.13 per mille. Hence, in the latter region, the land has been elevated about 13.5 metres more than it would have been, if the gradient of upheaval had been uniformly 0.44 per mille along the whole distance of 30.5 kilometres.

By his measurements of the levels of the ancient beaches left by the ice-dammed lakes in Northern Österdal, Gunnar Holmsen [1915, 1916, 1917] has found that the gabbro mountains may have had an influence upon the postglacial upheaval of the land which has taken place in this region. The isobases are deflected by, and go round, the intrusive masses of gabbro, and it looks as if the latter have risen somewhat more than the surrounding regions, and the gradient in these regions may thus locally be increased from 0.70 per mille to between 0.85 and 1.63 per mille.

[1] J. H. L. Vogt [1907, p. 30], however, remarks that according to later investigations by A. Hoel, these values are probable somewhat too low.

Gunnar Holmsen points out that A. Helland's measurements of the raised shore-lines [1900] in the Tromsø district indicate a similar local difference in the postglacial upheaval near intrusive masses of gabbro, especially conspicuous in the region of the Lyngen Peninsula. Grønlie [1918] also maintains that there has been appreciable local differences in the upheaval of the land in the Tromsø district.

It was previously mentioned that Kaldhol's measurements of the heights of the "upper marine limit" in the region of Nord Fjord seem to indicate considerable local variations in the upheaval of the land, the gradient varying even as much as from 1.2 to 3.6 per mille. His investigations in Nordmør [1916] give similar results. As was previously pointed out, however, the difficulty with these determinations of the "upper marine limit" is *first*, that to a great extent they are based on terraces of loose material which do not give the exact level of the shore-line; *secondly*, they are made in fjords, where ice-dammed lakes may easily have been formed during lateglacial time, and the terraces may thus have been formed at levels much higher than the sea. It is therefore of importance to have it proved that the terraces actually are marine. As the same terrace cannot be continuously followed from one fjord to another, it is often difficult to decide the identity of the terraces.

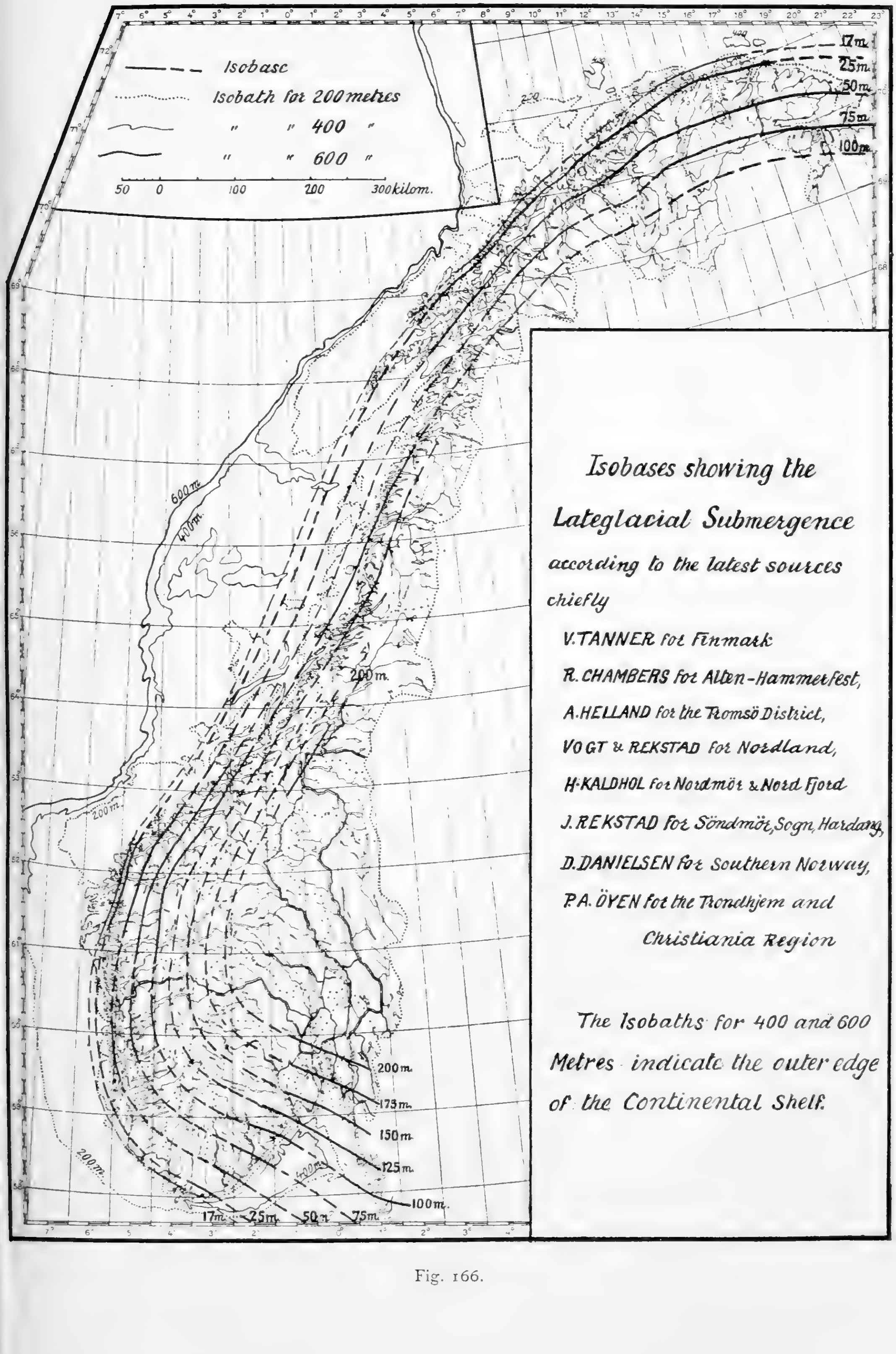
Although these numerous observations by Kaldhol and others in the fjords may, therefore, have to be carefully sifted, before conclusions of wide bearing are drawn from them, still it is hardly doubtful that, on the whole, they prove the probability of appreciable local differences in the upheaval of the land, and that the gradient of upheaval may change appreciably inside distances of no more than 10 to 20 kilometres.

The investigations of the Swedish geologists also indicate similar local differences in the upheaval of the land in Sweden.

Munthe's and Sundelin's map [Sundelin 1919, Pl. X] of the raised shore-line of the Ancylus Lake along the east coast of Sweden, in Östergötland and Småland, shows that the gradient of the upheaval of this shore-line varies a great deal inside the region of the map. Inside a distance of about 90 kilometres the gradient may increase from 0.24 per mille in the region of Västervik and Oscarshamn, to about 0.50 per mille in the region of Söderköping, Norrköping, and Linköping. The gradient of the upheaval of the Littorina shore-line seems to differ even still more locally in this region.

Similar local variations of the gradient of upheaval have been found at a good many places in Sweden, by the measurements of the heights of the "upper marine limit", as well as of the shore-lines of ice-dammed lakes.

The isobases drawn in Fig. 166 are not intended to show the possible local variations in the gradient of upheaval of the Norwegian coast. It was rather attempted to give a general idea of the upheaval according to the most trustworthy observations.


Isobase
Isobath for 200 metres
" " 400 "
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50 0 100 200 300 kilom.
17m.
25m.
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75m.
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175m.
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125m.
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17m.
25m.
50m.
75m.
Isobases showing the
Lateglacial Submergence
according to the latest sources
chiefly
V. TANNER for Finmark
R. CHAMBERS for Alten-Hammerfest,
A. HELLAND for the Tromsö District,
VOGT & REKSTAD for Nordland,
H. KALDHOL for Nordmör & Nord Fjord
J. REKSTAD for Söndmör, Sogn, Hardang,
D. DANIELSEN for Southern Norway,
P.A. ÖYEN for the Trondhjem and
Christiania Region
The Isobaths for 400 and 600
Metres indicate the outer edge
of the Continental Shelf.

Fig. 166.

Relation between the Inclinations of the two Conspicuous Raised Shore-Lines of Northern Norway and the Kola Peninsula.

In northern Norway there are two especially conspicuous raised shore-lines, to a great extent cut in solid rock. Amund Helland [1900] pointed out the fact that the planes of inclination of these two levels do not intersect the sea-level along the same line, zero isobase, outside the coast; but in the Tromsø region (Troms Fylke) the hypothetical zero isobase of the lower shore-line lies 8 to 17 kilometres further seawards than that of the upper one.

The two planes of inclination "intersect one another along a line in the air a few metres (on the average 5 metres) above the surface of the sea". This line lies just over the outermost islands and skerries in the Tromsø distrikt.

J. Rekstad states [1905, p. 21] that there is a similar relation between the sloping planes of the corresponding two levels of raised beaches and terraces in Helgeland, and also on the Norwegian west coast (between 60° and 62° N. L.).

Thinking that this peculiar relation between the two shore-lines proves that the postglacial upheaval did not extend so far seawards during its first period, before the time of the lower shore-line, as it did during its later period, Rekstad assumed this to be evidence against the probability of the isostatic nature of the postglacial upheaval of the land, for, he argued, as the load of the ice-sheet was first removed from the border regions of the depressed area, one might expect an isostatic upheaval of the crust to begin in those outer regions and gradually extend landwards, and not the other way.

The inference from our studies of the strandflat and the raised beaches — that there may be distinguished between two movements in the lateglacial and postglacial upheaval, a vertical change of the horizontal level of the shore-line as indicated by the strandflat, and a tilted elevation of the land as indicated by the raised beaches — gives a simple explanation of the above mentioned relation between the tilted planes of the two shore-lines.

Let us here, in order to simplify matters, assume for a moment that the former movement be due to a postglacial sinking of the sea-level, while the latter tilting movement is due to an upheaval of the depressed land. Let us then take as an example a special case, *e. g.* Helland's measurements of the heights of the two raised shore-lines at Helgøi (70° 7′ N. Lat.) and at Havnnes (69° 47′ N. Lat.) in Lyngen Fjord in the northern Tromsø district.

The heights of the two shore-lines were found to be 17 and 8 metres on Helgøi and 60.9 and 22.8 metres at Havnnes. Let us assume that 17 metres is the height of the lower level of the strandflat in this region,

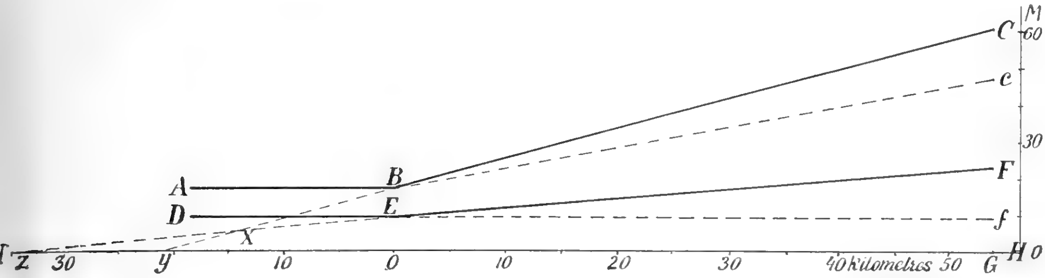

Fig. 167. Diagram illustrating the upheaval of the shore-lines between Helgoi (*O*) and Havnnes (*G*).

i. e. is the height of the lateglacial and postglacial relative sinking of the sea-level. At Mikkelvik on Ringvasoi, about 15 kilometres south-west of Helgoi, or very nearly in the direction of the isobases in this region, Helland found a raised shore-line at 10.7 metres above sea-level, which is obviously the same as his lower shore-line on Helgoi, 8 metres above sea-level. Let us therefore take the mean between the two and make the height of the lower shore-line in this region 9.3 metres. Let us furthermore assume that the distance between the isobases drawn through Helgoi and Havnnes is about 54 kilometres.

According to our assumption there has been no postglacial tilted upheaval of the land on Helgoi (Fig. 167, *O*), the upper raised shore-line standing at the level of the strandflat; there has only been a sinking of the sea-level. During the first period of upheaval, before the time when the lower shore-line was formed, the upper shore-line rose to the line *Bc*. The sea-level had then sunk 7.7 metres to the line *DEf*, along which the lower shore-line was eroded. During the last period of upheaval the upper shore-line rose to the line *BC*, the lower shore-line to *EF*, and the sea sank to its present-day level *HH*.

The result of these movements is that we now find the upper raised beach along *ABC*, the lower raised beach along *DEF*, and the present sea-level at *HH*.

If we continue the tilted lines *BC* and *EF*, they intersect one another at *x*, 6 metres above present sea-level. The plane of the upper shore-line will intersect the present sea-level at *y*, about 13 kilometres inside that of the lower shore-line (*z*).

Fig. 167 is naturally a simplified diagram. In reality there will probably be a more gradual transition from the horizontal outer parts *AB* and *DE* to the rising planes inside, *BC* and *EF*.

These results are in perfect accordance with Helland's computations mentioned above, and the explanation of the facts here given may be considered to be fully satisfactory.

On the other hand, the facts described above seem to support the probability that we are right in assuming that the lower level of the strandflat (about 15 to 17 metres above the sea) actually marks the level of the shore-line before the subsidence of the land during the last glacial period.

Tanner's investigations [1906, 1907] of the raised shore-lines in Finmark show a relation between inclinations of the planes of the two shore-lines which he calls *Iε* and *II.1*, quite similar to what Helland has found in the Tromsø district. As will be mentioned later, Tanner's shore-lines *Iε* and *II.1* correspond probably to the two well known shore-lines of the Tromsø district and Alten.

Tanner found [1906, p. 130] that the planes of the two shore-lines intersect one another about 50 kilometres north of Kvitnes (in the mouth of Tana Fjord) and 80 kilometres north of Havningberg (25 kilometres north-west of Vardø), at heights of 8 and 7 metres above sea-level.

The explanation is obviously the same as before. Besides the tilted upheaval of the land, there has also been an elevation of the land in its horizontal position, or a sinking of the sea-level, which has the same effect. And this change of level has probably been of about the same magnitude as in the Tromsø district and in the region of Nord Fjord and Sogne Fjord, or perhaps a trifle higher if we may judge from the height of intersection of the two planes.

In the region, however, of the Varanger Peninsula the plane of the upper shore-line (*Iε*) will intersect the horizontal plane of elevation (the plane of the lower level of the strandflat) far outside the coast. If we assume the height of the latter plane to be 18 metres the distance will be about 25 kilometres north of Kvitnes (in the mouth of Tana Fjord) and 54 kilometres north-north-east of Havningberg. This might seem to indicate that the inland-ice, which pressed the land down, extended far seawards outside the coast in this region.

Ramsay's measurements show a similar relation between the inclinations of the two planes of shore-lines on the Ribachi Peninsula, on Kildin Island, and along the Murmanski Coast, as well as along the south coast of the Kola Peninsula. Along the east coast of this peninsula, however, in the region of the mouth of Ponoi River, there seems to have been no postglacial upheaval of the land.

Fig. 168 gives a profile of the heights of the two shore-lines along a line at right angles to the approximate direction of the isobases in this region according to Ramsay's map [1898, p. 132]. The gradients of both shore-lines decrease outwards in a similar manner as the gradient of Kaldhol's upper limit of submergence decreases seawards in the region of Nord Fjord.

According to recent statements by Ramsay [cf. A. G. Högbom, 1921, p. 137], however, the land at the entrance to the White Sea, should have been so much higher than now during the lateglacial period when the ice-sheet retreated from that region, that the White Sea may have been cut off from the Ocean, and transformed into a fresh-water lake, similar to the Ancylus Sea of the Baltic region. Hence the heights found for the upper limit of submergence along the south coast of the Kola Peninsula may possibly have to be somewhat corrected.

Relation between the Altitudes of the two conspicuous Raised Shore-lines in the Tromsø—Hammerfest Districts.

Let us now study the relation between the heights of the two levels represented by the two conspicuous raised shore-lines in the different regions of northern Norway.

Tanner [1906, 1907] and Grønlie [1914] are probably right in assuming that the upper raised shore-line (of Helland) in the Tromsø and Hammerfest districts corresponds to the level of the Finmark shore-lines which Tanner has called *Iε*.

It seems to me to be probable that this shore-line marks the upper limit of lateglacial submergence in these northern regions. If so, it probably also corresponds to the level of the upper limit of submergence (the upper marine limit) observed in the different parts of southern Norway.

It was previously mentioned (p. 251) that the old raised shore-lines and terraces, found by Ramsay, Tanner, and Grønlie above the level corresponding to Tanner's *Iε*, may probably be survivals from a previous submergence.

The lower raised shore-line in the Tromsø and Hammerfest districts obviously represents the same level as Tanner's line *IIA* in Finmark. There seems to be good reason for accepting Grønlie's and Tanner's assumption that this shore-line corresponds to the so-called Tapes-level in southern Norway. Grønlie therefore calls this shore-line the Tapes-line.

Probably owing to the mildness of the Tapes climate, which has not favoured the shore erosion by frost, this level is not marked by shore-lines cut in solid rock south of the Tromsø district (68th parallel), but as a rule merely by marine terraces and wave-built shore ridges, which are less reliable marks of the actual level of the shore-line existing at the time of their formation. The surface of a terrace may have been somewhat lower than the sea-level, and a wave-built ridge may have been thrown up above high-tide level during storms.

According to the figures given above, the height of the lower raised shore-line (the Tapes level) is 37.4 per cent of the height of the upper raised shore-line (the upper limit of submergence) at Havnnes, while this percentage is 54.7 on Helgøi if the height of the Tapes-line be 9.3 metres. According to what has been said above, it is obvious that this percentage should decrease with increasing height of the upper limit of submergence, and it is therefore useless to try to find a fixed figure of percentage which would suit all cases.

Provided that the upheaval of the land has increased regularly inland, and provided that the relation between the inclinations of the two planes of the shore-lines has been similar to what is represented in Fig. 167, then we should be able to compute the probable height of the Tapes level at any place where we know the upper limit of submergence.

Between Helgoi and Havnnes (Fig. 167) the upper limit of submergence rose 43.9 metres (from 17 metres to 60.9 metres), while the Tapes-line rose 13.5 metres (from 9.3 metres to 22.8 metres). Hence, for every metre which the upper limit of submergence rises landwards the Tapes-line will rise 0.308 metre. If x be the height above the sea of the point, where the planes of the upper limit of submergence and of the Tapes-line intersect one another, and H be the height of the upper limit of submergence above sea-level, the height h of the Tapes-line will be:

$$h = (H - x) \times 0.308 + x$$

According to the above values of H and h on Helgoi and at Havnnes x is = 5.87 metres. Hence:

$$h = (H - 5.87) \times 0.308 + 5.87$$

$$h = H \times 0.3 + 4 \qquad (1)$$

By taking the mean of Helland's measurements of both shore-lines at six places where the height of the upper shore-line was between 57 and 62.7 metres and at seven places where it was between 28.7 and 38.4 metres we find the formula to be:

$$h = H \times 0.315 + 3.4 \qquad (2)$$

The values computed by this formula does not differ much from those computed by the former formula.

In order to test the correctness of our formula let us take some reliable observations of the upper marine limit and the Tapes-level in a region as far away from the Tromso district as the Christiania valley.

At Skådalen Station, on the Holmenkollen tramway, near Christiania, P. A. Öyen has found the upper limit of submergence at a height of 220.8 metres above sea-level. At Ullern, west of Christiania, he found the Tapes-level at a height of 69.5 metres. The distance between Skådalen and Ullern is about 4 kilometres at right angles to the probable direction of the isobases in this region. If we assume the gradient of elevation to be about 0.7 per mille, the height of the upper limit of submergence at Ullern should consequently be 218 metres. Hence the height of the Tapes-level at Ullern should be:

$$h = 218 \times 0.3 + 4 = 69.4 \text{ metres}$$

or

$$h = 218 \times 0.315 + 3.4 = 71.3 \text{ metres.}$$

This agrees well with Öyen's value, 69.5 metres, especially considering that our formula is based only on some few observations by Helland in the Tromso district.

Locality		N. Lat.	Height in Metres of: Upper Shore-line	Lower Shore-line observed	Lower Shore-line computed	Difference
Hammerfest Island	Molstrand	70° 36′	32.4	13.3	13.6	—0.3
	Sjåholmen	70° 33′	34.9	13.7	14.4	0.7
South of Hammerf.	Kvalsund	70° 30′	41.8 [1]	16.2	16.7	—0.5
Vargsund south of Hammerfest	Kvænklubben	70° 28′	46.0	17.4	18.2	—0.8
	Mainland opposite Storbekk Fjord ...	70° 20′	49.1	19.5	18.9	+0.6
Region outside Lyngen Fjord and Ulfs Fjord	Helgoi—Mikkelvik...	70° 6′	17.0	9.3	8.8	+0.5
	Kvitnes, Vannoi	70° 6′	28.7	11.0	12.4	—1.4
	Lanesøren, Vannoi ..	70° 3′	29.4	11.1	12.7	—1.6
	Karlsoi	70° 1′	32.1	15.0	13.5	+1.5
	Reinsvoll, Reinoi ...	69° 58′	33.5	15.5	13.9	+1.6
	Skjervoi	70° 3′	41.7	18.0	16.5	+1.5
	Finkroken, Reinoi ...	69° 51′	38.1	14.5	15.4	—0.9
	Glimma, Ringvaroi ..	69° 49′	37.2	14.4	15.1	—0.7
Near Tromso	Movik	69° 43′	42.6	17.8	16.8	+1.0
	Kalsletta, Bals Fjord..	69° 37′	41.6	19.3	16.5	+2.8
Lyngen Fjord	Havnnes	69° 47′	60.9	22.8	22.6	+0.2
	Rotsund	69° 46′	59.7	23.4	22.2	+1.2
Ulfs Bjord	Ulsnes	69° 42′	57.0	19.6	21.4	—1.8
Malangen Fjord	Greipstad	69° 31′	38.4	14.5	15.5	—1.0
	Ansnes	69° 30′	42.8	17.2	16.9	+0.3
Inside Senjen	Bukskind, Gi-sund	69° 22′	48.6	18.8	18.7	+0.1
South of Senjen	Bjørnerå, Grytoi	68° 53′	43.8	16.8	17.2	—0.4
	Lundesnes »	68° 53′	44.4	18.3	17.4	+0.9
	Kjeoi, Vågsfjord	68° 51′	46.5	17.1	18.0	—0.9
	Vinje	69° 1′	60.8	21.6	22.6	—1.0
	Andervåg, Andorja ..	68° 55′	61.4	22.2	22.7	—0.5
	Anstad, Andorja	68° 49′	62.7	22.7	23.2	—0.5
						0.0

[1] Shore terrace of loose material.

The table above gives the measurements of the altitudes of the upper and lower raised shore-lines measured by Chambers in the region between Hammerfest and Alten (the five first stations), by A. Helland at eighteen places in the Tromso district (Troms Fylke), and by K. Pettersen at four places (Movik, Greipstad, Ansnes, and Bukskind) near Tromsø. The values of the height of the lower shore-line (the Tapes-line) computed by the formula (2) above from the altitude of the upper shore-line, are given in the sixth column of the table.

The differences between the computed values and the observed ones are in most cases less than a metre, and no greater than what might be expected to be within the limits of observational error. Even in the case of shore-ledges cut in solid rock as here, it may often be difficult to decide where exactly the actual level is.

If, however, the differences be marked on a map, it looks as if there may be certain areas where the heights of the Tapes-line are slightly lower than the computed values, *e. g.* between Kvitnes and Glimma, and in the region of Vinje, Anstad, Bjornerá, while especially in the region inside a line Skjervoi, Karlsoi, Reinsvoll, Movik, and Kalsletta the heights are 0.2 to 1.6 metres higher than the computed values, and in one case. Kalsletta, as much as 2.8 metres (if this measurement be correct). This may indicate that there has been some irregular warping of the land during the first period of upheaval before the Tapes period, by which the areas with too low heights of the Tapes-line were elevated relatively more than those with too high values.

According to what was previously said about the local variations of the gradient of upheaval it seems probable that there should be such irregularities in the relation between the heights of the upper limit of submergence and those of the Tapes-line. It might rather seem surprising that the departures are not greater.

Ole F. Gronlie has measured the heights of shore-lines and terraces in the Tromso district and further south, but unfortunately he only gives [1914, p. 226] the heights of the Tapes-line, and its percentage of the height of the upper shore-line (his *M*-line). If we compute the heights of the upper shore-line from his figures, we obtain, however, values which show great irregularity in their relation to the height of the Tapes-line, and differ in this respect very strikingly from Helland's values. It seems probable that this is due to inaccuracy of some kind, either in Gronlie's measurements or in the figures given in his paper.

Relation between the Altitudes of Tanner's Shore-lines *Iε* and *IIA* in Finmark.

In Finmark Tanner [1906, 1907] has found a great many raised beaches. It was mentioned before that his shore-line *Iε* probably corresponds to Helland's upper shore-line in the Tromso district and in the Hammerfest—Alten region, while Tanner's line *IIA* corresponds to the lower shore-line or Tapes-line in the Tromso and Hammerfest region.

It is not always easy, however, to decide which is his line *Iε* among the different shore-lines observed at the various places.

On the other hand it has to be considered that, to a large extent, Tanner's shore-lines are not cut in solid rock, but are marked by wave-eroded terraces of loose material, or by wave-built shore-ridges of pebbles and boulders. The one may easily give too low values, and the other too high, as compared with the heights of shore-ledges cut by frost in solid rock. We cannot therefore expect such a degree of regularity in the relation between the two levels of shore-lines as we found in the Tromsø and Hammerfest—Alten region.

If, however, we compute the probable height of the Tapes-line from the heights which Tanner himself gives for his line *Iε*, we find on the whole fairly good agreement with his heights for his line *IIA*, except in the region south of the Varanger Fjord.

As far as I can see, however, Tanner has mistaken his line *Iε* in the region east of Bugofjord. He has there observed three levels of shore-lines, and he has assumed the middle one to be *Iε* and the lower to be *IIA*, but I consider it probable that the uppermost level is his line *Iε*. This would give good agreement with our formula for the relation between *Iε* and *IIA*. It would also give the isobases a more natural shape in this region, without the sudden turn southward which Tanner had to give them on his map [1906, Pl. 5].

Furthermore it would give a gradual incline of the plane of this shore-line from the region south of Varanger Fjord and northwards across the Varanger Peninsula, without any break, as Tanner has on his diagram [1907, Pl. 4, Fig. 1]. Hence there will be no necessity to assume that there has been a postglacial dislocation along Varanger Fjord, as Tanner suggests in order to explain the break in the inclination of the line.

It might be objected that Tanner has also found three conspicuous levels of shore-lines at several places in the inner part of Varanger Fjord, *e. g.* at Nyelv, Veinesbukt, Adelsberg, and Nesseby, and there the middle shore-line is obviously *Iε*. It has, however, to be noticed that at most of these places, more than three shore-lines have been observed, and there is one below *Iε* which might well correspond to the middle shore-line in the region to the south-east.

Although it may be a mere accident, I may just mention that these three shore-lines in the region south of Varanger Fjord have a certain similarity to the three shore-lines Kaldhol has observed in Nord Fjord, which he calls the upper marine limit, the epiglacial shore-line, and the Tapes-line.

With the corrections mentioned above, Tanner's heights (in metres) of his shore-lines *Iε* and *IIA*, have been introduced in the following table. The probable heights of the Tapes-line computed by our formula (2) from the heights of his line *Iε*, are given in the fourth column, and the difference between these and the observed heights are given in the fifth column. (*s, s*) added to the name of the place in the first column indicates that both shore-lines are marked by shore-ledges cut in solid rock, and (*t, t*) that they are marked by terraces of loose material or are ledges cut in moraine material. (*t, s*) or (*s, t*) indicate that the upper shore-line is marked by terraces of loose material, and the lower line by shore-ledges cut in solid rock or *vice versa*. (*p*) indicates that they are marked by

Tanner's Shore-lines Iε and IIA.

Locality	Height in Metres of			Difference
	Shore-line *Iε*	Shore-line *IIA* or Tapes-line observed	Shore-line *IIA* or Tapes-line computed	
Porsanger Fjord.				
Iggildas (*t, t*)	65.3 (*l*)	24 (*l*)	24	0.0
Banines (*t, p*)	ca. 65	< 25	23.8	< + 1.2
Annika (*t, t*)	63 (*l*)	23.5 (*l*)	23.2	+ 0.3
Anopset (*t, p*)	62.3 (*l*)	<23.6 (*l*)	23	< + 0.6
Bille Fjord (*t, p*)	58 (*l*)	23.3—21 (*l*)	21.7	
Skriveroi (*t, t*)	55.5 (*l*)	22 (*l*)	20.9	+ 1.1
Yttre Veinesbukt (*p, p*)	55 (*l*)	22.3—21 (*l*)	20.7	
Russermark (*t, t*)	49 (*l*)	19.5 (*l*)	18.8	+ 0.7
Treviknes, Kistrand (*s, t*)	47 (*l*)	19 (*l*)	18.2	+ 0.8
Sauberget (*s, s*)	45 (*l*)	16.5 (*l*)	17.6	— 1.1
Brennelv (*t, s*)	42 (*l*)	ca. 15 (*l*)	16.6	— 1.6
Skarvberget (*s, s*)	41.2 (*l*)	16.5 (*l*)	16.4	+ 0.1
Inre Sortvik (*s, s*)	38 (*l*)	15 (*l*)	15.4	— 0.4
Irvinyarga (*s, s*)	35	14	14.4	— 0.4
Molvik (*s, s*)	33.5 (*l*)	14.8 (*l*)	14.0	+ 0.8
Repvåg (*s, p*)	33.5 (*l*)	16.2—14.2 (*l*)	14.0	
„ (*s, s*)	30.5 (*l*)	14 (*l*)	13.0	+ 1.0
Honningsvåg, Mageroi (*t, t*)	24 (*l*)	11 (*l*)	11	0.0
				— 0.7
Lakse Fjord.				
Landersfjord (*t, t*)	50 (*l*)	20.5 (*l*)	19.2	+ 1.3
Hammervik (Eikvik) (*p, t*)	47	18.5	18.2	+ 0.3
Lebesby (*t, s*)	ca. 45	18 (*l*)	17.6	+ 0.4
Måroi (*t, s*)	38 (*l*) [1]	15.2 (*l*)	15.4	— 0.2
Kjøllefjord (*s, p*)	ca. 25 (*l*)	15.2—11.6 (*l*)	11.3	
Sværholt (*s, s*)	26.5 (*l*)	11.5—12 (*l*)	11.8	0.0
Mehavn (*t, t*)	19.1 (*l*)	10 (*l*)	9.4	+ 0.6
„ (*s, t*)	21	10	10	0.0
				+ 0.3
Tana Fjord.				
Smalfjord (*s, p*)	55	18	20.7	— 2.7
Benjaminbukt (*s, t*)	50	16—19	19.2	— 1.7
Gavisluoht (*p, t*)	51.5	17	19.6	— 2.6
Lavvo'njarga (*s, s*)	49 (*l*)	16.2 (*l*)	18.8	— 2.6
Vagge (*s, s* & *t*)	51.5—48.5	16—19	19.2	— 1.7
Between Vagge and Stangenes (*s, t*)	48.9 (*l*)	18 (*l*)	18.8	— 0.8
Lille Molvik (*t, t*)	42	15.5	16.6	— 1.1
„ „ (*s, s*)	40	14	16.0	— 2.0
Store Molvik (*s, p*)	33	14.5	13.8	+ 0.7
Kvitnes (*s, t*)	28	12.5	12.2	+ 0.3
				— 1.4

[1] Tanner assumes a terrace he found at 32.1 metres above sea-level to be his line *Iε*, but it seems to me more probable that the broader terrace found at 38 metres is his *Iε*, as it agrees better with his Tapes line (*IIA*).

Tanner's Shore-lines Iε and IIA.

Locality	Height in Metres of			Difference
	Shore-line Iε	Shore-line *IIA* or Tapes-line observed	Shore-line *IIA* or Tapes-line computed	
North coast of the Varanger Peninsula.				
Makur (*s*, *s*)	35.5	15	14.6	+ 0.4
Sylteklubben (*s* & *t*, *t*)	38—39	16—16.5	15.5	+ 0.7
Syltefjord (*p*, *t*)	43—47	17.5—18 (*l*)	17.6	+ 0.2
Nordfjord, Syltefjord (*t*, *t*)	41	18	16.3	+ 1.7
Havningberg (*s*, *s*)	41	17.5	16.3	— 1.2
				+ 0.8
South coast of the Varanger Peninsula.				
Kiberg (*s*, *t* & *p*)	48	18.5—19.5	18.5	+ 0.5
Falkeflauget (*t*, *p*)	50	18.5	19.2	— 0.7
Kvalnes (*s*, *s*)	46	17—19	17.9	+ 0.1
Skålnes (*s*, *t*)	58.5	20	21.4	— 1.4
Krampenes (*s*, *s*)	60 (*l*)	23 (*l*)	22.3	+ 0.7
Store Ekero (?, *s*)	60 (?)	22.5	22.3	+ 0.2
Makkefjell (*s*, *s*)	67.5	23.5	24.7	— 1.2
Paddeby (*t*, *t*)	70	24.5	25.4	— 0.9
Klubben (*t*, *s*)	70	26	25.4	+ 0.6
Per-Larsavik (*s*, *s*)	68.5	27	25.0	+ 2.0
Mortensnes (*s*, *s*)	70.5	26.5	25.6	
Nesseby (*t*, *s*)	70	24.5	25.4	— 0.9
Adelsberg (*s*, *t*)	71	27	25.8	+ 1.2
Meskelv (*t*, *t*)	69	ca. 27	25.1	+ 1.9
				+ 0.2
Southern side of Varanger Fjord.				
Karlbotten (*t*, *t*)	69—73.5	26	25.3—26.5	+ 0.1
Reppen (*t*, *t*)	74.5	25.5	26.7	— 0.8
Veinesbukt (*t*, *t*)	74.5	27.5	26.7	+ 0.8
Nyelv (*t*, *t*)	74.5—79	28	26.7—28.3	+ 0.5
Sopnes, Bugofjord (*t*, *t*)	86.8 (*l*)	31.4 (*l*)	30.8	+ 0.6
Stånga, Neidenfjord (*s*, *t*)	89	30.5	31	— 0.5
Munkvaselv, „ (*t*, *t*)	91	33	32	+ 1.0
Renoi (*t*, *t*)	80	27.5	28.5	— 1.0
Nilsheim (*s*, *t*)	82 (*l*)	31.1 (*l*)	29.2	+ 1.9
Kirkenes (*s*, *t*)	85 (*l*)	30	30	0.0
Sandnes (*t*, *t*)	90.2 (*l*)	34.2 (*l*)	31.8	+ 2.4
Langfjord-Botn (*t*, *t*)	90.5	34	31.9	+ 2.1
Langfjord Lake (*t*, *t*)	92 (*l*)	32.5	32.4	+ 0.1
				+ 0.6

shore-ridges of pebbles. (*l*) after the figures in the second and third columns indicate that the heights are taken by levelling. Otherwise the heights are measured by the aneroid-barometer.

According to this table Tanner's observed heights of the Tapes-line *IIA* in the inner end of Tana Fjord are 0.8 to 2.7 metres lower than the computed heights, while at Store Molvik and Kvitnes, near the mouth of the fjord, the observed heights of the Tapes-line (*IIA*) are slightly higher (+ 0.3 to + 0.7 metre) than the computed heights.

Along the north coast of the Varanger Peninsula the observed heights of the Tapes-line are also comparatively high, and along the north and south side of Varanger Fjord they are partly higher partly lower than the computed values, but on the average slightly higher. In Lakse Fjord and Porsanger Fjord to the west of Tana Fjord the observed heights of the Tapes-line are also on the whole higher than the computed ones, but there is no distinct regularity in the differences.

Provided that the observed heights of the two shore-lines are fairly correct, the distribution of the negative and positive differences in eastern Finmark, as given by Tanner's observations, may indicate — either that, in the region of the inner end of Tana Fjord, the land has risen comparatively less during the later period of emergence, after the Tapes time, than in the region to the east, and also less than in the region of Hammerfest—Alten and Tromso, while especially along the north coast of the Varanger Peninsula and also along the southern side of Varanger Fjord this upheaval may have been comparatively greater — or that the upheaval during the first period of emergence, before the Tapes period, has been comparatively great in the inner part of Tana Fjord, and comparatively small along the north coast of Varanger Peninsula, &c.

As long as we have no reliable investigation and measurements of the strandflat and its levels in this region, it is hardly possible to decide which of these alternatives are most probable. If we could assume that the upheaval of the land is not yet quite completed in the region of inner Tana Fjord, and that there is still left about 2 metres, this might give a simple explanation, although it would not explain that the Tapes-line seems to stand nearly 1 metre too high along the north coast of the land.

The Upper Limit of Lateglacial Submergence and the Tapes Level on the Kola Peninsula.

On the Ribachi Peninsula (Fisker Halvoen), Kildin Island, and the coasts of the Kola Peninsula Wilhelm Ramsay has investigated and measured the heights of several levels of raised beaches [1898]. The highest of these are higher than the shore-line which seems to correspond to the upper shore-line in northern Norway, generally assumed to represent the upper limit of submergence.

Ramsay assumes these higher shore-lines to be of interglacial age, as they have a much older appearance than the lower ones.

The heights of Ramsay's two lower shore-lines corresponding to the Norwegian shore-lines of the upper limit of submergence and the Tapes-level, are given in the following table (in metres). (*l*) added to the figures indicates measurements by levelling, (*a*) by aneroid-barometer. The heights of the Tapes-line computed by our formula (2) are given in the fourth column, and the difference between these values and the observed heights of the Tapes-line are given in the fifth column.

Heights of Shore-lines observed by W. Ramsay.

Locality	Height in Metres of			Difference
	Upper Shore-line	Tapes-line observed	Tapes-line computed	
Waida-Guba, Ribachi Peninsula ...	ca. 55	22	20.8	+ 1.2
Tsip-Navolok, — — ...	ca. 55	21	20.8	+ 0.2
Srednij, Kola Fjord	73—79	28	27.4	+ 0.6
Malaya Goryæla, Kola Fjord	86	32	30.5	+ 1.5
Mys. Bykoff, Kildin Island	51.2	20 (*l*)	19.6	+ 0.4
Mys. Prigonnij, — —	50	ca. 21	10.2	+ 1.8
My Mogilnij, — — N	55	20.8 (*l*)	20.8	0.0
— — — — E	50	20.5	19.2	· 1.3
Teriberka, Murmanski Coast	46	ca. 19 (*a*)	17.9	+ 1.1
Gavrilovo, — —	39 (*l*)	16—17 (*l*)	15.7	+ 0.8
Kekora, — —	38	15.5	15.4	− 0.1
Rynda, — —	39.5	15.5	15.7	— 0.4
Kharlofka, — — (*t*) ...	35 (*l*)	13	14.4	— 1.4
Varsinsk — —	24	11	11.0	0.0
Ponoi, Terski Coast	< 1	0		
Sosnofka — —	15 (*l*)	7 (*l*)	8.1	— 1.1
Pyalitsa — —	25	10—11	11.3	· 0.8
Chavanga — —	>32	15.5 (*l*)	>13.5	
Turya, Gulf of Kandalak	99 (*a*)	34	34.5	− 0.6
				+ 0.3

The observed and the computed values of the height of the Tapes-line agree fairly well, but we find here a somewhat similar distribution of the positive and negative differences. The observed heights of the Tapes-line are relatively a little too high along the north coast of the land, from Ribachi Peninsula to Kekora on the Murmanski Coast, while they are slightly too low along the coast of the eastern and southern part of the Kola Peninsula. The differences are no greater than might be expected to be within the limits of observational error, but, nevertheless, there seems to be a certain system in their geographical distribution.

It was previously mentioned (p. 258) that according to Ramsay the White Sea may probable have been transformed into a fresh-water lake

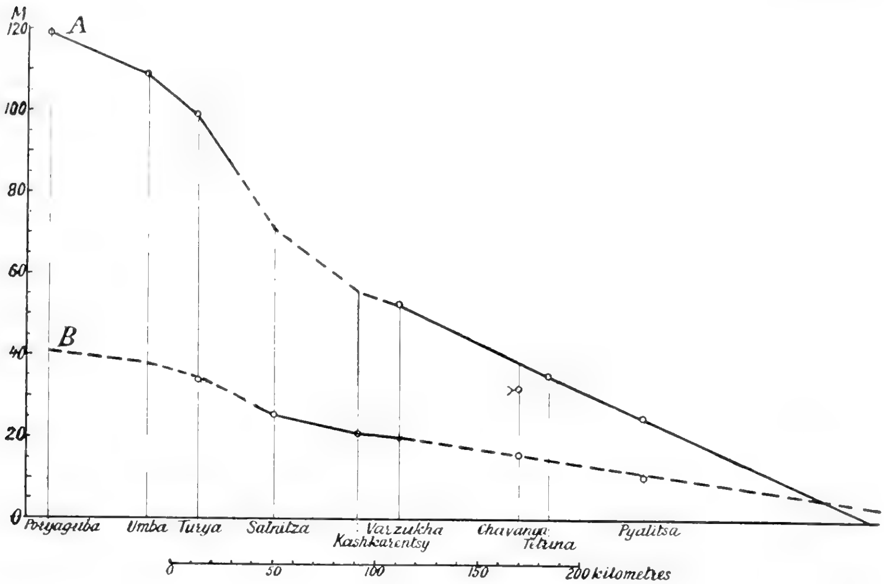

Fig. 168. Curves illustrating the upper limit of lateglacial submergence (*A*) and the Tapes-line *B* along the south coast of the Kola Peninsula. The profile is drawn at right angles to the isobases, according to Ramsay's observations [1898].

during lateglacial time. If so, the observed heights of the upper limit of submergence may have to be somewhat reduced along the south coast of the Kola Peninsula. In that case our computed values of the height of the Tapes-line would also have to be reduced, and the observed heights of this line would not then be too low. It does not, however, seem probable that the observed heights have to be much altered.

In Fig. 168 are given the heights (in metres) of the upper shore-line and the Tapes-line observed by W. Ramsay at several places along the south coast of the Kola Peninsula. The stations are projected on to a profile at right angles to the isobases of this region. The upper curve (*A*) gives the incline of the upper limit of submergence (*i. e.* the upper shore-line) according to Ramsay's observations. The lower curve (*B*) gives the height of the Tapes-line as computed by our formula from Ramsay's values of the upper limit of submergence. This curve *B* agrees remarkably well with the heights of the Tapes level observed by Ramsay and indicated in the figure by rings. At Salnitza and Kashkarentsy the upper shore-line or limit of submergence was not observed, and in the figure is, therefore, given the values computed from the observed heights of the Tapes level at these stations.

We do not know the height of the strandflat in this region, but if we may judge from the relation between the heights of the upper and lower shore-lines in the above table, the upheaval of the land seems to be very nearly completed, and the level of the strandflat, corresponding to the level of the shore-line before the last glacial and postglacial submergence, may be assumed to stand about 17 or 18 metres above present sea-level along the north coast, but perhaps slightly lower along the south coast of the peninsula. It is, however, a remarkable fact that there seems to have been no upheaval at Ponoi on the easternmost coast. If so, we must assume that the level of the strandflat has here been depressed. We may discuss this question later.

The Upper Limit of Submergence and the Tapes Level along the Norwegian Coast south of the Tromsø District.

In Norway south of the region of Ofoten and Vesterålen, there are as a rule no raised shore-lines cut in solid rock, corresponding to the lower shore-line, the Tapes-line, of the Tromso and Hammerfest districts. As was previously mentioned, the explanation is, probably, that, during the warm Tapes period, the climatic conditions in these more southern regions were no longer favourable to the frost erosion of shore-ledges in solid rock. In these regions the Tapes-line is therefore marked by marine terraces only and by shore-ridges built up of loose material.

J. H. L. Vogt, Rekstad, and Hoel have observed two raised shore-lines, cut in rock, in Tysfjord, Helgeland (Vik, Leka), and also near Trondhjem, but the lower of these shore-lines, at any rate, does not correspond to the Tapes-line of northern Norway. The two raised rocky shore-lines observed by Kolderup in the region near Bergen are obviously from a different period.

The table pp. 270 to 272 gives the observed heights (in metres) of the upper limit of lateglacial submergence and of the Tapes-line at several places along the Norwegian coast where the observations might be considered to be fairly reliable. The heights of the Tapes-line computed by our formula (2) from the observed heights of the upper limit of submergence, are given in the fourth column.

On the whole, the observed and the computed heights of the Tapes-line agree fairly well, considering that the observed heights are based on measurements (very often with the aneroid-barometer) of raised terraces of loose material, which may often have been somewhat lower than the level of the actual shore-line when they were formed, while on the other hand shore-ridges (of pebbles) may often have been built up by waves a few metres above the mean level of the shore-line. It is also very often difficult to decide what has been the actual level of the Tapes-line, without finds of fossil shells. And where shells of the Tapes-period are found in the terraces, it may be very difficult to decide exactly at what depths below the sea-surface they have been living, when the terrace was formed.

Nevertheless, it is a striking fact that especially those heights in our table, which are based on the most reliable observations (printed with

Locality Observer	Height in Metres of Upper Limit of Submergence	Tapes-level observed	Tapes-level computed	Difference
Værøi, Lofoten (Keilhau)	ca. 20 (?)	ca. 9.4	9.7	— 0.3
Røst, „ (Helland)	ca. 17 (?)	9	8.7	+ 0.3
Alsvik, Salten (Rekstad)	80.4	> 22.2	28.8	
Breivik, „ „	> 122.5	46	> 42.2	
Moljord „ „	ca. 110	43	ca. 38.2	+ 4.8
Tvervik „ „	ca. 113	43	ca. 39.1	+ 3.9
Storjord „ „	*120*	*42*	41.3	+ 0.7
Skomo, Brønnøi (Rekstad & Vogt) ...	*123*	*42*	42.2	— 0.2
Trondhjem (Öyen)	*201*	*68.5*	66.9	+ 1.6
Guldalen „	*198*	*64—67*	65.9	— 0.4
Christiania Valley, Ullern (Öyen)	*218*	*69.5*	71.3	— 1.8
„ „ Skaugumsås „	ca. *212*	*66—67*	69.4	— 1.4
Ås (Öyen)	ca. *200*	*68*	66.5	+ 1.5
Nordmør.				
Hjelledal, Årvåg Fjord (Kaldhol) ..	130.7	45.3	44.4	+ 0.9
Rodal, Vinje Fjord „ ..	118.8 [1]	41.4	40.9	+ 0.5
Valsøibotten, Valsøi Fjord „ ..	134.5 [2]	*46.5*	45.9	+ 0.6
Henden, Arisvik Fjord „ ..	*111.5*	*39.3*	38.6	+ 0.7
Torhjul, Halse Fjord „ ..	114.5 [3]	37.7 (?)	39.5	— 1.8
Vagbø, „ „ „ ..	134 (?)	44 (?)	45.8	— 1.8
Bruset-Talgo, Todalen „ ..	> 148.6	*50—51*	50.3	+ 0.2
Ulvund, Ulvund Fjord „ ..	132.6 [4]	45.4	45.1	+ 0.3
Gjøvikli, „ „ „ ..	123	39.0 (?)	42.3	— 3.3
Tingvoll, Tingvoll Fjord „ ..	*111*	*35—42*	38.4	— 0.1
Reinsvik—Frei (near Christiansund)	77	26.8—31.1	27.7	+ 1.1
Visnes, Kornstad Fjord (Kaldhol)	*55—56*	22	21.0	+ 1.0

[1] Kaldhol [1916, p. 9] found a higher terrace at 147 metres, which marks the upper limit of submergence according to his opinion. It seems to me improbable that the submergence has been as great as this in this region, and I doubt therefore, the marine origin of the highest terrace.

[2] Kaldhol [1916, p. 10] thinks that this terrace may probably represent what he calls the epiglacial level, and that the upper limit of submergence is a little higher; but this seems to me to be doubtful.

[3] Kaldhol [1916, p. 12] found a small terrace at 122.5 metres which he considers to mark the upper limit of obmergence; but this seems to be too high. The terrace may possibly have been formed on land.

[4] Kaldhol thinks that a higher terrace, attaining a height of 170.3 metres above the sea, marks the upper limit of submergence; but Rekstad considers this terrace to have been formed on land.

Locality	Observer	Height in Metres of Upper Limit of Submergence	Height in Metres of Tapes-level observed	Height in Metres of Tapes-level computed	Difference
Sondmor.					
Ulsteinvik, Hareid	(Rekstad)	35	15	14.4	+ 0.6
Valderhaug, Valderoi	„	*43.6*	*15.3*	17.1	— 1.8
Gjosundseter, „	„	43.5	15	17.1	— 2.1
Roald, Vigra	„	37.8	12.5	15.3	— 2.8
Östnes, Haram	„	39.1	12.6	15.7	— 3.1
Longvad, Flemsoi	„	41.3	13	16.1	— 3.1
Slogstad, Stranden Storfjord	(Kaldhol)	70.9 (?)	24.0	25.4	— 1.4
Stave, Stat	(Kaldhol) . . .	*16.6*	*7.2*	8.6	— 1.4
Leikanger, Stat	„ . . .	*16.8*	*7.1*	8.7	— 1.6
Sandvik, „	„ . . .	28.9 [1]	13.4	12.5	+ 0.9
Hammersvik, Selje	„ . . .	*23.9* [1]	*10.4*	10.8	— 0.4
Vedvik, Vågsoi	„ . . .	15.8	10.5 (?)	8.4	+ 2.1
Revik, „	„ . . .	14.9 (?)	9—10	8.1	+ 1.4
Skavpoll	„ . . .	ca. 16	*8*	8.4	— 0.4
Gjeitholmen, Froien	„ . . .	*17*	*9*	8.8	+ 0.2
Botnene, Froi Fjord	„ . . .	*16*	*9.2*	8.4	+ 0.8
Strommen, Rugsund	„ . . .	*18.2*	*9.5*	9.1	+ 0.4
Elde, Nord Fjord	„ . . .	ca. 22	*9.2*	10.3	— 1.1
Myklebust, Alfot Fjord	„ . . .	36.0	13.4	14.7	— 1.3
Skjærdal, Hyen Fjord	„ . . .	57.3	19.4	21.4	— 2.0
Langeland, Eid Fjord	„ . . .	ca. 61	21.5	22.6	— 1.1
Sond Fjord.					
Hauka, Nordal Fjord	(Rekstad) . . .	28	10.5	12.2	— 1.7
Sandvik, Eike Fjord	„ . . .	29.5	10.3	12.7	— 2.4
Sogne Fjord.					
Vik, Sogne Fjord	(Rekstad)	*115.5*	*40*	39.8	+ 0.2
Tune, Ortnevik	„	*87.2*	*29.7*	29.9	— 0.1
Vadeim	„	*77.4*	*27*	27.8	— 0.8
Sondhordland.					
Åkre, Åkre Fjord	(Rekstad)	100	31	34.9	— 3.9
Halsenoi, Hardanger	„	*75.9*	24	27.3	— 3.3

[1] As the map Fig. 164 shows these heights are considerably higher than the upper limit of submergence found by Kaldhol at other places in the same neighbourhood, and if these values be correct, they will give the isobases a very crooked course in this region, but as the above figures show, the observed heights of the supposed Tapes line agree fairly well with the heights computed from the observed heights of the upper limit of submergence.

Locality Observer	Height in Metres of			Difference
	Upper Limit of Submergence	Tapes-level observed	Tapes-level computed	
Randeberg, near Stavanger (Bjorlykke, Danielsen)	22.5	10.6	10.5	0.1
Viste-Kvernviken, near Stavanger (Öyen, Danielsen)	20 34(?)	13.4		
Malletuva, near Stavanger (Öyen) .	38.1(?)	13.4	15.4	2.0
Klepp, Obrestad, Jæderen (Öyen, Danielsen).	35	14	14.4	0.4
Lintjonn Ogne-Hobberstad (Bjorlykke, Öyen)	27	9 10.7	11.0	(2.0)
Aen Sire (Danielsen)	25 28(?)	11(?)	11.8	0.8
Kviljo-Borhaug, Lister (Danielsen) .	17(?)	8.5 9.5	8.8	0.2
Rister (Öyen)		9 10		
A, Lyngdal (Danielsen)	ca. 20	> 8	0.7	< 1.7
Topdal river, Christiansand „	ca. *50*	ca. *20*	19.2	0.8
Christiansand „	ca. 40	ca. 15	16	1.0
Askero-Bergendal, Dybvag „	ca. 85	25—30	30.2	

italics), give the most perfect agreement with the computed values, and the differences are on the whole no greater in the cases of the greatest heights than at the lower ones, which indicates that the formula is fairly correct.

The observed heights of the Tapes-line are in most cases somewhat lower, often between 1 and 2 metres lower, than the computed ones. This may be due to the fact that the terraces have not, as a rule, been built quite up to mean water-level, but may have stood one or two metres below it, even in cases where shore pebbles have been found on their surface. It is also obvious that when a terrace is raised above sea-level, its surface may sink more or less, owing to compression, and to the loss of water contained in its layers, &c. Our formula is, however, based on the measurements of shore-ledges cut in solid rock, where this has not been the case, and which may have been formed slightly above mean sea-level.

There are some observations of the upper limit of submergence and the Tapes-line by Kaldhol in Romsdal which are not given in our table because they showed too great disagreements. Introduced in a map, these observations exhibit great irregularities in their distribution, and this is also to some extent the case with Kaldhol's observations in Nordmor. Lower values of the heights, both of the upper limit of submergence and of the Tapes-line, very often occur a good deal farther inland than higher values, and it seems very difficult to draw the probable isobases according to these observations. It seems to me to be probable that Kaldhol's heights of the upper limit of submergence in this region are often too high.

Kolderup's observations in the Bergen district were also to a great extent difficult to bring into harmony with our formula, but he has obviously estimated his Tapes levels much too low as a rule.

The Uniform Character of the Lateglacial and Postglacial Upheaval along the West and North Coast of Fenno-Scandia.

On the whole the results of the preceding investigations demonstrate that, in spite of the possible local differences in the gradient of upheaval (mentioned p. 253), the lateglacial and postglacial upheaval of the land has proceeded remarkably regularly and uniformly along the whole of the western and northern coasts of Fenno-Scandia, from the region of Christiania Fjord to the east and south coast of the Kola Peninsula.

Its relative rate appears to have been so uniform along the whole of this long coast, that, when its height be reduced by 5 metres, very nearly the same proportion, or about 68.5 per cent, of the rest of the upheaval has everywhere been accomplished during the period between the time of the deepest lateglacial submergence and the transgression of the Tapes-sea; and this relation seems to be the same in the outer coastal regions where the upheaval has been relatively small, as farther inland where it has been much greater. We are thus actually able to compute approximately the probable level of the Tapes-sea at any place where we know the upper limit of submergence, or *vice versa* where we know the height of the Tapes-line we can compute the height of the upper limit of submergence.

An important result of our previous investigations was that, on the whole, the levels of the strandflat appear to stand at very similar heights above the sea in all regions of the Norwegian coast where they have been investigated.

These facts constitute conclusive evidence that *the earth's crust in these regions has very nearly returned to the same horizontal position which it had before the last glacial submergence, only that the shore-line stood then perhaps between 10 and 17 metres higher, in relation to the land, than it does now.*

The uniform relation which we have found between the heights of the observed upper limit of lateglacial submergence and those of the Tapes-line confirms in a striking manner the correctness of these conclusions.

May we assume that the upheaval of the land is now practically at an end along the coast of Norway and that the earth's crust has very nearly found its new position of equilibrium after the last glacial submergence?

The nearly horizontal position of the strandflat in all regions of the Norwegian coast, and the fact that it very nearly maintains this horizontal level along lines at right angles to the direction of the isobases, seem to indicate that we may answer this question in the affirmative.

We may, for instance, point to the fact that the level of the strandflat at Varaldsoi in Hardanger Fjord, about 80 kilometres from the outer coast, has practically the same height (17—19 metres) above the sea as the lower level of the strandflat at Haugesund and Karmsund, although the height above present sea-level of the upper limit of submergence is in the former region about 90 metres, while in the latter it is probably less than 50 metres.

Along Sogne Fjord this relation is still more conspicuous. The level of the strandflat is nearly horizontal along the whole of this fjord, while in its inner part, in Sogndal and Norum Fjord, the total upheaval of the land may have been about 135 metres; at Vadheim it has only been 77 metres, and at Rutletangene, near the mouth of the fjord, probably less than 40 metres.

As, however, the level of the strandflat appears to be a few metres, perhaps about 6 or 7 metres, lower in the inner part of the fjord than in its outer part, if our observations be correct, it is possible — either that the upheaval is not yet quite completed in the inner region of the fjord, or that the strandflat has been raised slightly higher in the outer coastal region by the crust's new level of equilibrium.

In northern Norway we find the same striking features. The strandflat lies very nearly in the same level along the coast of the mainland as well as on the islands of Træna, Rost, Værøi, and Lofoten far outside this coast, although the lateglacial and postglacial upheaval of the land has been about 80 to 90 metres along the coast of the mainland and probably not appreciably more than the elevation of the strandflat on Røst, and not much more along the outer coast of the Lofoten Islands. There is, however, here possibly the same difference between the levels of the strandflat in the inner and outer regions as we have found in Sogne Fjord. On Dønna and Herøi the lower level of the strandflat is probably about 10 metres, or less, above the sea, while on Røst and Værøi its height may be 14 to 16 metres. The explanation may be the same here as in Sogne Fjord.

In the inner end of Christiania Fjord the strandflat has very nearly the same height above present sea-level as along the west coast of Norway, in spite of the great difference in the upper limit of lateglacial submergence, which at Christiania was about 220 metres.

There are, as we have already seen, other indications that the present shore-line has remained practically stable for a considerable time.

The fairly broad modern shore-ledges cut in solid rock along the shores of the Fornebo Peninsula near Christiania, just above mean water level and below high-water level are convincing proof that, during the long time needed for the formation of these ledges, the level of the shore-line cannot have changed more than one or two metres at most.

The recent shore-ledges, 8 to 10 metres broad, cut in fairly resistant solid rock (dolomite and gabbro with bands of syenite), in Kvænangen, just above high-tide level, described by Thorolf Vogt, are still more convincing proof that the present relation between land and sea-level cannot have changed much, perhaps one metre at most, for a very long time in that northern region.

Hence we may then conclude that *the postglacial upheaval of the land has been very nearly completed along the whole of the west and north coast of Fenno-Scandia*, from Christiania Fjord to the Kola Peninsula, but there is a possibility that, in the inner parts of the fjords, *e. g.* in inner Sogne Fjord, and along the coast of Helgeland, the land may still have to rise some few metres before the upheaval is quite completed.

By the find of a bronze-celt imbedded in the marine layers of a terrace (4 metres above present sea-level) between Skien and Porsgrund, in southern Norway, W. C. Brogger [1916] has shown that the land in that region may probably have risen about 9 or 10 metres since the fourth period of the Bronze Age (about 1000 years B. C.). He thinks, however, that the upheaval of the land in south-eastern Norway was practically completed in the beginning of the Iron Age, and before the Christian era.

The Lateglacial and Postglacial Submergence and Emergence in Central and Eastern Fenno-Scandia and in Jutland.

If we now try to compare our results with the process of upheaval in regions further east in Fenno-Scandia (Sweden and Finland) and in Denmark we meet with several difficulties, as the conditions have been more complicated in those regions during the periods of upheaval.

First. A great part of Sweden and some part of Finland was still covered by the retreating ice-cap when the upheaval after the lateglacial submergence began, and even a long time after that. Hence the highest marks of marine action now found in those regions date from a period subsequent to the retreat of the ice, when the land had already been elevated to some extent. Their level, "the upper marine limit", is therefore lower than the upper limit of submergence, and the difference may obviously be considerable in some regions, especially in Swedish Norrland.

Secondly. By the warping of the land surface the Baltic was during some part of the lateglacial and postglacial period transformed into a fresh-water lake, with levels higher than the actual sea-level. The height of the raised shore-lines will, therefore, have to be corrected accordingly in order to give the depression of the land below actual sea-level.

Thirdly. The weight of the water masses of the extensive sea covering the submerged areas may have retarded the upheaval of the land to some extent, and may thus have made its relative rate differ somewhat from what it was along the Norwegian coast.

Fourthly. In southern Sweden and in Denmark the crustal movements have been somewhat complicated, as during some part of the late-glacial and postglacial period there has probably been a subsidence of the land instead of an upheaval.

Fifthly. Along the Baltic coasts of Sweden and Finland the land is still rising.

The Present Crustal Movements in the Regions round the Baltic Sea and the Gulf of Bothnia.

The present upheaval is most rapid (about 1.2 metre in 100 years) along the Swedish coast of Bottenviken and decreases southwards and south-eastwards.

According to the investigations of Rolf Witting [1918] the mean yearly upheaval, during the fifteen years from 1898 to 1912, was 1.1 cm. in the region of Umeå to Piteå on the west coast of Bottenviken, 1.0 cm. at Sundsvall, 0.8 cm. south of Söderhamn, 0.7 cm. at Gäfle, about 0.45 in the region of Stockholm, 0.1 at Kalmar, and 0.0 at Karlskrona. Along the southern coast of Scania there seems again to have been a slight rise of about 0.1 cm. yearly, while in southern Jutland and Schleswig, and in the region of Riga there seems to have been a sinking of 0.1 cm. yearly.

Along the west coast of Sweden, in Bohuslän, there are indications of an upheaval still going on, which has been estimated to be as much as 0.4 cm. yearly.

It is a striking feature that lines drawn through the places with equal recent upheaval, according to the observations of Witting [1918, see map p. 274] as well as those of Blomqvist and Renquist [1914, see map p. 83], seem to have directions roughly similar to those of the isobases of the postglacial upheaval, as has already been pointed out by Swedish writers [cf. A. G. Högbom, 1921, p. 139].

It seems probable that the present upheaval of the coasts of the Baltic and the Gulf of Bothnia is a continuation of the postglacial upheaval of Fenno-Scandia, which is not yet quite completed in this region.

Witting points out the interesting fact that especially in the years with most seismic activity there are certain irregularities in the rise of the land.

The Possibility of a Strandflat along the Baltic and Bothnian Coasts.

No formation has been described along the coasts of the Baltic and the Gulf of Bothnia, which seems to correspond to the strandflat of Norway. The Skjærgård (belt of islands and skerries) of the Swedish and the Finnish coasts and round the Åland Islands have certainly a great resemblance to the "Skjærgård" of the Norwegian strandflat, but it has obviously not the same kind of horizontal planes, and is more like a low flat land which has been submerged. As has been pointed out by A. G. Högbom [1910a], this low plain probably represents a precambrian plain of denudation which is widely extended in Sweden, and may be seen continuing in under cambrian-silurian deposits.

As long as we do not know the level of the strandflat we have hardly any means of determining to what extent the rising land surface of this region has approached the level which it had before the last glacial submergence.

As the land is still rising, the strandflat, if there is one, may not yet have been elevated above the sea.

In my opinion there may have been quite favourable conditions for the planing of a strandflat in solid rock, especially along the coast of Bottenviken, during the cold periods of the interglacial epochs. It is true that the wave action cannot have been very effective in this enclosed sea, and there was practically no tide. There was, however, a very severe climate in this northern region, favouring an active shore-erosion by frost, which also was much increased by the fact that the surface layers of the sea consisted very nearly of fresh water, which by freezing has a much greater disintegrating effect on the rocks than sea-water. The winds would also cause frequent changes in the level of the sea, which to some extent would make up for the lack of tide, and the wave-action would be sufficient to render substantial help in transporting the débris of the shore-erosion.

There is, therefore, good reason to expect that a strandflat, cut in solid rock, may actually exist at some level below present sea-level. In that case it might be possible to trace it on the sea-floor.

Through the kindness of Prof. A. Högbom I have obtained a chart with soundings of Bottenviken (Chart No. 20 of the Swedish geodetic Survey). The soundings are not numerous enough for a study of the detailed topography of the sea-bottom.

By drawing contour lines for every ten metres of depth, a great number of sharply defined submerged valleys and channels become conspicuous. They form, as a rule, continuations of the bays and of the valleys on land. Some of them are quite narrow, with fairly steep side slopes. In Fig. 169 a small portion of this chart is reproduced as an example. They often seem to descend to depths of 60 and even 70 metres; but as they have probably been deepened by glacial erosion it is hardly possible to decide what their base-level may have been. In several places there are hollows with somewhat higher ridges outside indicating excavation by glaciers.

Between these submerged valleys there are shelves or platforms, extending as much as 40 kilometres, or even more, from the coast.

To a great extent these platforms have depths between 10 and 20 metres. They are bounded by fairly steep side slopes, descending to depths of more than 80 metres (Fig. 169), and, as it seems, by well defined edges, which along their outer margin appear to be between 20 and 30 metres below sea-level; but the soundings are too scattered for an exact tracing of them.

The north-eastern part of Bottenviken is very shallow with an extremely flat bottom, at depths mostly between 10 and 20 metres, extending 60 to 70 kilometres from the coast and being bounded by a steeper slope outside, descending to depths of 80 and 100 metres. There are not sufficient soundings to trace the topographical features of this flat floor; but it seems to be traversed to some extent by drowned valleys and channels. Some of them forming hollows 25 to 30 metres deep near the coast with somewhat higher platforms outside.

To what extent these submerged platforms of Bottenviken are built up of waste and glacial drift is not easy to decide. The narrow drowned valleys and channels, 25 to 30 kilometres long, which the chart indicates, especially along the west coast of Bottenviken, seem, however, difficult to explain unless they are cut in rock, at least to some extent. The glaciers would hardly be able to form such narrow channels by submarine erosion in extensive terraces of loose material; and if they had been formed by fluvial erosion on land before the last submergence, they would have been more or less obliterated by the ice-cap unless they were cut in rock.

The existence of these narrow drowned valleys also make it probable that Bottenviken cannot to any great extent have been filled up by glacial drift, or by waste after the beginning of the last glacial period, or after the last submergence of the land in this region.

If, however, the drowned valleys are cut in solid rock, it is also obvious that the platforms between them, with their well marked edges and side slopes, are to a considerable extent cut in solid rock.

It is then a question whether we here have formations which correspond more or less to the strandflat of the west coast of Norway. If so, we may expect that the coast has still to be elevated 20 to 30 metres before the strandflat is raised above sea-level, and if the latter shall be raised to levels similar to those of the Norwegian strandflat a still greater upheaval will be needed.

In a letter A. G. Högbom has drawn my attention to the interesting fact that at Hernösand (on the west coast of Bottenhafvet) interglacial fresh-water deposits occur at present sea-level [A. G. Högbom, 1909, pp. 578 ff.]. This also seems to prove that during the last interglacial period the land stood higher than it does now.

On the other hand it seems probable that in the southern part of Sweden the land surface has approached its level of isostasy; for the

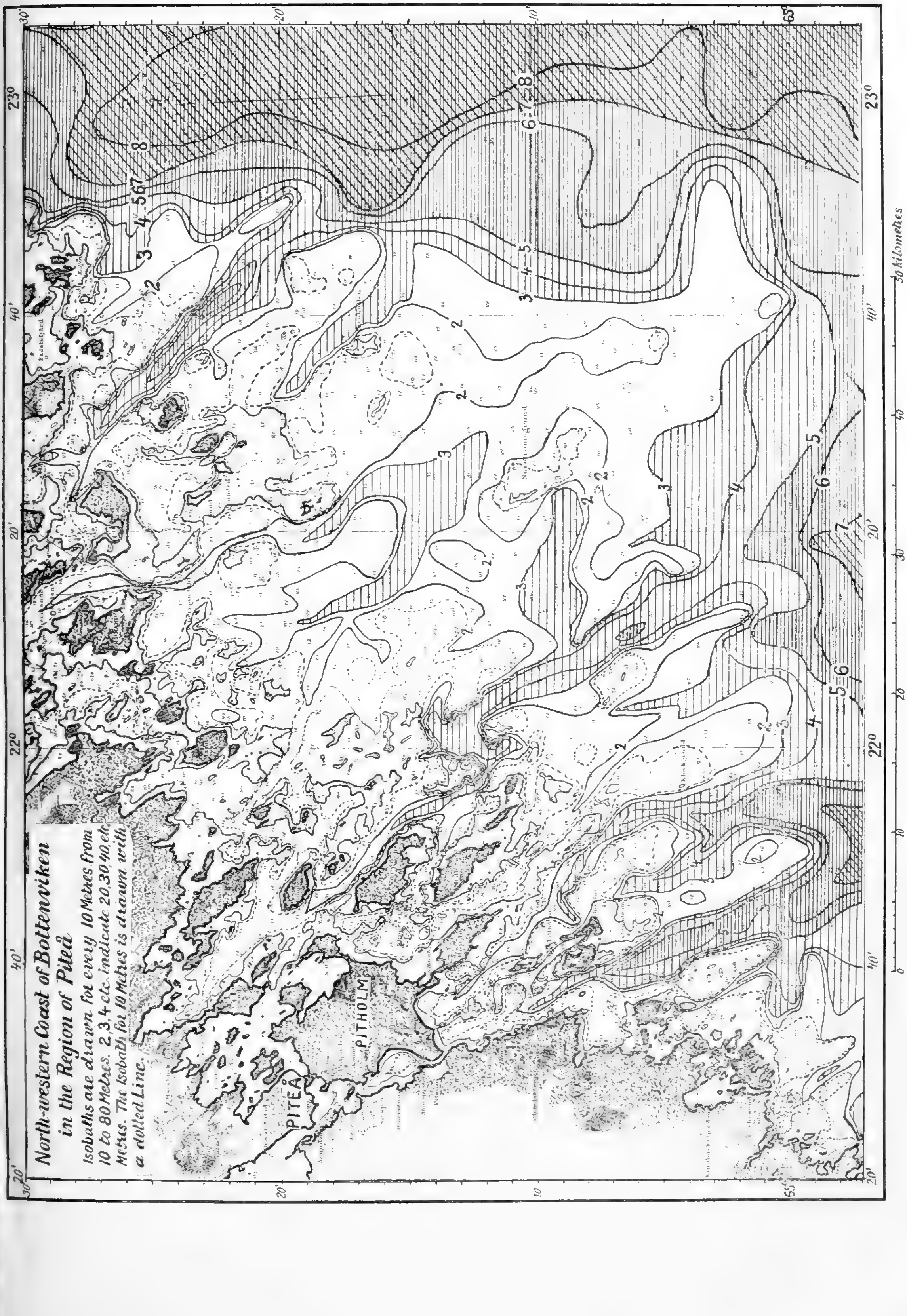
North-western Coast of Bottenviken
in the Region of Piteå
Isobaths are drawn for every 10 Metres from 10 to 80 Metres. 2,3,4 etc. indicate 20,30,40 etc. Metres. The Isobath for 10 Metres is drawn with a dotted Line.
PITEÅ
PITHOLM
50 kilometres

Fig. 169.

striking evenness of the flat plain so widely extended in this region, seems to indicate a kind of base level towards which the land has been denuded, and cannot probably have been much above previous sea-level.

As far as I am aware, the determinations of gravity have not given considerable deficiencies in Sweden; this also indicates that the crust has nearly attained its level of equilibrium. A. G. Högbom has drawn my attention to W. Ramsay's statement in his textbook (2nd ed., p. 14) that "in Finland, Sweden, and in great parts of Norway the observed values of the acceleration of gravity show, as a rule, a deficiency (= —0.004 cm.), while along the Norwegian coast, and in southern Norway as well as in Denmark the observed values of the acceleration are in most cases slightly higher than the normal.

The Reasons why the Postglacial Crustal Movements have been retarded in the Regions round the Baltic Sea and the Gulf of Bothnia.

It seems to me to be probable that there are especially two reasons why the postglacial upheaval is still continuing in the regions round the Baltic Sea and the Gulf of Bothnia, while it was practically completed long ago along most parts of the west and north coast of Fenno-Scandia.

First. While the margin of the last glacial ice-cap retreated at a comparatively early stage from the outer regions of the west and north coast of Norway and the Kola Peninsula, if they were ever covered by it, the interior parts of Fenno-Scandia were covered by ice for a much longer time, and especially in the region west of Bottenviken, where the lateglacial submergence was greatest, the last remnant of the ice-cap remained till late in postglacial time. This would naturally retard the upheaval of the land in those regions.

Secondly. Long after the disappearance of the ice-cap the land was pressed down by the weight of the water-masses covering the submerged land. First the Yoldia Sea was widely extended over great parts of Sweden and Finland, submerging also a wide area across middle Sweden, the regions of the great lakes, to Bohuslän, Halland, &c., and also some part of south-eastern Norway. Later the water-masses of the Ancylus Lake covered a wide area of eastern and southern Sweden and western and southern Finland. During this period Bohuslän and the surrounding regions were still greatly submerged, and also some part of south-eastern Norway in the region of the Christiania Fjord. Even as late as the Tapes-Littorina period considerable areas of land were still submerged round the coasts of the Baltic and the Gulf of Bothnia. It is obvious that the water covering the land weighed it down; but the addition of load over the sea-floor outside was still greater. The floors of the Gulf of Bothnia, the Baltic Sea, Kattegat, and Skagerrak were extensive parts of the depressed area of the Fenno-Scandian region. Over these depressed sea-floors the depth of the water was increased by the whole height of the depression. During the deepest submergence after the retreat of the ice-sheet, the additional layer of water over Bottenviken was at least 280 metres thick probably a great deal more, over the Baltic Sea in the latitude of Stockholm it was about 120 metres or more, in the northern part of Skagerrak, at the mouth of Christiania Fjord, it was about 160 metres thick, and along a line between Christiansand, Skagen, and Scania it was more than 50 metres thick.

Even as late as the Tapes-Littorina period the sea in Skagerrak was about 50 metres deeper than now at the mouth of Christiania Fjord, and about 15 to 20 metres between Christiansand and Skagen. In Bottenviken the sea may then have been more than 100 metres deeper than now.

The great weight of these extensive water-masses covering the central, as well as the southern and south-eastern parts of the depressed Fenno-Scandian area, must naturally have greatly retarded the lateglacial and postglacial upheaval of the sea-floor and the land; and this retardation has obviously been of much greater importance than that caused by the late disappearance of the last remnants of the ice-caps in Swedish Norrland.

In this manner we obtain a simple explanation of the fact that the upheaval of the land has not yet been completed along the coasts of the Gulf of Bothnia and the Baltic Sea, and perhaps also along the Swedish coast of Kattegat and Skagerrak.

We also understand that the upheaval of the land may have continued until comparatively lately along the Norwegian coast of Skagerrak and especially near the outer part of Christiania Fjord, while it was completed much earlier along the west and northern coast of Norway, where there was hardly any depression of the sea-floor outside the coast, and where only a very small area of the steeply ascending coast-land was submerged. An exception forms the coast of Nordland, between Trondhjem and Lofoten, as previously mentioned (p. 225), where a great deal of the broad continental shelf outside the coast was also depressed, and the sea in its inner part was as much as 90 metres deeper than now.

When we here speak of the upheaval of the land having been completed, it is of course, not meant absolutely completed.

The probability is that after the removal of the load of the ice-cap it will take some considerable time before the upheaval of the crust begins, but when fairly started, it may probably increase in a comparatively short time till it attains a maximum rate, and will then procede according to an asymptotic curve, being relatively rapid at first, then decreasing gradually, and the crust will approach its level of equilibrium asymptotically.

This process may, however, be modified more or less, where the whole load is not yet removed when the upheaval starts, and is only gradually diminished by the melting and retreat of the ice, and by the decrease (caused by the upheaval itself) of the water-masses covering the rising land and sea-floor.

Relation between the Heights of the Tapes Level and of the Upper Marine Limit in Central and Southern Fenno-Scandia.

A retardation of the upheaval of the land caused in the manner described above, may influence the relation between the heights to which the land was raised during the periods before and after the Tapes-Littorina period. We may, therefore, be prepared to find that our formula, based on the upheaval of the north-western coast of Fenno-Scandia, will not hold good in its central and eastern regions.

The retardation of the upheaval caused by the weight of the transgressing sea, may be expected to have been most considerable, comparatively, during the earlier periods of the upheaval, when the transgressing sea was deepest. Hence we may expect that in the regions where this sea was especially deep, the height of upheaval between the upper limit of submergence and the Tapes-line was lower in relation to the upheaval after the Tapes period, than it was in other regions. This seems to be borne out by the observations. In southern Sweden the observed heights of the Tapes-Littorina level depart, on the whole, less from the values, computed by our formula from the heights of "the upper marine limit", than they do further north in Sweden.

A. G. Högbom has attempted a comparison at the following localities:

Locality	Height of Upper Marine Limit	Height of Littorina Level		Difference
		Observed	Computed	
Bollnäs, Norrland	240	114	79	÷ 35
Salpanulka, Tavastehus, Finland	136	53	47.2	÷ 5.8
Mariestad, Lake Vener	130	6	44.3	+ 15.7
Linköping	120	40	41.2	— 1.2
Skagen, Jutland	60	14	22.3	— 8.3

This is already sufficient to show that the departures of the observed values from the computed ones of the heights of the Tapes-Littorina level are in these regions of quite a different order than those we have found along the whole of the north and west coast of Fenno-Scandia.

It may especially seem striking to find such a great departure of +15.7 at Mariestad, Lake Vener, while in the region of Christiania Fjord, about 200 kilometres to the north-west, the departures were between —1.8 and +1.5. The fact that the region of Lake Vener was covered by the Yoldia Sea after the retreat of the ice-sheet does not seem sufficient to account for this remarkable difference, as the Yoldia Sea also extended over the Christiania region, and had there even a greater depth, but its extent was less. The isobases of "the upper marine limit" seem, however, to have very irregular shapes in the region of Lake Vener [cf. Munthe's map, 1910, Pl. 46].

Taking the heights of "the upper marine limit" from H. Munthe's isobase map of southern Sweden [1910, Pl. 47], and the heights of the Tapes-Littorina level from his map of the Littorina isobases [1910, Pl. 46], and from Sundelin's map [1919, Pl. X] of the Swedish east coast between Norrköping and Kalmar, I have compiled the values given in the following table. The heights at a few places in Jutland taken from A. Jessen [1920] have also been added.

Locality	Height of Upper Marine Limit	Height of Littorina Level		Difference
		Observed	Computed	
Swedish East Coast:				
Söderköping	122	43	41.9	+ 1.1
Västervik	93	25	32.7	— 7.7
Oscarshamn	83	21	29.5	— 8.5
Kalmar	65	16	23.9	— 7.9
Karlskrona	48	11	18.7	— 7.7
Swedish West Coast:				
Kullen, Scania	50	12	19.2	— 7.2
Gotenborg	90	24	31.8	— 7.8
Jutland:				
Frederikshavn	ca. 58	ca. 13	21.7	— 8.7
Aalborg	ca. 22	7.5	10.3	— 2.8

It seems surprising that along the Swedish west coast, *e. g.* at Gotenborg about 150 kilometres from Mariehamn, the departure is found to be —7.8, which differs much from +15.7 at the latter place.

The figures of the above table seem, however, to prove that along the Swedish west coast, as well as along the Swedish east coast, south of the region of Söderköping and Linköping, the Tapes-Littorina level is considerably lower, about 8 metres lower, than it should be if computed by our formula from the height of "the upper marine limit". This is obviously the same relation between the Tapes-Littorina level and "the upper marine limit" as is found in the northern part of Jutland, at Skagen and Frederikshavn, where the departure of the observed height of the Tapes-Littorina level is also about —8 metres (see the tables p. 282 and above), according to the figures given by Axel Jessen [1920]. In Jutland the departure seems to decrease somewhat towards the south. It was found to be about —3 in the region of Aalborg.

The cause of these great minus departures of the heights of the Tapes-Littorina level in southern Sweden and in northern Jutland may probably be that the lateglacial and postglacial crustal movements have been more complicated in these regions than they probably were along the west and north coast of Fenno-Scandia. During the Ancylus period these coasts were upheaved partly even to a higher level than they have at present. Then they again sank to their maximum submergence before or during the Tapes-Littorina period, after which time they have again risen.

It has to be remembered, however, that the determinations of the levels of "the upper marine limit" as well as of the Tapes-Littorina submergence are always difficult and more or less uncertain, where they cannot be based on direct measurements of raised shore-lines cut in solid rock. If, for instance, they are based on marine deposits, it may often be doubtful at what depth below the surface of the sea they were deposited, &c. It is, therefore, easy to understand that in the course of time the heights given by the various investigators for the Tapes-Littorina level have differed a great deal.

Nevertheless, there seems to be a certain regular system in the distribution of the positive and negative departures of the heights of the Tapes-Littorina level found in Sweden and Denmark, which may indicate that these differences are real, and that the process of upheaval of these regions has differed from that of the west and north coasts of Fenno-Scandia.

In this connection I may mention an apparent anomaly which A. G. Högbom thinks [1920] to have occurred in the upheaval of Finland and eastern Sweden after the Stone Age. He points out that the height which the land has risen after the time of the characteristic Stone Age culture, generally called the Åloppe culture, differs a great deal in relation to the total upheaval after the Littorina period in the various regions. He gives the following table:

Locality	Height above sea-level in Metres of Åloppe-Level	Height in Metres of Littorina Level above Sea-Level	Relation of former Upheaval to latter Upheaval in *per cent*
Upland, Åloppe group	35–38	80	44–48
„ Alunda	29.5	70	42
Åland, Jättböle	30	61 [1]	48 [1]
Finland, Viborg	12–13	22 [1]	51–56 [1]
Östergötland, Säter	25	47	53
Gottland, Gullrum Hemmor	10.5–11	15–16	70–72

[1] The heights of the Littorina level have been reduced at these two places according to Ramsay's latest map of the Littorina isobases of southern Finland [1920, p. 257].

According to this table the land in southern Gottland should only have been raised 28 to 30 per cent of the whole upheaval between the maximum submergence of the Littorina period and the Aloppe period, at the same time as the land in Östergötland and Viborg, Finland was raised 44 to 49 per cent of that amount, and the land in the other northern regions, mentioned in the table, was raised 52 to 58 per cent.

Högbom thinks this is entirely opposite to what might be expected, as we know that the upheaval of Gottland was "completed long ago", while the upheaval of the other regions mentioned is still continuing.

I cannot quite follow Högbom's argument, for as far as I can see, a continued upheaval of the land in the northern regions would reduce the anomalies. If we assume, for instance, that in Upland the land will still be raised as much as 20 metres before the upheaval is completed, we see that the Åloppe level will be raised to 55—58 metres above sea-level and the Littorina level to 100 metres. Hence the upheaval of the former level will be 55 to 58 per cent of that of the latter one, which will be nearer to the relation found on Gottland.

A still better explanation of the observed anomalies may possibly be obtained if we assume that there have also been two kinds of movements of the shore-line after the time of the Åloppe culture, *viz.* one due to the upheaval of the land, and another due to a sinking of the sea-level.

Let us assume, for instance, that the sea-level has sunk about 6 metres after the Åloppe period. Let us furthermore assume that before the upheaval is completed, the land will still have to rise, for instance, 15 metres at the Åloppe group, 13 metres at Alunda, 11 metres at Jättböle (Åland), 2 metres at Viborg, and 7 metres at Säter (Östergötland), and nil on Gottland. The actual upheaval of the two levels, the sinking of sea-level being deducted, will then be the following:

Locality	Upheaval (in Metres) of Åloppe Level	Upheaval (in Metres) of Littorina Level	Relation of former Upheaval to latter Upheaval in *per cent*
Aloppe group	44—47	89	50—53
Alunda	36.5	77	47
Jättböle	35	66	52
Säter	26	48	54
Viborg	8 9	18	44—50
Gottland	4.5—5	9—10	45—55

The differences in the relation between the heights of the two raised levels given in this table are hardly greater than may well be due to errors in the determinations of the heights of these levels. On the other hand, our estimates of the amounts which the sea-level has sunk, and which the land will still rise before the upheaval is completed, are quite arbitrary. With other estimates a still greater agreement might be obtained. *E. g.* at Viborg in Finland the land may probably rise more than here assumed before the upheaval is completed. It seems also doubtful whether the upheaval of Gottland is already completed.

The Cause of the Transgression of the Sea in the Tapes-Littorina Period.

If we assume that the postglacial crustal movements of Fenno-Scandia were entirely isostatic, it seems difficult to understand that the apparent pause in the upheaval or even a transgression of the sea in the Tapes-Littorina period can have been due to a temporary sinking of the land as a whole; for the Scandinavian ice-cap can certainly not have been extended again during that warm period. It is more probable that this transgression was caused by a rise of sea-level which took place while the greater part of the land continued to rise.

Such an assumption agrees well with the observed facts. It is obvious that the height of the actual transgression of the sea, caused by a rise of the sea-level, would vary inversely to the rate of the upheaval of the coast.

If the sea-level rose at about the same rate as the land, there would be no transgression; but the shore-line would remain more or less stable as long as the sea was rising with the land, and a beach might be formed, or ledges cut in the rock where the climate favoured it.

If the sea-level rose more rapidly than the land, there would be a transgression of the sea, which would be greater in proportion as the upheaval of the land was slower. During this transgression marine terraces and even broad beaches may be formed, as a comparatively long time would pass before a negative shift of the shore-line again began, and a lengthened stand of the shore-line at about the same level of the coast would thus be caused.

Along the coast of Norway the transgression of the sea during the Tapes period was obviously greatest in regions where the postglacial upheaval of the land was slow, while it was small in regions where there has been a considerable upheaval.

On Jæderen where the upheaval of the land after the Tapes period has only been about 12 to 15 metres, J. Holmboe's [1901] and P. A. Öyen's [1903] investigations seem to indicate that the Tapes transgression of the sea has been as much as 8 or 9 metres in height. In the region of Christiania Fjord, where the upheaval after the Tapes period has been 60 to 70 metres, the Tapes transgression has been at most a few metres in height. P. A. Öyen [1905, p. 10] thinks he has discovered evidence to show that it was about 3 metres in the Christiania valley, but no quite conclusive proof of such a transgression has been found.

Considerably greater than in Norway has been the transgression of the Littorina sea in southern Sweden, where there was partly a sinking of the land before the Tapes-Littorina period, and the upheaval after that time has been very small, and in Denmark, where there has been a sinking of the land after that period. A. G. Högbom [1919, p. 177] estimates the height of this transgression to have been about 16 metres in the region of Kalmar, and about 30 metres in the region of the Great Belt, an estimate which, however, is uncertain. Where the land has sunk and the marks of the transgression are now under the sea, it is difficult to determine what its height may have been. If the sea-level rises along a coast which is sinking, the transgression will obviously be increased in a similar manner as it is decreased along a rising coast. A part of the great apparent transgression of the sea in these southern regions, however, may have occurred already before the Littorina period by the sinking of the land in these regions, which may have been caused by the comparatively rapid upheaval of the land to the north.

The transgression of the Littorina sea seems to have decreased towards the north along the east coast of Sweden, and as Sundelin points out [1919, p. 204], no traces of a transgression could be found north of the region of Västervik.

What may have been the Cause of a Rise of the Sea-Level during the Tapes-Littorina Period?

As was previously mentioned (p. 222) the principal cause of changes in the sea-level in recent times, which cannot be ascribed to crustal movement, is probably the abstraction of water from the Ocean by the increase of the glaciers on land, and the addition of water to the Ocean by their decrease.

If the rise of climatic temperature during the Tapes-Littorina period was universal for the whole earth, as seems probable, it may have caused a considerable reduction in thickness of the ice-caps of the Antarctic as well as of Greenland, which will have caused an immediate rise of the general sea-level.

According to the computations made on p. 223, we see that if the average thickness of the present ice-caps and glaciers of the world were reduced by an amount of about 257 metres the immediate result would be a rise of the Ocean-level and the shore-line of about 10 metres, which would remain until it was gradually somewhat reduced by the crustal movements of the sea-floor and the coasts, in the manner discussed on pp. 234 ff. As, however, the crustal movements are extremely slow, and are gradually started only a considerable time after the isostasy has been disturbed, the sea-level may have remained fairly stable for a considerable time after its rise.

As far as I can see, a shift of the sea-level and the shore-line such as this would be sufficient to give a simple explanation of the Tapes-Littorina transgression.

During the periods preceeding the Tapes-Littorina period the climatic temperature of the earth was on the whole rising, but there were probably several fluctuations in this rise, due to fluctuations in the radiation of heat from the sun. There has been a corresponding reduction of the ice-caps of the earth, with similar fluctuations, which caused a correspondingly fluctuating rise of the general sea-level.

Along great parts of the coasts of Fenno-Scandia, this rise of sea-level was more or less masked by the still faster upheaval of the land, and it was only during certain periods when the temperature was much raised and the melting of the ice-caps much increased, that the rise of sea-level was sufficiently rapid to cause a pause in the negative shift of the shore-line so considerable that conspicuous marine terraces, beaches, or shore-lines could be developed.

It seems possible that the different stages or interruptions in the upheaval of the land, marked by the series of marine terraces and raised beaches along the coast of Norway may be thus explained.

In the Tapes-Littorina period the rise of the general sea-level was sufficiently rapid to cause a transgression of the sea along some parts of the slowly rising coasts.

After this period the climates of the earth have again become somewhat colder. It is, therefore, possible that the ice-caps of the Antarctic and of Greenland have increased somewhat in thickness. In Spitsbergen, as was previously mentioned, there are indications of such a recent increase of the glaciers.

Hence a slight sinking of the general sea-level would be caused after the Tapes-Littorina period. A sinking of sea-level would also be caused by the gradual isostatic depression of the sea-floor, caused by the previous increase of the water masses of the Ocean. If at the same time there has been some upheaval of the coasts caused by the depression of the sea-floor, the negative shift of the general shore-line would be increased accordingly.

We would thus obtain an explanation of the general negative shift of the shore-line, or apparent sinking of the general sea-level, of about 20 feet or 6 metres in recent time to which Reginald A. Daly [1920] has drawn attention.

It was previously mentioned that the apparent anomalies pointed out by A. G. Högbom in the relation between the upheaval of the land since the Åloppe culture (of the Stone Age), and the upheaval since the Littorina period, may be explained by a sinking of sea-level since that time.

It should, however, be kept in view that the lower level of the emerged strandflat in Norway may have a low height similar to that of the transgression of the Tapes-Littorina sea, and that this level dates from a time before the last glacial epoch. If its apparent upheaval is to some extent due to a sinking of sea-level, as seems probable, we must conclude that there have been several oscillations of sea-level during and after the last glacial period.

When the relation between the inclinations of the upper and lower shore-lines of northern Norway was discussed (pp. 256 ff.), it was assumed that a general movement of the level, equal to a sinking of the sea-level, has occurred. It may here be pointed out, that the relation between the inclinations of the two raised shore-lines may of course also be explained only by a rise of the sea-level of about 6 metres during the Tapes period and a subsequent sinking of the same amount.

The horizontal, raised levels of the strandflat seem, however, to indicate that there has actually been some sinking of sea-level since interglacial times, and the observations of Kaldhol, previously mentioned (pp. 248 ff.), in the regions near the mouth of Nord Fjord, would be difficult to explain without such an assumption.

XVII. ISOSTASY.

What is the cause of the late-glacial submergence and the postglacial upheaval of the land in Fenno-Scandia, Spitsbergen, Scotland, Iceland, Greenland, and North America?

T. F. Jamieson was the first to suggest [1865, 1882, 1887] that the earth's crust had been depressed by the load of the ice-caps, and that the postglacial upheaval of the land was due to the removal of this load. N. S. Shaler [1874], evidently without knowing Jamieson's first paper, gave a similar explanation of the quaternary changes in the level of the land.

After this theory had been supported by the investigations of Gilbert [1882, 1890] and of Russell [1885] in the United States, and especially by Gerard de Geer [1888, 1890] in Sweden, and by Andr. M. Hansen [1890] in Norway, it has more and more universally been accepted by geologists.

The fact, proved by the strandflat and by the raised shore-lines, that the coast of Norway has been depressed during the last glacial period, and has again in postglacial time risen to a level slightly higher than the level it had before the subsidence, while the upheaval of the land is not yet completed in the central and Baltic regions of the depressed area, which after the retreat of the ice was covered by a thick layer of sea, seems to me to form convincing evidence of the correctness of the theory that it was the load of the ice which caused the depression of the crust, and the unloading which caused its upheaval. I do not think that serious objections can any longer be raised against this theory.

It is, therefore, hardly necessary to spend much time in discussing the other attempts made to explain the cause of the postglacial upheaval of the land, *e. g.* the suggestion that it was due to a rise of the temperature of the earth's crust after it had been cooled by the ice-cap — or that it was due to some kind of tangential pressure in the earth's crust similar to that causing mountain-folding [R. Sieger 1993, A. G. Nathorst 1894] — or that the upheaval of the land was not real, but that the appearance was produced by the sinking of the sea which had been attracted by the mass of the ice-cap [Penck 1882].

The first explanation is sufficiently disproved by the fact that *e. g.* in northern Fenno-Scandia and in Spitsbergen the temperature of the upper strata of the crust would be raised, in Spitsbergen even as much as about ten degrees centigrade, and not lowered if the land were covered by a thick ice-sheet.

As to the second theory, it is in itself inconceivable that tangential pressure of any kind should be able to produce an upheaval so regular and so gradual over an area as extensive as Fenno-Scandia, especially considering the comparatively narrow ridges produced by mountain-folding. A conclusive proof against this theory, however, is given by the strandflat, showing that the crust has first been pressed down in late-glacial time, and has then again been raised to its original level. A tangential pressure or strain causing such regular vertical movements of the crust is not conceivable.

Penck's theory has been disproved by Hergesell [1887], Drygalski [1887], Woodward [1888], and de Geer [1888] and was abandoned by Penck himself. The fact that the rise of sea-level caused by the attraction of the ice-masses would cease the moment the ice retreated, while the upheaval of the land occurred long after that time, is in itself conclusive proof against this theory.

It seems to me that the more one studies the whole process of the late-glacial and postglacial subsidence and upheaval of Fenno-Scandia, and the related crustal movements in the surrounding regions, in all their details, the more one must be convinced that these movements are isostatic. One will find that the theory of isostasy gives a simple and natural explanation of almost all phenomena, and even of many details which may seem startling at the first glance.

The Theory of Isostasy.

It seems strange that although the idea of isostasy is now more than seventy years old in literature, and in spite of all that has been written about it, the views regarding it still differ widely, especially amongst geologists.

Elie de Beaumont suggested already in 1848 that accumulation of load depresses the disks of the crust, and removal of load will cause their upheaval. Some years later Pratt [1855 and 1859] and Airy [1855] clearly propounded the theory of the isostasy of the lithosphere. The name isostasy was, however, introduced much later by C. E. Dutton [1892]. A long series of prominent geophysicists have further developed the theory of isostasy, and the correctness of Airy's views seems to have been supported by numerous observations.

Airy's theory was based on Archdeacon Pratt's determinations of the deflection of the plumb line in India, showing that the attraction of the Himalaya mountains was less than might be expected to be exerted by such great masses of rock above sea-level. According to Airy, the natural explanation was that the excessive mass of the high mountains was compensated for by a relatively low density of the masses of the crust below the mountain system. This might seem to indicate that the rigid continental crust is, as it were, floating on a plastic, denser substratum, and, as also assumed by Heim, the lighter "floating" lithosphere seems to be thicker under the mountain region, being there submerged deeper into the denser substratum or magma. Later observations seem to have borne out in essentials the correctness of Airy's views.

A series of pendulum observations made during the Fram-Expedition in 1893 to 1896 by Captain S. Scott-Hansen on the floating ice over the deep North Polar Sea, seemed to prove that similar conditions also prevail under the Ocean. By the computation of these observations Prof. O. E. Schiotz [1901] found the gravity over the North Polar Sea to be normal, which proves that the deficiency of density of the deep layer of water, 3800 metres thick, being not much more than one third of that of rock, must be compensated for by an excess of density of the lithosphere under the Ocean, which must be appreciably denser than the continental crust. It is also in remarkably good harmony with this result that a deficiency of gravity was observed over the deep sea near the edge of the continental shelf, corresponding to the excess of gravity found on land near the coast-lines of the continents.

In addition to the dynamic reasons for this peculiar distribution of the variations in gravity near the edge of the continental shelf, I think that it ought also to be taken into consideration that by the deposition of sediments, the continental shelves and the slope towards the deep Ocean floor will gradually sink towards their level of equilibrium; but owing to the rigidity of the crust, the Ocean floor outside the slope will also be bent down to some extent, although no appreciable addition of sediments has been deposited on it. A deficiency of mass will consequently arise in this boundary region of the Ocean.

The important discovery that the gravity is normal over the Ocean, has been confirmed by numerous observations by Hecker [1903, 1908, 1910] over the deep Ocean in various regions of the earth. Hecker's determinations of gravity were made onboard ship by simultaneous measurements of atmospheric pressure by means of boiling-point thermometers and the mercury barometer, a method first suggested by H. Mohn of Christiania.

Although the accuracy of this method is much less than that of determinations with the pendulum, still Hecker's observations over various parts of the Ocean agree on the whole so well that, in connection with the pendulum observations on the Fram-Expedition, they may be considered to prove that the gravity is, on the whole, approximately normal over the deep Oceans. The deficiency of mass of the Ocean water must be compensated for by a relative excess of mass of the crust under the Ocean floor, due to a higher density than that of the continental crust at corresponding depths.

In other words we may assume that the earth's crust has attained its level of isostatic equilibrium, under the Ocean as well as under the continents.

The theory of isostasy was placed upon a more solid physical basis of numerous reliable observations by F. R. Helmert [1908, 1909] and especially by J. F. Hayford's report [1909] on "The Figure of the Earth and Isostasy from Measurements in the United States", and by later publications by Hayford and Bowie.

While the theory has been accepted by most leading geophysicists, the attitude of the geologist towards this theory has differed more. Some geologists like Reid, in 1911, and Becker, in 1908 and 1915, accepted Hayford's geodetic analysis and interpretation unreservedly, and even assumed a nearly perfect isostasy to exist.

Others, like Hobbs, in 1909, were more or less opposed to the idea of isostasy, while some, like Bailey Willis [1907, 1911, 1920], received the theory with much reserve and criticism.

Gilbert, who was an early advocate of a partial isostasy, thinks that the rigidity of the earth's crust can only permit of a regional compensation distributed over wide areas, and Barrell arrived at very much the same result.

It would be out of place here to go more deeply into the vivid discussion which has been going on, especially between American geologists and geophysicists, about the theory of isostasy. The controversies show that the observed apparent anomalies of gravity may be interpreted in different ways, depending on the postulates as regards the vertical distribution of density in the lithosphere, on which the argumentation is based. An instructive summary of the outstanding points in this discussion has been given by Barrell [1919a].

It seems to me that the results of the synthetic discussion, though interesting, must remain very uncertain as long as the speculations have to be based upon assumptions regarding the conditions of the lithosphere prevailing at great depths below the surface, which our present knowledge gives us no means of controlling. If these assumptions should prove fallacious, as they easily may, the whole structure of conclusions will be more or less overthrown.

The fact is that at present we do not know the conditions of the rock at the high temperature and pressure prevailing at great depths below the earth's crust; we know nothing about the degree of plasticity or viscosity of the rock at these depths; and we do not know even approximately the vertical distribution of density in the lithosphere.

As long as such fundamental factors are unknown, it seems to be somewhat hopeless to make certain assumptions and then try to find out what can take place at the surface of the lithosphere.

A more natural way may be to examine as closely as possible what has actually happened at this surface, and from this we may possibly draw some conclusions as to the state of the deeper strata.

I think that, for a better understanding of the isostatic problem, it may be especially valuable to study in all possible detail the vertical movements of the crust in the regions where it has been depressed by the load of the ice-caps, and has again been upheaved after their removal.

For this kind of study there is at present hardly any better field than Fenno-Scandia, and especially the coast of Norway, where the limits and the process of the vertical movements are now fairly well established, where the postglacial upheaval of the land is practically completed, and where there is a strandflat indicating the level of the shore-line before the land was depressed by the load of the ice.

The Crust's Capacity of Isostatic Readjustment.

There has been much difference of opinion as to how far the crust may be able to approach its level of perfect isostatic equilibrium. Most geologists have assumed that, owing to the rigidity of the crust, there can only be a rough approximation to isostasy.

Hayford's computations seemed to indicate a high degree of local isostasy of the continental crust inside even comparatively limited areas, with a radius of no more than 19 kilometres. He predicted that future investigations would show that the horizontal extent which a topographic feature may have without a corresponding compensation of density would be between one square mile (2.6 square kilometres) and one square degree. The average vertical departure of the land surface from the elevation giving perfect isostasy he stated to be less than 73 metres (250 feet).

J. Barrell [1914, 1915] although an adherent of the theory of isostasy, does not consider local compensation to be probable, as he thinks that the diameters of the areas of notable departure from normal gravity run up to about 300 kilometres, and he and Putnam [1912] are of the opinion that only regional isostasy may be attained inside areas with radial distances of at least 167 kilometres. Even there Barrell thinks that the distribution of compensation gives only a very rough approximation to isostasy.

Bowie [1917], however, finds that in mountainous regions regional compensation with a radius of 59 kilometres satisfies the data as well as does local compensation, but regional compensation to a distance of 167 kilometres does not do so quite so well, and he considers that local compensation is much nearer the truth than this degree of regional compensation [cf. Barrell, 1919a, p. 306].

Barrell, in his opposition to the hypothesis of local compensation, even goes as far as to postulate that a great local load will have no ability to depress the crust isostatically while even a smaller load distributed over a sufficiently wide area will produce an isostatic depression of the crust. It is hard to see the validity of this statement. If the crust is so rigid that it does not yield to the local load, the depressive effect of this load will naturally be distributed over as wide an area as the crust is capable of retaining perfectly rigid, and there will be no essential difference in this respect if the load be equally distributed over this area. But if the crust is not so rigid as to cause the effect of the load to be distributed in this manner, then the crust will yield within a smaller area to the local load, and the result will be a deficiency of compensation (*i. e.* an excess of gravity and deflection of the vertical) near the local load, and an excess of compensation (*i. e.* deficiency of gravity) in the depressed region round it.

It has also been maintained that great disturbances over extensive areas are necessary to start the crustal movements for adjustment of isostasy, and such movements will occur, as a rule, only during periods of special mobility of the earth's crust, and within certain specially mobile regions.

As far as I can judge the late-glacial and postglacial vertical movements of Fenno-Scandia and surrounding regions, and especially the movements of the Norwegian coast, and the present position of its strandflat, conclusively disprove the correctness of views such as these. They indicate that the earth's crust in the course of time approaches its level of perfect isostatic equilibrium much more closely than even the most extreme advocates (like Hayford) of perfect isostasy have considered to be possible.

Our studies of the present level of the strandflat in the Norwegian fjords as well as along the outer coast of Norway, in connection with the measurements of the heights of the upper limit of late-glacial submergence and the heights of the Tapes-line, may be considered to prove conclusively that the earth's crust in these regions has returned, at least within a few metres, and along the outer coast probably even nearer, to the same horizontal level which it had before the last glacial submergence. And this level of equilibrium has been reached along the whole coast although the late-glacial submergence of the land has differed very much in magnitude. In some regions it was as much as 90 and 100 metres (along the coast of Helgeland) and 120 to 150 metres (in the inner parts of the western fjords) or even more than 200 metres (at Christiania), while in some parts of the outer coast, at Stat and outside Nordfjord, there has hardly been any submergence below the level of the strandflat. Nevertheless the strandflat has returned to its previous horizontal level in the outer regions along the coast, while in the inner regions of the fjords, and perhaps also along the coast of Helgeland, there may perhaps be some few metres left before this level is attained. At the same time, however, the strandflat as a whole is now standing perhaps 10 to 17 metres relatively higher above sea-level, than it did before the submergence, which may at least to some extent be due, as was previously mentioned, to a vertical movement of sea-level.

The different levels of the extensive strandflat of Norway prove that the Norwegian coast must have stood at these levels during very long periods before the last submergence, and probably even in preglacial time, and it seems probable that after each submergence during the different glacial periods, the earth's crust has returned to the horizontal level of the strandflat.

A natural conclusion must then be that the level of the strandflat represented the level of isostasy at times when the land was not depressed by the load of the ice-caps; for otherwise it seems to be inconceivable why the crust should always return to the same horizontal level after each depression.

The crust in these regions is to a great extent built up of very old Archæan rocks, while in others, especially in northern Norway, there are younger formations, but they all show the same horizontal levels of the strandflat and very nearly the same relative degree of submergence.

Moreover this is a region of exeptionally stable and tranquil character. During the long ages since the great Caledonian mountain-folding at the end of Palæozoic time, there has been singularly little crustal movement in the region of Fenno-Scandia. Besides, the Pleistocene age has certainly not been a period of special crustal mobility in any parts of the globe.

When we, nevertheless, find that during the tranquil Pleistocene period this stable part of the earth's crust has been so responsive to the load and removal of the last, not very extensive, ice-sheet of Fenno-Scandia, as well as those of each previous glacial period, and the sinking and rising movements have proceeded so continuously, and have been so regularly distributed over the whole area concerned, as is proved by the raised beaches, the relation between the heights of the upper limit of submergence and the Tapes-line &c., and by the strandflat — then a logical conclusion obviously is that this cannot be due to a special quality of an exceptionally flexible or mobile area of the earth's crust, but must indicate a general quality of the lithosphere, nor can the isostatic crustal movements be limited to periods of special crustal mobility.

We may, therefore, infer *that the earth's crust is on the whole very responsive to disturbances of its equilibrium, and has a great ability to re-establish it. After a sufficient time it will attain its level of isostasy at least within some few metres.*

The above inference is strongly supported by the fact that similar evidences of a late-glacial submergence and a postglacial elevation of the land have been found in all other regions that were covered by fairly extensive ice-sheets during the last glacial epoch, although these regions may have so very different geologic structure as Fenno-Scandia, Novaya Zemlya, Franz Joseph Land, Spitsbergen, Scotland, Iceland, Greenland, and North America. Some of these regions, *e. g.* Southern Greenland, Labrador, and Eastern Canada, are especially stable and tranquil Archæan regions.

The fairly regular distribution of postglacial elevation in Fenno-Scandia, *e. g.* the regular rise of the raised beaches from the outer coast inland, the uniform relation between the heights of the upper limit of elevation and the Tapes-line along the whole of the west and north coast of Norway and the Kola Peninsula, furthermore the retardation of the elevation in the flooded regions &c., prove that the upheaval of the land cannot have proceeded by jerks and irregularly, but must have been on the whole a very gradual and regular process.

It is true that there seems to be a connection between certain irregularities in the slow emergence of the land i Sweden and Finland, and the seismic activity of the crust, as is indicated by Witting's investigations; but, on the one hand, these seismic movements are in fact very insignificant, and, on the other hand, they are obviously fairly local. They must not, therefore, be connected with the general crustal upheaval over extensive areas, but are due to more local strain in the crust, in regions where local deformities cause greater local disturbances of equilibrium. I may mention our deep fjords and the submarine Norwegian channel as such regions, where there may be a special strain in the crust, owing to the erosion of these deep channels. We may summarize the results of the above investigations as follows:

It is a general tendency of the lithosphere to readjust its isostasy after disturbances, and in the course of time to approach its average level of isostatic equilibrium within som few metres at least.

The isostatic movements of the lithosphere are not limited to especially mobile regions, nor to periods of special crustal mobility.

How are the Isostatic Vertical Movements of the Lithosphere effected?

Pentti Eskola has recently [1920] put forward some ideas regarding transformations in the chemical composition of minerals and rocks effected by changes in pressure, which, if correct, may prove to be of great importance when the above question comes to be answered.

He draws attention to the fact that pressure influences the nature of minerals "by moving the equilibria towards the associations and modifications which have the smallest volume", and he points out that certain rocks, belonging to what he calls the "eclogite facies", which have probably been suddenly pressed up from very great depths, are all of them very heavy with a specific gravity of about 3.3 to 3.5, and contain heavy minerals like garnet and diamond. These rocks are unstable at the pressure at which they are now found near the surface, and have, as it were, been "quenched" by the sudden reduction of the pressure. If the pressure had been reduced slowly, as would have been the case if these deep-seated rocks had been brought up towards the earth's surface by gradual denudation, they would gradually have been transformed into rocks composed of more voluminous and lighter minerals, conditioned by the existing pressure.

Eskola points out that "eclogites occupy a volume about 15 per cent smaller than that of corresponding gabbros, and the magma probably has a still larger volume. The volume of jadeitite (sp. gravity = 3.33) is as much as 22 per cent smaller than that of the corresponding molecular mixture of albite and nephelite (sp. gravity = 2.61)".

He also maintains that as the melting point of eclogites is raised by pressure, it seems "likely that there exists a zone in the deepest parts of the earth's crust where gabbroid material exists stable in the form of eclogite, at temperatures under which a gabbro would melt if the pressure were reduced".

Eskola mentions that this conclusion was formerly drawn by L. L. Fermor, who states that eclogite must be the high pressure form of gabbro, and that "we must, therefore, assume that in the infra-plutonic zone the basic rocks are present as eclogites and the more acid rocks as garnetiferous granites". Fermor thinks that this infra-plutonic zone may form "a continuous shell round the earth, the whole of which shell is a potential magma. This shell, being composed of rocks of the consistency of a plastic solid, may afford a cushion upon which the isostatic operations of the earth, believed in by some geologists, have their foundation".

It is in my opinion obvious that if changes in volume, of the order mentioned above, can be effected by changes of pressure, appreciable vertical movements of the surface level of the lithosphere may be thus produced.

The magnitude of these movements would depend on the thickness of the layer of those deep-seated rocks, the pressure of which is changed beyond the critical point. If we suppose, for instance, that, by the denudation of 100 metres of the continental surface (sp. g. = 2.6), the pressure in a layer of deep-seated eclogite (sp. g. = 3.45), 75 metres thick, be reduced below the critical point, and this layer of rock gradually be transformed, it may cause an upheaval of the continental surface of about 13 metres.

This vertical movement would be effected without any "flow" of the plastic substratum underlying the rigid crust. If the transformed rocks form parts of the lithosphere the rise of the crustal surface caused by their expansion would be added to the isostatic upheaval of the crust caused by the denudation.

If it is rocks of the plastic substratum underlying the lighter, rigid crust, which are transformed, they may by their expansion become parts of the lighter crust, and will then increase the upheaval of the latter caused by the denudation. In that case the thickness of the lighter crust would not be much reduced by denudation.

If the transformed rocks remain parts of the plastic substratum, their expansion may reduce the isostatic upheaval of the latter, because the expansion makes the layers of the substratum lighter, and the crust may sink deeper into it, which would, however, necessitate a "flow" in the substratum.

If instead of a reduction of the weight of the crust (*e g.* by denudation) we suppose an increase of its weight by deposition of sediment, or by the formation of an ice-cap, the deep-seated rocks may be inversely transformed, and a gradual increased sinking of the crustal surface would be caused.

As, however, we still know much too little about the actual conditions at these depths below the earth's surface and about the possible transformations that may take place there, we must leave the crustal movements, thus caused, out of our present considerations.

If we try to form an idea of the isostatic movements of the earth's crust caused by a load, *e. g.* by an ice-cap, the simplest supposition is that the crust is floating on a semifluid or viscous, molten magma, in a manner similar to that in which an ice-sheet floats on water. In that case the conditions may be considered as being practically hydrostatic below a certain depth. *I. e.* there is practically a uniform pressure in all directions, and when the crust is depressed by an additional load, it will gradually sink down into the magma, in a manner similar to that in which a loaded ice-sheet will bend under a load and sink deeper into the water, until it attains its new level of equilibrium. The plastic magma under the sinking crust will be gradually pressed out towards the sides, and an "undertow" will arise. This will continue till the crust has reached its new level of equilibrium. The volume of the magma displaced sideways by the "undertow" will be equal to the total volume of the depression of the crust below its initial level, the possible changes in the volume of the magma caused by pressure not being taken into consideration.

We do not know what the state of matter may be at the depth of the zone of compensation, perhaps at 120 kilometres, or more, below the earth's surface — whether it is solid, viscous, fluid, or some other state unknown to us. The experimental researches by F. D. Adams [1912, 1917] and also those made at the Carnegie Geophysical Laboratory indicate that the problem is a complicated one [cf. Bailey Willis, 1920]. As the interior friction of solid rock, and thus its absolute strength or rigidity, is increased by pressure to a certain limit, where the rock is potentially crushed, the "zone of flowage", where the rock may be considered to be plastic, lies much deeper than was generally estimated.

We may, however, assume that this zone begins a great deal higher than the zone of compensation. As high temperature is essential to the mobility of the rock, and as the temperature of the lithosphere increases rapidly with depth, we may assume that at a depth of 50 to 60 kilometres the rock is in what may be called a plastic state, and that its plasticity increases with the depth.

We shall not here try to discuss whether at a certain depth there is a continuous substratum of molten magma or not. The chief point for our consideration is that at some depth under the rigid surface of the lithosphere there is a zone of flowage, where the rock material, in whatever state it may be, is plastic and mobile. That it must be so, and that this plastic substratum behaves to a certain extent like a viscous fluid, seems to be fully corroberated by our investigations of the strandflat and the crustal movements of Norway after the last glacial epoch.

The coefficient of viscosity of this plastic substratum is probably very high, but even if it be as high as estimated by Schweydar [1921], *i. e.* ten thousand times that of sealing-wax at normal room temperature, we must keep in mind that the pressure is also extremely high, and the substratum, therefore, is responsive to changes of pressure, and possesses a certain degree of mobility, so that in the course of time, as is proved by our observations, it gradually adapts itself to the conditions of equilibrium.

It is, however, obvious that this must require a very long time. On the one hand because the rigidity of the crust will offer great resistance to deformation, and it will give way only very slowly, probably by shearing. On the other hand because, as was just mentioned, the internal friction of the plastic substratum is so very great.

The flow in the plastic substratum will, therefore, be extremely slow, and besides it will meet with great resistance, because, for instance, the crust, in the zone surrounding a depressed area, will have to be lifted in order to make room for the displaced plastic matter.

Let us try to imagine what will happen, if the crust be gradually pressed down by an increasing ice-cap, provided that the conditions are fairly hydrostatic at a certain depth under the earth's surface.

Supposing the ice-cap begins to be formed in the central area of an extensive region like Fenno-Scandia, the load of the ice-cap will press the crust down in this central area, and in a zone surrounding it the crust will be pressed up and will there form a kind of concentric wave, as in-

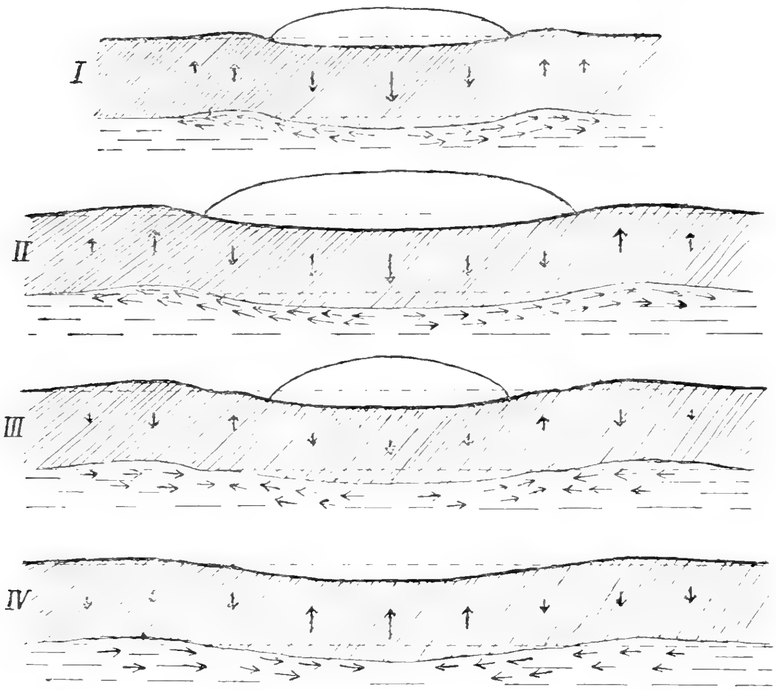

Fig. 170. Diagram showing, with much exaggeration, the depression of the crust under an ice sheet, and the upheaval on the sides. The vertical arrows indicate the vertical movement of the crust, the horizontal arrows the "undertow" in the plastic substratum.

dicated in Fig. 170, I. As, however, this wave will not represent a state of equilibrium, it will gradually extend outwards, and will be flattened down as it becomes wider and wider.

If now the ice-cap increases in thickness and in extent, the crust will continue to be pressed down, and the surrounding upheaval wave will increase somewhat in height, while it will be moved outwards by the advance of the ice-cap (Fig. 170, II).

The depression of the crust will continue a long time after the ice-cap has ceased to increase, and will only very slowly and asymptotically approach its level of isostatic equilibrium. The wave of upheaval surrounding the depressed area, will continue to widen, and the real level of isostatic equilibrium will not be fully reached, before this surrounding wave is entirely flattened out, and the depression of the ice-covered area is fully compensated for by the upheaval of the floor of the Ocean, as was mentioned on p. 233, but this is a state which is never reached.

When the ice-cap begins to decrease towards the end of the glacial period, the underlying crust will probably not yet have been fully depressed to the level of equilibrium conditioned by the weight of the ice. The subsidence will, therefore, continue inside the area which is still covered by the retreating ice-cap, and it will not stop as long as the weight of the ice masses is in excess of the load corresponding to the amount of depression. After that time an upheaval of the crust will gradually begin.

Meanwhile an upheaval of the land will start in the outer zone of the previously ice-covered region, soon after it has been left free by the retreating ice. This upheaval may be facilitated by a double "undertow" of matter coming from the still subsiding area inside, under the ice-cap, as well as from the upheaved peripheral zone (the upheaved wave) outside, as is indicated in Fig. 170, III. This may possibly have been what happened during the period before the Tapes-Littorina period in the regions of Skagen and Kalmar, &c. (cf. above p. 284).

When the upheaval of the more central area began, an undertow of matter towards this rising area from the surrounding previously upheaved zone would arise, and this would cause a sinking of the land in that zone (Fig. 170, IV), corresponding to the previously mentioned sinking of the land in the region of Skagen and Kalmar, &c. (cf. p. 284), before or at the beginning of the Tapes-Littorina period.

As, however, the upheaval of the depressed area advanced, the undertow of matter from the peripheral, formerly upheaved regions (outside the ice-cap at its widest extent) would be increased, and a general upheaval of the whole depressed region would be developed, and this would now continue, till the upheaval was completed. At the same time, the land in the peripheral, formerly upheaved zone, surrounding the ice-covered region, would gradually sink.

Where the retreating ice-cap was to some extent replaced by a transgressing sea, the upheaval of the crust would be retarded, as was previously pointed out (cf. p. 280).

It seems to me, that a development as here indicated agrees well with what we now know about the late-glacial and postglacial crustal movements which probably have taken place in Fenno-Scandia and the surrounding regions.

Along the coast of Norway, where the retreat of the margin of the ice-cap was very much slower *e. g.* than in Southern Sweden and in Denmark, and where the ice remained near the coast till late-glacial times, the crustal movements have probably been less complicated, and the upheaval may have been fairly continuous from its beginning.

In regions where the ice-cap left great quantities of moraine material, as for instance in Denmark and in Northern Germany, the crust was naturally depressed by the weight of these deposits, and this fact would also cause a sinking of the land which may have continued long after the ice retreated. The quantity of moraine material, however, carried by the last ice-cap, may probably not have been very great, and the sinking of the land thus caused after the last glacial period may, therefore, have been less considerable than after the previous glacial periods.

Of much importance are the two questions of the time required for the isostatic readjustment of the crust, and of the size of the area within which it can take place.

How long a time does the earth's crust require to reach its new isostatic level after a disturbance of its equilibrium?

As the internal friction in the plastic or mobile substratum, under the rigid crust, is, at any rate, extremely great, whatever the state of this matter may be, we may expect that when the substratum is exposed to stress it will take a long time before this friction is gradually overcome, and motion is started. In addition to this there is naturally also an enormous resistance to overcome in the rigid crust itself, before it can be depressed or upheaved. Hence the isostatic movements of the crust will always show a great deal of lag.

For this reason many geologists have assumed that the establishment of isostasy at the earth's surface will require extremely long geological periods. I think, however, that our study of the strandflat and the raised shore-lines of Norway may prove that the time required for the attainment of approximate equilibrium is very much shorter than is generally believed.

Although it may be very difficult to estimate the length of time elapsed since the ice-cap of the last glacial epoch actually began to decrease, there are now many careful researches by Gerard de Geer and his school in Sweden as well as by others, especially in North America, which will help to estimate the length of the late-glacial and postglacial periods. According to the results of De Geer's investigations, it is not more than 13,000 years since the margin of the retreating ice-sheet stood in Southern Scania. Even if we take other estimates we cannot possibly assume the time since then to have been more than 16,000 or 20,000 years. During this period nearly the whole of the late-glacial and postglacial upheaval of Fenno-Scandia has been accomplished. A very considerable part of the upheaval has even been accomplished in about half that time, since the ice-margin had retreated to Northern Sweden, 8,000 years ago, *e. g.* the land near Bottenviken has been upheaved about 270 metres during that space of time.

We know that along the coast of Norway the upheaval of the land was practically completed at least before the beginning of the Christian era. Hence we may assume that along the Norwegian coast the upheaval of the land and the re-establishment of equilibrium was completed during a period of probably 11,000 years, and at any rate of not more than 18,000 years. This is a remarkably short period, and seems to indicate that the plastic substratum of the earth's crust is more mobile, than many geologists are prepared to allow.

What is the extent of the smallest area within which isostatic movements may occur?

This is a very difficult question, which we cannot answer at present. It is obvious that the question of time is here of much importance. The smaller the area is within which the equilibrium is disturbed, the longer it will take before it can be re-established. It may be possible that in the course of a very long time equilibrium may be more or less attained within quite small areas, although the process is so extremely slow that it is not yet the case in many localities examined.

We have seen (pp. 253 f.) that in Norway and Sweden there may be quite considerable differences in the upheaval of the land within small distances of no more than a few kilometres. As, however, we do not know the causes of these differences, they can hardly be used as proofs of a great local adaptability of the crust to isostasy.

It may, however, be pointed out, that the comparatively small ice-cap of Scotland, of the last glacial period, has caused a considerable depression and subsequent upheaval of the land, within an area with a diameter of less than 500 kilometres. The last glacial ice-cap of Iceland also caused a depression and subsequent upheaval of that island.

Lake Bonneville in the region of the present Great Salt Lake, in Utah, with a diameter across of probably about 230 kilometres, caused a depression and subsequent upheaval of the flooded land, although the depth of the water above the present level of Great Salt Lake may have been no more than 320 metres [cf. Gilbert, 1890]. The depression caused by the load of water may possibly have been about 45 metres in the central area of the lake.

These facts indicate that considerable isostatic movements may take place within areas no more than a few hundred kilometres wide, and probably even much smaller.

Isostasy and Erosion.

Our views regarding the ability of the earth's crust to attain its level of isostasy must greatly influence our views as regards the morphological changes due to erosion on the continental surfaces.

The rapidity with which the crust responds to the changes of pressure caused by the deposition of sediments or by denudation is of essential importance for the development of these processes and for their effect upon the surface topography of the crust.

Let us consider the probable effect of the isostatic crustal movements upon the denudation of the land surface and especially upon the development of peneplains.

It is obvious that the time required for the planing down of a mountainous region to a peneplain will be essentially increased by the isostatic upheaval of the land taking place according as its surface is denuded by erosion.

If the density of the rocks eroded from the surface of the crust be 2.6 and the density of the plastic substratum underlying the rigid crust be 3.5, it would be necessary to erode a surface layer with an average thickness of about 385 metres in order to reduce the average height of the land above the sea by 100 metres, provided that the isostatic readjustment be complete.

If there is less difference than assumed above between the density of the surface rocks and that of the plastic substratum, the thickness of the surface layer which has to be eroded in order to reduce the average height of the land above the sea by 100 metres, will be proportionately greater. If the density of the surface rocks be 2.6 and that of the substratum be 3.0, a surface layer with an average thickness of about 770 metres would have to be eroded in order to reduce the average height of the land above the sea by 100 metres.

As the subaërial and fluvial erosion of a high land is most active along the mountain slopes and in the river valleys as long as the floors of the latter have sufficiently steep gradients and are sufficiently elevated above the sea — it is obvious that in many cases the ridges of the mountains may be raised by the isostatic upheaval to levels higher above the sea than those at which the summits of the mountains stood before the erosion began.

The result of the erosion during its first stage may thus be to make the mountain ridges higher above the sea than they were before, while the valleys are made lower. This may probably continue until the level of the floors of the great river valleys approach the base level, after which time the erosion will actually begin to reduce the height of the mountains above sea-level, and will tend towards making the land less uneven.

If, as above, we assume the density of the eroded rocks to be 2.6 and that of the plastic substratum to be 3.5, the erosion will not begin to reduce the height above sea-level of the mountain ridges before the thickness of the layer of rock removed from above them is as much as 74 per cent of the average thickness of rock removed by the erosion from the whole land surface.

If the density of the plastic substratum be only 3, the thickness of rock removed from above the mountain ridges would have to be as much as 87 per cent of the average thickness of the layer of rock removed by érosion from the whole land surface, in order for the height of the mountain ridges above sea-level to be reduced.

The relation between the erosion, the isostatic movement and the reduction of the mountain heights may be somewhat altered where there is an active erosion by frost (local glacial erosion) in the higher parts of the mountains, in which case their heights above the sea may possibly be reduced even during the first stage of erosion.

As the erosive effect of a moving glacier is so enormously increased with the velocity of the movement (probably by the third power of the velocity, cf. p. 21) the denudation of the land caused by the erosion of a big ice-cap will obviously be concentrated on the deepening of the valleys and fjords, while the surface of the higher parts of the mountains between them may be comparatively little denuded.

Hence the final isostatic upheaval arising from this denudation may have a tendency to increase the height above the sea of the mountains and the land between the much deepened valleys and fjords. As has previously been pointed out, the strandflat may probably have been somewhat elevated in this manner after its formation, although the probability is that the present elevation of the strandflat above sea-level is largely due to a change in the sea-level itself.

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Printed, December 20th, 1922.

HIPPOPHAËS RHAMNOIDES L.
FRA EN NORSK KALKTUF

AV
P. A. ØYEN

(Videnskapsselskapets Skrifter. I. Mat.-naturv. Klasse. 1921. No. 12)

KRISTIANIA
I KOMMISSION HOS JACOB DYBWAD
1921

Fremlagt i den mat.-naturv. klasses møte den 20. septbr. 1918.

A. W. BRØGGERS BOKTRYKKERI A/S

Utbredelsen av denne merkelige plante inden norsk omraade angives av Blytt & Dahl saaledes: „Tørre strand- og elvbredder nordenfjelds fra Trondhjemsfjorden til Stegen 67° 56'. Angives ogsaa for Nordfjord" (Norges Flora, 1906, pag. 511). Og Dyring har bemerket: „Denne busk, der ellers er bunden til havkysten, optræder merkelig nok i Junkersdalsuren ved et af de midtre flaug i en liden koloni" (Nyt Mag. f. Naturv. B. 37, pag. 297). Man kan ellers merke sig dens temmelig almindelige forekomst i egnene omkring Trondhjemsfjorden, hvor den almindelig naar en høide av 3—4 m., saaledes f. eks. Strinden, Frosta, Stjørdalen, Levanger og Inderøen. Den gaar langs kysten fra Ørlandet til Valdersund og Helgelandskysten, saaledes Løvø, Tjøtta, Dønna og Alstenøen. Den findes ved Leines ytterst i Meisfjorden og i Dunderlandsdalen indtil ca. 450 m. o. h. et par mil fra riksgrænsen. Den er endvidere fundet paa Fiskvaagfjeldet i Saltdalen og ved Prestkontindens fot i Steigen 67° 55—56', dens nordgrænse. Man bør merke sig at den i Nordland særlig holder sig paa kalkgrusbund. Litteratur: — Blytt: Norges Flora, s. 552, Schübeler: Virid. Norv. I, s. 598, Norman: Norges Arktiske Flora I, s. 937 og II, s. 486, O. Dahl: Bot. Undersøkelser i Helgeland I, s. 175.

I den forbindelse her omhandlede plante ved denne anledning drages frem, kan vi ikke gi os til at diskutere dens forekomst ut over hele jordflaten, men det har dog en betydelig interesse at kaste et ganske kort tilbakeblik paa dens utbredelse inden de nærmest tilgrænsende landomraader.

Naar vi lar ute av betragtning den gamle og kanske ikke helt sikre findestedsangivelse fra Indviken i Nordfjord, saa ser vi at dens nuværende forekomst i Norge er meget karakteristisk og bestemt avgrænset. Gaar vi saa over til vort naboland i øst, Sverige, saa finder vi den her og der meget almindelig langs den Botniske Bugts sandede strandkanter fra Haparanda helt ned til Roslagen, hvor den dog i Uppland gaar en halvfjerde mil ind i landet. Men som Högbom sier: „Hippophaë rhamnoides (haftorn) som numera växer i Norrland endast vid kusten, men, såsom flera fynd i kalktuffer utvisa, fordom förekommit i västra Norrland" (Norrland, naturbeskrifning, 1906, pag. 335). Desuten angives en enkelt forekomst ved Gullmarsfjorden i Bohuslän. Og gaar vi over til den anden side av den Botniske Bugt, saa finder vi den i Finland som en kystplante paa samme maate som i Norrland fra Torneå til omegnen av Nystad, hvor sydgrænsen falder ute i skjærgaarden i „regio aboensis". Og her sammenbindes den finske forekomst med den svenske ved den av PALMGREN beskrevne rike forekomst av arten paa Alandsøene (Hippophaës rhamnoides auf Aland, Helsingfors 1912). Den mangler fuldstændig i det europæiske Rusland med undtagelse av et par noget tvilsomme findesteder i Kurland, men saa optrær den ofte i mandshøide paa den tyske Østersjøkyst. Og man kunde nok med KÖPPEN spørge: „warum er im südwestlichen Finland wächst und dann, das westliche Estland, Livland und Oesel überspringend, erst wieder in Kurland auftritt?" KÖPPEN slutter sig saa til NATHORSTS hypotese, at dens forekomst sammen med Dryas i norrlandske kalktuffer viser dens alpine karakter, og at den derfor er trængt ned til kysten av senere indvandrede planter. Det er til denne anskuelse ogsaa HÖGBOM har sluttet sig: „hvad förklaringen af nu vidrörda växtgeografiska företeelse angår, så synes det vara antagligt, att dessa växter förut haft ett mera sammanhängande utbredningsområde, men att de blifvit sprängda genom förändrade geografiska och klimatologiska förhållanden och därmed följande invasioner af nya florelement" (Norrland, naturbeskrifning, 1906, pag. 335). GUNNAR ANDERSSON synes derimot at ha sluttet sig til den av HANSEN fremhævede betragtningsmaate: „Ich habe schon, wo die Verbreitungswege der arktisch-alpinen Flora besprochen wurden, hervorgehoben, wie von dem früher eisfreien Land im Westen dieselbe sich gegen Osten verbreitet. Diese Verbreitung talaufwärts von der milderen Westküste der Halbinsel aus ist während der ganzen Spätquartärzeit in bedeutendem Umfange weitergegangen, besonders in gewissen Gebieten und während des Temperaturmaximums. Die Pässe lagen teils infolge des wärmeren Klimas, teils wegen der Landsenkung biologisch um rund ca. 300 m. niedriger als heutzutage. Besonders im nördlichen Skandinavien haben wir aus dieser Ursache in unseren Tagen von vielen Pflanzen nicht weniger als drei verschiedene, der Längsaxe der Halbinsel parallel verlaufende Verbreitungsgebiete" (Résultats scientifiques du Congrès International de Botanique Vienne 1905, pag. 79), og derpaa utvikler han dette sammesteds i tekst og kartografisk som 1) Atlantisches Gebiet, 2) Alpentäler-Gebiet, 3) Bottnisches Gebiet, og tilføier: „in einigen Fällen, wie Hippophaë rhamnoides, kann die Art in einem von dem drei Gebieten ganz ausgestorben sein, wird aber fossil gefunden" (l. c. pag. 79).

HALLE, der diskuterer artens forekomst i de jemtlandske kalktuffer, anfører saavel NATHORSTS opfatning av disse som tidligere liggende nærmere kysten som den ogsaa ovenfor anførte sprængningsteori med hensyn til vegetationsforholdene. Desuten omtaler han ogsaa ANDERSSONS anskuelse: „Hippophaë har med björkskogen spridt sig öfver Sverige till norra Skandinaviens såväl kust- som fjälltrakter. Från dessa har den genom de jämtländska och lappländska fjällpassen utbredt sig utefter floddalarna till Atlantiska hafvets stränder. På grund af förhållanden, som det ännu icke är möjligt att med bestämdhet afgöra, har arten troligen under senare delen af furens tid äfven utdött i Norrlands centralare delar" (cfr. ogsaa ANDERSSON: Svenska Växtvärldens Historia, 1896, pag. 27—29), og videre fortsætter Halle: „Vad Hippophaës vertikala utbredning i tufferna angår, har ett rätt märkligt förhållande framgått ur undersökningen av de ovan beskrivna avlagringarna. Hippophaës vertikala utbredning i de undersökta kalktufferna inom nordöstra delen av kalktufområdet sammanfallar i stort sett med *Dryas*, d. v. s. arten är inskränkt till de undre delarna av tufferna" (Sveriges geol. unders. Årsbok 8, 1914, No. 1, pag. 38—39). Og Halle synes nærmest at stanse ved den ogsaa av tidligere forfattere fremhævede „ståndortens avgörande betydelse — — — underlägsenheten i konkurrensen med andra former jämte en stor plasticitet i förhållande till klimatet" (l. c. pag. 40) som betingelse for den eiendommelige utbredelse. Og han finder da at „ur denna synpunkt synes associationen *Dryas—Hippophaë* lätt förklarlig och naturlig. Det är i båda fallen den rikliga tillgången på nytt land vid isens recession och issjöarnas avtappning, som varit bestämmande. Särskilt är det klart, att synnerligen gynnsamma växtplatser måste ha stått *Hippophaë* till buds utmed issjöarnas stränder, där de successiva avtappningarna framkallade nya landvinningar. Genom dessa avtappningar nåddes alltså samma resultat som genom den pågående landhöjningen vid Bottniska viken" (l. c. pag. 40). Og Halle kommer med den forresten meget fornuftige bemerkning: „för övrigt är det ju möjligt — då det är ovisst, om vi känna den alra första flora, som tog landet i besittning — att *Hippophaë* inkommit något efter *Dryas* liksom den sannolikt kvarlevat längre" (l. c. pag. 41). Men naar han saa direkte fortsætter: „på grund av klimatets snabba förbättring behöver i alla händelser tidsskillnaden ei hava varit lång" (l. c. pag. 41), saa berører han med en gang netop et av de punkter hvor jeg, paa grund av den maate hvorpaa den kvartærgeologiske utvikling viser sig at ha fundet sted i vort land, har set mig nødsaget til at stille mig i skarp opposition til den svenske kvartærgeologiske forsknings resultater med hensyn til tidsspørsmaalet.

Og til en nærmere belysning av dette forhold igjen blir det nødvendig at vi fortsætter vor undersokelse av *Hippophaës* nuværende forekomst i syd og sydvest for om mulig at bli istand til at se dens utbredelsesforhold under en noget anden synsvinkel, i lys av fund jeg gjorde av denne merkværdige plante i kalktuffen ved Gillebu forrige aar, og hvorav jeg leverte en foreløbig oversigt under titelen „Norges største Kalktuf" (Aftenposten, 1917, Nr. 440), likesom jeg ogsaa i en senere artikel „Vor planteverdens utspring og dens utbredelse til det nuværende omraade" (Trondhjems Adresseavis, 8de april 1918) har behandlet det samme emne paa en mere korrelativ maate, om end rent populært. En mere systematisk fremstilling saavel i geografisk som geologisk henseende har jeg netop under trykning i „Norsk Geologisk Forenings Tidsskrift".

Der ligger i grunden en skjæbnens og utviklingens ironi deri, at Halle og nærværende forfatter, som anskuer de her omhandlede forhold saa vidt forskjellig, dog kan enes om følgende, som Halle har formet side 41 i sin allerede ovenfor citerte avhandling: „De edafiska förhållanden, som medförde, att arter med väsentligen så olika utbredning som *Dryas* og *Hippophaë* kunna i så stor utsträckning förekomma tillsammans i kalktufferna, äro påtagligen ganska analoga med dem, som göra att nordliga och sydliga former mötas i de s. k. sydbergen. Det torde därför kunna anses vara mer än en tillfällighet, att båda de nämnda arterna ingå i den bekanta sydbergsfloran från Junkerdalsuren i Saltdalen" (cfr. DYRINGS avhandling i Nyt Mag. f. Naturv. B. 37, 1900, pag. 297 og 298).

Vi stanset ovenfor med *Hippophaës* forekomst paa den tyske Østersjøkyst. Den mangler fuldstændig paa den tyske Nordsjøkyst, men forekommer paa de Østfrisiske øer, hvor den i det 19de aarhundrede har utbredt sig mot øst uten dog at naa Spiekeroog og Wangeroog. Paa Borkum, som jeg besøkte sommeren 1910, fylder den hele dynedale, som den gjør ganske ufarbare, og truer der med at bli en virkelig landeplage. Paa de Nordfrisiske øer mangler den. I Danmark er den almindelig i klitterrænget nord for Limfjorden, findes enkelte steder inde i landet, hist og her paa østkysten samt spredt og sjelden paa den sydlige vestkyst, likeledes paa Moens Klint og paa Skagens nordstrand. Gaar vi videre mot sydvest og vest, finder vi den meget almindelig paa Hollands og Belgiens dyner og kyster og videre „in Britain, very local, and only near the seacoasts of some of the eastern and southern counties of England" (BENTHAM & HOOKER: Handbook of the British Flora, 1912, pag. 389), saaledes f. eks. i York, Norfolk, Suffolk, Sussex (WATSON: Topographical Botany, 1883, pag. 361).

Dermed har vi vundet et grundlag for en videre betragtningsmaate av den arts utbredelsesomraade og utbredelsesmaate. Og der kan nok være grund til med HALLE at opkaste følgende spørsmaal: „då *Dryas* i kalktufferna säkerligen är av västligt ursprung, kan man fråga sig, om ej också *Hippophaë* kan ha inkommit på samma väg" (Sveriges geol. unders. Årsbok 8, 1914, no. 1, pag. 42). Nu, vi har i det foregaaende set HALLES anskuelse, der slutter sig temmelig nøie til PALMGRENS, ANDERSSONS og WARMINGS (Acta Soc. pro Fauna et Flora Fennica, B. 36, 1912, no. 3, pag. 32), eller i det hele en østlig og sydlig oprindelse. Selv fremhæver han ogsaa den alternative karakter i følgende: „från Nordsjöns södra kusttrakter bör arten ha kunnat sprida sig till norra Skandinavien lika lätt utmed Norges västkust som genom Sverige och kan i så fall från Trondhjemstrakten över fjällpassen ha inträngt till Issjölandet. En senare spridning efter isens bipartition ned för älvarna till Bottniska viken bör ha kunnat gå för sig lättare än en vandring i motsatt riktning" (Sveriges geol. unders. Årsbok 8, 1914, no. 1, pag. 42). Og videre indgaar i samme ramme fortsættelsen: „det är möjligt, att den fossila förekomsten på Gottland er en framskjuten utpost av denna sydliga invandringsström. Däremot är det ej bevisat, att arten spritt sig vidare upp utefter kusten" (l. c. pag. 42). Samtidig gjør ogsaa HALLE opmerksom paa „att en positiv strandförskjutning allvarligt måste hota artens bestånd och i de flesta fall utrota den" (l. c. pag. 43). Og det er vel da i samklang med HALLES hele betragtningsmaate naar han herigjennem fremhæver: „det är möjligt, att *Hippophaë* på detta sätt utrotats utmed södra Sveriges Östersjökust under Ancylus- och Littorinatransgressionerna“ (l. c. pag. 43).

Det turde vel i denne forbindelse være paa sin plads at minde om det forhold HALLE omtaler fra kalktuffen ved Filsta, hvor *Hippophaë* forekommer „i undre delen av tuffavlagringen“, men hvor, som han sier: „*Dryas* lyckades jag trots ivrigt letande ej återfinna här, men däremot gjordes helt nära ett fynd, som synes visa, att arten förekommit i närheten av lokalen en avsevärd tid innan den bekanta tuffavlagringen började bildas“ (l. c. pag. 44).

Som det vil fremgaa av den ovennævnte avhandling, som jeg nu har under trykning, „Kalktuf i Norge“, saa faar vi *Hippophaës* optræden i Gillebutuffen i et geologisk temmelig nøie bestemt nivaa. Ti hvad vort lands indlandsavsætninger viser, sammenstillet med vore gamle havavsætninger, er følgende generelle geologiske hovedtræk:

Havavsætninger:	Indlandsavsætninger:
Portlandia-nivaa	Brægrus og bræelvavsætning
Littorina-nivaa	Rustfarvet ler uten fossiler
Pholas-nivaa	Bjerke-tuf
Mactra-nivaa	Dryas-tuf og ler
Tapes-nivaa	Furu-tuf
Trivia-nivaa	Forvitring og mulddannelse
Ostræa-nivaa	{ 1. Mulddannelse 2. Erosion (gruskegle)
Mya-nivaa	Tør nutid med forvitring

Og her viste det sig ved Gillebu at *Hippophaës* forekom helt til bunden av bjerketuffen. Naar vi saa erindrer fundet av *Dryas* i ældre avsætning i vort land og HALLES uttalelse om *Dryas* og *Hippophaës* relative alder ved Filsta, saa ser vi der er den bedste overensstemmelse palæontologisk-stratigrafisk set. Men saa vet vi fra Leine at vi har en *Dryas-tuf* yngre end bjerketuffen og atter en furutuf yngre end Dryas-tuffen. Og efter furutuffens avsætning har der fundet saavel forvitring som erosion sted, som muldlag og furutufblokker sammen med andre tufblokker viser os i gruskeglen ved Tingvold.

Et enkelt fossilfund av en art er jo ikke meget, men det kan allikevel ofte faa en noksaa stor betydning, som i dette tilfælde med henblik paa forekomsten av *Hippophaës* i Gillebutuffen. Kaster vi nemlig nu blikket paa et kart over den nuværende og tidligere forekomst av denne art, saa blir billedet for Skandinaviens vedkommende et helt andet end det før opdagelsen av denne forekomst var.

Der synes nemlig ikke at være tvil om at *Hippophaës* inden de tre omraader hvorfra den kjendes som fossil: Gottland, Jemtland og Gudbrandsdalen, med hensyn til indvandring tilhører væsentlig i det store og hele set omtrent samme tid, *Pholas-nivaaets*. Om vi saa ser disse i et helhetsbillede som bindeled mellem de to kystomraader for dens forekomst i nutiden i det nordlige Skandinavien, nemlig paa den norske kyst og om den Botniske Bugt, saa ser vi de fossile forekomster danne en naturlig forbindelse, ikke efter nogen bestemt linje over det hele omraade i sydvestlig retning med de mere spredte forekomster i syd og sydvest. De teoretiske betragtninger over forskjellige indvandringsveier fra syd og sydvest til de forskjellige omraader av den skandinaviske halvø kan saaledes for denne arts vedkommende ikke opretholdes. Og større værd har heller ikke resultatet av de spekulationer som har fundet utformning i vandring, snart den ene vei, snart den anden vei, over fjeldpassene mellem det Trondhjemske og omgivelsene av den Botniske Bugt.

Det hele viser os tvertimot et klart billede av en tidligere sammenhængende langt større utbredelse av *Hippophaës* end den nutiden frembyr, forsaavidt det gjælder det skandinaviske omraade. Og billedet viser os mere, nemlig at denne utbredelse har været av karakteristisk sydvestlig oprindelse. Den synes derfor at være paa det nøieste sammenknyttet med den her omhandlede periodes hele klimatpræg, der var av utpræget sydvestlig karakter. Det er det vestbritiske faunaselskap *Pholas candida-komplekset* som vi gjenfinder i vore leravsætninger fra den tid saavel inden Kristianiafeltet som inden Trondhjemsfeltet. Det er derfor heller ikke helt utelukket, at de nordlige grænser for artens nuværende utbredelse er noget snævrere end de var paa den tid.

Det vigtigste resultat turde ligge deri, at utbredelsen, fremrykning og tilbakegang, ogsaa for *Hippophaës* sees at omfatte ganske bestemte landomraader i sin helhet fuldstændig overensstemmende med forandringen i de klimatologiske forhold, som heller ikke bevæger sig kun efter nogen bestemt optrukne linjer, men indbefatter større klimatiske provinser der i sin helhet styres av klimatologiske lover, lovbestemte forandringer i temperatur og nedbør, eller som jeg for en tid siden i en artikel, „Fimbulkulde“ (Aftenposten 1918, 21de April, Nr. 198) søkte at vise at dette helt enkelt kan tilbakeføres til forandringer i lufttrykkets fordeling over jordoverflaten, og at dette er et helt generelt forhold der kan følges fra nutidens rent empiriske iagttagelsesrækker tilbake gjennem den historiske tid og sagntiden helt til de store jordperioder med ogsaa deres klimatiske vekslinger, der da som nu var av samme overordentlig store betydning for det organiske livs utbredningsformer, planter saavel som dyr, end ikke mennesket undtat.

Trykt 18. oktober 1921.

STUDIER OVER CIRRIPEDIENES FYLOGENETISKE SLEGTSKAPS-FORHOLD

AV

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(Videnskapsselskapets Skrifter. I. Mat.-naturv. Klasse 1921 No. 13)

KRISTIANIA
I KOMMISSION HOS JACOB DYBWAD
1921

Fremlagt i den mat.-naturv. klasses møte den 15de april 1921 ved prof. H. H. Gran.

A. W. BRØGGERS BOKTRYKKERI A/S

Et gjennemsyn av litteraturen om cirripediene viser os at man endnu er et godt stykke borte fra en velbegrundet dom om gruppens avstamning, og man finder ogsaa at meningene om hvilke av de nulevende former man maa anse som de mest oprindelige, er ganske delte. DARWINS klassiske monografi over gruppen (1852—53) indeholder vistnok ikke nogen klart formulert dom; men saa meget fremgaar dog av fremstillingene, at vi kan se at han anser *Oxynaspis* eller denne slegtstype som meget primitiv, og at han utleder de øvrige cirripedier fra den. En diametralt motsat opfatning blev fremholdt av P. P. C. HOEK (1883) i hans bearbeidelse av cirripediene fra »Challenger«; han anser *Mitella (Pollicipes)* som alle nulevende cirripediers stamform. Da *Mitella* har flere skeletplater end alle andre cirripedier, maa derfor efter hans teori alle andre slegter være opstaat gjennem en sukcessiv reduktion av plateantallet. HOEK baserer væsentlig sin opfatning paa de palæontologiske data, og da særlig derpaa, at *Mitella* er den av de nulevende slegter som er fundet tidligst i jordens historie, om end bare kort før *Scalpellum*. GRUVEL adopterer i sin monografi (1905) HOEKS teori og føier ind i stamformenes rækker de utdødde slegter *Turrilepas* og *Loricula* med deres platerike skeletter, trods rækkefølgen geologisk set her ikke helt stemmer. Ganske nylig har ogsaa KRÜGER (1920) fastholdt HOEKS teori paa samme grundlag.

Studiet av skeletutviklingen hos *Scalpellum Strømii* førte mig (1912) til det resultat, at DARWINS opfatning bedre lar sig forene med den postembryonale utvikling end HOEKS teori, og i en netop offentliggjort foreløbig notis om utviklingen av *Mitella* (1921) har jeg fundet at maatte hævde det samme standpunkt, om end med en liten reservation. Senere har jeg ogsaa hat anledning til at studere andre arters utvikling og morfologiske forhold under mit arbeide med de rikholdige samlinger av cirripedier som den danske forsker, curator ved universitetets zoologiske museum i Kjøbenhavn dr. TH. MORTENSEN har bragt hjem fra sin reise i Stillehavets forskjellige egne 1914 og 1915 og med stor elskværdighet stillet til disposition for mine undersøkelser.

Naar vi trækker en sammenligning med de fleste andre krebsdyr, vil det være vanskelig at fastholde at utskillelsen av kalkskeletter er et primært træk; dette rent teoretiske ræsonnement vil med engang kaste et tvilsomt skjær over den hypotese som opstiller de former som har det sterkeste kalkpanser, som stamformene for hele gruppen. Derimot er det likesaa klart at netop slike sterkt bepansrede dyr har ulike større sandsynlighet for at bevares som fossiler end dyr med et tyndt eller kanske helt chitinøst skelet uten kalkinkrustationer; forsteningenes fylogenetiske bevisværdi blir derfor betydelig svækket i det foreliggende tilfælde. Man er derfor nødt til at søke efter bevisene ad andre veier, og der er da ingen tvil om, at der er flere ting som taler mot end for teorien om at de cirripedier som har det største antal plater i sit skelet, er de fylogenetisk ældste inden hele gruppen. Det er tilstrækkelig at holde sig til de stilkete cirripedier — Darwins familie *Lepadidae* — i dette tilfælde; der er ingen tvil om at de i sin hele organisation er mere oprindelige end de øvrige fritlevende former og danner utspringet for disse.

I alle de tilfælder hvor det er lykkedes at studere de stilkete cirripediers postembryonale utvikling helt ut, viser det sig at cyprislarven eller puppestadiet, som det ogsaa nævnes, først danner fem chitinplater eller »primordialplater«, som Darwin har kaldt dem, nemlig dorsalsidens uparrede carina og paa sidene de parrede terga og scuta. Dette holder ogsaa stik i slegter som *Mitella* og *Scalpellum*, hvor den voksne form har et skelet bestaaende av mange flere plater. Disse chitinøse primordialplater er fylogenetisk av betydelig større interesse end Hoek og Gruvel synes at ha været opmerksomme paa. De viser os, at cirripedienes stamformer har hat fem chitinplater eller chitinfortykkelser i kappen før de utviklet sin nuværende evne til at utskille kraftige kalkplater; det tyder ogsaa utpræget i retning av at de akcessoriske plater som ikke er chitinpræformert, er en senere akkvisition.

Vi kommer paa denne maate tilbake til Darwins hypotese, men med det forbehold, at stamformen neppe vil findes hverken blandt de nulevende arter eller blandt de cirripedier som har efterlatt sig spor i forsteningene; den har hat fem chitinplater paa capitulum, men neppe anden antydning av de skeletplater man ellers finder paa capitulum og paa stilken hos mange av cirripediene. Vi maa derfor forkaste teorien om at *Mitella* er en stamform for nutidens cirripedier, og kommer derved ogsaa til at maatte foreta adskillige ændringer i de fylogenetiske og systematiske linjer som er optrukket av Hoek, Gruvel, Pilsbry og Annandale. Jeg skal her søke at gi et billede av den opfatning som studiet av dr. Mortensens samlinger fører frem til; disse samlinger synes at være mere systematisk indsamlet end de fleste andre, og der er lagt en betydelig vegt netop paa de smaa former og utviklingsstadier som synes at være borte i tidligere indsamlede materialer.

Hvis vi tar et overblik over krebsdyrenes kolossale gruppe i sin helhet, falder det i øinene at hermafroditismen ikke alene er en undtagelse, men at den er et sekundært fænomen og beror paa særlige biologiske tilpasninger. I analogi hermed maa vi anse cirripedienes hermafroditisme som en sekundær tilpasning til deres fastsittende levevis og gaa ut fra at deres forfædre har hat adskilte kjøn, sandsynligvis ogsaa like høit organiserte hanner og hunner.

Vi finder i KRÜGERS sidste avhandling (1920) gjentat det gamle postulat at »Als ursprüngliche Geschlechtsform müssen wir bei Tieren die hermaphroditische ansehen«. Det er en gaate, hvorfor dette aksiom skal søkes gjort gjældende for hver stor eller liten dyregruppe i særdeleshet. Allerede i de primitivere grupper opgives hermafroditismen, og det er uforklarlig, hvordan man da ved hver høiere dyregruppe kan hævde at dens stamformer atter skal maatte ha været hermafroditer. Hos krebsdyrene er hermafroditismen, hvor den optrær, et tydelig sekundært fænomen som nævnt. Da vi nu ikke kan gaa ut fra andet end at cirripediene har sit utspring hos en eller anden krebsdyregruppe av de mere primitive, tvinges vi til at benegte postulatets gyldighet her.

KRÜGER kommer til den slutning, at dverghannene hos cirripediene er en sekundær akkvisition; denne slutning gir sig dels av det nævnte postulat, dels av teorien om at *Mitella* er en av de ældste former og ren hermafrodit. Han overser at *Scalpellum* synes at være næsten likesaa gammel i de geologiske fund, trods denne slegt er en dypvandsslegt med spredt optræden, mens *Mitella* med sit kraftigere skelet er en strandform og derfor har større sandsynlighet for at optræ blandt forsteningene. Hos *Scalpellum* optrær dvergmænd dels som »erstatningsmænd« hos hermafroditer og dels som dvergmænd paa rene hunlige individer.

Efter HOEKS teori gaar utviklingen fra *Mitella* gjennem *Calantica* og *Smilium* til *Scalpellum*. Det blir da en uforklarlig selvmotsigelse at dvergmændene hos *Calantica* og *Smilium* viser en betydelig høiere organisation end hos *Scalpellum*, at altsaa den nye biologiske tilpasning er høiest utviklet hos de mest primitive gjennemgangsformer. Det blir ikke lettere at forstaa hvordan den aberrante slegt *Ibla* ogsaa har en dverghan at opvise. KRÜGER forklarer dette ved en ny hypotese, som bringer ham selv i opposition mot det førnævnte postulat; han hævder nemlig at *Mitella* og *Scalpellum* allerede i oversilur paa grund av sin fastsittende levevis »wieder hermaphroditisch geworden waren«. Der maa altsaa i cirripedienes utvikling ogsaa efter KRÜGERS mening ha været indskutt et fylogenetisk interregnum med særkjønnete individer.

Er dette rigtig, og der er som nævnt al mulig grund til at hævde det, saa maa vi søke de mest primitive former blandt dem som har de høiest organiserte dvergmænd. Alle er enige i at av slegtene *Calantica, Smilium* og *Scalpellum* maa *Calantica* anses som mest primitiv. Det har derfor sin store interesse at merke sig, at dr. MORTENSEN har bragt hjem fra farvandene ved Ny Zealand en ny art som jeg har tillat mig at kalde *Calantica Mortenseni* efter opdageren, og som har en forholdsvis stor dverghan med det bedst utviklede skelet som endnu er fundet hos nogen cirriped. Den har en *Scalpellums* komplette platetal. Dette viser os dels at nævnte slegt er meget primitiv, dels at reduktionen av hannen først er indtraadt efterat dyrene alt har naadd frem til et høit utviklingstrin. Der maa altsaa ha forekommet en hel utviklingsrække av mellemformer mellem *Calantica* og den hypotetiske stamform med sine fem chitinplater.

Idet nu en av de akcessoriske plater i nedre række forskyves op og emanciperer sig for at indgaa som fast komponent i øvre række, kommer vi over i slegten *Smilium*, hvor hannens reduktion skrider fremad og danner overgangen til *Scalpellum*, hvor hannene reduceres til nogen smaa forplantningssække eller helt forsvinder, og utviklingen fører videre op til den nye slegt *Scalpellopsis*[1], hvor en reduktion av den nedre platerække har fundet sted paa ventralsiden av dyret. Begge de sidstnævnte slegter skiller sig fra *Calantica* og *Smilium* ved at mangle dorsalsidens akcessoriske subcarina.

Teoretisk maatte man nu forutsætte, hvis *Calantica* er stamformen for *Mitella*, at der maa ha eksistert mellemformer, d. v. s. *Mitella*-lignende cirripedier med dverghanner. Naar man betænker, at *Mitella* er en slegt som ialfald har eksistert siden silurtiden, vil man forstaa min overraskelse da jeg i dr. MORTENSENS materiale fandt denne mellemform repræsentert i nogen faa eksemplarer fra Plimmerton og Slipper Island, Ny Zealand; det er en strandform som jeg har fundet at maatte stille i en egen slegt *Protomitella*[2]. Hvis ikke dverghannene var tilstede, vilde man utvilsomt indordnet arten i slegten *Mitella*, og jeg kan ikke benegte muligheten av at det er denne art som har dannet grundlaget for HUTTONS *Mitella (Pollicipes)* DARWINI; men dette spørsmaal kan først avgjøres ved studiet av originaleksemplarene, som findes i de australske museer. Hannen viser her

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[1] *Scalpellopsis* n. gen. Capitulum med 9 eller 11 plater: rostrum og rostral latus mangler, inframedium latus rudimentær, carinal latus velutviklet. Superior latus indskutt mellem carina, tergum og scutum. Stilken med kalkplater. — Hermafroditer uten dvergmænd. Type: *Scalpellopsis striatociliata* n. sp. kjendelig ved sine kransstillede haar paa capitulum.

[2] *Protomitella* n. gen. Capitulumplatene talrike, av to slags. Carina, terga, scuta og rostrum velutviklede, ofte ogsaa superior latus og subcarina. De nedre latera lange og smale, fingerformige og meget talrike. Stilkens skelet smaa, sammentrængt stillede pigger. — Dverghannen med carina, terga, scuta og rostrum; akcessoriske plater kan forekomme. Type: *Protomitella paradoxa* n. sp.

noksaa nær samme forhold som hos *Calantica*; men den optræer tydelig i et faatal og varierer i sin skeletutvikling, et tegn paa at den er under degeneration.

Fra *Protomitella* fører et kort skridt over til *Mitella*, hvis individer er hermafroditer; her er hannene helt forsvundet. En anden slegt som morfologisk staar meget nær *Mitella*, er *Lithotrya*, hvor ogsaa dverghannene mangler; her er de øvre stilkskjæl kraftigere utviklet, men tilhører tydelig stilkens skelet og er ikke gaat ind i capitulumskelettet som hos *Mitella*.

Herhen hører da ogsaa den gaatefulde slegt *Ibla*, hvis utvikling desværre er daarlig kjendt. I denne slegt er der ikke nogen kalkinkrustation av skelettet; dette bestaar for capitulums vedkommende bare av terga og scuta; utviklingsstadier av slegten var i dr. MORTENSENS materiale bare at finde av en liten dvergart fra farvandene ved Ny Zealand, *Ibla pygmaea* n. sp., og deres diminutive størrelse tillot ikke med sikkerhet at fastslaa forekomsten av en embryonal carina, selv om den synes at vise sig under visse belysninger. Stilkskelettet repræsenteres av chitinhaar, som hos en av artene igjen forsvinder hos fuldt utvoksede individer. Naar man tar hensyn til de forskjelligheter som betinges av tilstedeværelsen og manglen paa kalkdannelser, blir dog forskjellen mellem *Ibla* og *Protomitella* temmelig liten, og dertil har *Ibla* beholdt en relativt høit organisert dverghan undtagen hos *Ibla pygmaea*, hvor hannen stanser sin utvikling paa cyprisstadiet med et par ualmindelig store sammensatte øine ved siden av naupliusøiet.

Inden vi forlater denne gruppe av slegter, skal vi se litt paa om man kan finde en forklaring for dvergmændenes optræden. Denne maa søkes i slegtenes biologiske forhold. Vi skal da først se paa de slegter som har dverghanner. *Calantica*, *Smilium* og *Scalpellum* er, stort set, dypt levende former hvis individer sjelden optræer sammenhopet i større ansamlinger; skrapetrækkene bringer sjelden mere end et par individer op av samme art. En undtagelse danner nogen enkelte *Scalpellum*-arter, og det er da netop hos disse, man av og til har kunnet fastslaa at dverghannene helt er forsvundne. Denne enkeltvise optræden vilde da utelukke krydsbefrugtninger i de fleste tilfælder om ikke hannen var bibeholdt. Det samme ræsonnement passer for *Ibla*, trods arten lever grundt. For *Protomitella* mangler vi endnu alle biologiske data; den er en strandform, men dens upaaagtethet synes at tyde paa at den ikke er særlig hyppig, og da dr. MORTENSEN i alt bare har tat med 5 individer, mens han av almindeligere arter altid har sikret sig et større materiale, antar jeg at ha lov til at slutte at den ikke lever i store samfund. Paa den anden side er hannene tydelig sjeldne;

om dette er et temporært fænomen, eller om det er et konstant forhold, maa fremtidige undersøkelser avgjøre.

Hvor vi kjender de biologiske forhold for de andre slegter, er de ganske andre. *Mitella* er en strandform som lever i tætte ansamlinger. Noget lignende synes at gjælde for *Lithotrya*; men da den fører en mere skjult tilværelse, er dens biologiske forhold endnu litet opklaret; vi faar haabe at den projekterte tropestation vil løse denne opgave blandt mange andre. For *Scalpellopsis'* vedkommende kan nævnes at denne dypere levende art bare er fundet en eneste gang nede ved Philippinerne, men da i stort antal paa en enkelt hydroidekoloni. Saavidt vi kan bedømme det, trænges der altsaa her ingen adskilte kjøn for at sikre krydsbefrugtningen, og følgelig er her dverghannene forsvundet helt.

Den gruppe av pedunkulate cirripedier vi har betragtet hittil, bestaar av en række nært beslegtede genera, som alle har to grundtræk fælles, nemlig for det første at deres stilk er forsynt med skelet; dette stilkskelet forsvinder hos den utvoksne *Ibla quadrivalvis* Cuv. og mangler helt hos *Calantica affinis* n. sp. fra Philippinerne, saavidt jeg har kunnet finde; imidlertid maa for sidstnævnte art merkes at utviklingsstadiene er ukjendt. Det andet træk som forener alle de nævnte slegter, er at carina, terga og scuta samtlige har apikalt stillet vekstcentrum, som bare hos en del *Scalpellum*-arter sekundært forskyves nedover mot midten av carina hos ældre individer.

Hos alle de andre pedunkulate cirripedier mangler ethvert spor av stilkskelet, og scuta og carina viser en fundamentalt forskjellig vekst, idet her umbo er basalt beliggende. Hos to slegter — *Oxynaspis* og *Megalasma* — blir umbo for scutums vedkommende gjennem en eiendommelig vridning av basalkanten sekundært forlagt et stykke opover langs forkanten, men naar ikke halvveis op mot apex, og hos *Oxynaspis* ser vi en paralel foreteelse til *Scalpellum*, idet umbo sekundært forskyves opover under den senere vekst, uten at den dog naar midten av carina.

De to skillemerker kan høres smaa ut; men specielt den fundamentalt forskjellige vekstretning hos primordialplatene maa tillægges stor vegt, saa stor at man er berettiget til at basere en familiegrænse paa den. Hele den gruppe av slegter som hittil er behandlet, danner da familien *Scalpellidae*.

Den anden gruppe er *Lepadidae* i nyere forstand. Her kan vi se bort fra dverghannene, da saadanne ikke er paavist hos nogen av slegtene. Platetallet er fem eller færre, og vi maa da gaa ut fra at den av dem som staar stamformen nærmest, maa være i besiddelse av de fem primordiale plater. Vi har da at vælge mellem slegtene *Oxynaspis, Lepas, Poecilasma, Megalasma* og *Octolasmis*. Hos sidstnævnte slegt er der som følge av biologiske forhold indtraadt en svakere eller sterkere reduktion av skelettet ved en underlig opsplitning av platene, saa den kan med én gang sættes ut av betragtning. *Oxynaspis* blev av DARWIN anset som meget primitiv; men jeg kan ikke følge ham heri: *Oxynaspis* viser paa den ene side forskyvninger av vekstcentrene hos scuta og carina, og at dette paa den anden side er sekundært, antydes ogsaa av slegtens eiendommelige symbioseforhold med Antipatharier, et træk som ikke kan være primitivt. Dr. MORTENSENS materiale indeholder komplette utviklingsserier av *Megalasma*, og da de tydelig viser at vekstcentrets forskyvning langs den ventrale kant av scutum ogsaa her er et sekundært fænomen, som først indtrær senere i utviklingen, kan heller ikke denne slegt anses som primitiv.

Vi har altsaa borteliminert alle slegter paa to nær, og studiet av disse to — *Lepas* og *Poecilasma* — gir for nærværende ingen grund til at anse den ene som mere primitiv end den anden. De staar hverandre meget nær, saa nær endog at DARWIN gjør undskyldning fordi han skiller dem ad. Senere tider har ved den større vegt man nu tillægger f. eks. munddelenes struktur, ydet DARWIN sin tribut for hans skarpsyn ved at trække skillet mellem de to slegter. De er utvilsomt utgangspunktene for de andre Lepadid-slegter, og det synes at være likesaa sikkert at man ikke kan avlede dem fra nogen av *Scalpellidae*-familiens former.

Studiet av munddelene gir os her to konvergente utviklingslinjer. Fra *Lepas* har slegten *Conchoderma* utviklet sig ved reduktion av platenes forkalkede partier, og tilpasningen til livet som manetbeboer gjennem en komplet forsvinden av alle plater undtagen en liten chitinrest av scutum fører til slut op til *Gymnolepas*.

Inden den anden gruppe av slegter finder vi at *Poecilasma* gjennem reduktion av kalkutskillelsen gaar over i slegten *Octolasmis* og videre til *Heteralepas*-artene, hvor platene helt er forsvundet, eller hvor i det høieste en chitinøs rest av scutum har formaadd at persistere. Hvilke biologiske forhold som har betinget utviklingen av *Heteralepas*, kan man endnu ikke bedømme, trods der er kjendt adskillige arter av denne slegt.

Megalasma er ved flere overgangsformer saa tæt knyttet til *Poecilasma* at man har vanskelig for at trække en tydelig grænse mellem de to slegter, og munddelene hos *Oxynaspis* tyder paa at ogsaa denne slegt staar nærmere ved *Poecilasma* end ved *Lepas*; dens leveomraade er da ogsaa i bedste overensstemmelse med *Poecilasma*.

Det er ikke uten interesse selv ved en saa gammel gruppe som cirripediene er, at se om man i de geografiske forhold kan finde sammenhæng med de fylogenetiske linjer som andre studier av gruppen gir. Mens nu *Lepadidae* for samtlige slegter viser en temmelig uniform utbredelse gjennem alle varmere have, gir *Scalpellidae* et meget interessant zoogeografisk billede. *Calantica*, den mest primitive av dem, lever hovedsagelig i de indomalayisk-østaustralske farvand i noget større dybder. Dens ætlinger *Smilium*-artene har spredt sig videre ut og optrær med hovedmassen i den indopacifike regions varmere have; dertil har den specialisert ut en egen artgruppe i Atlanterhavets dypere partier. Dypvandsslegten *Scalpellum* er rent kosmopolitisk, men har, sandsynligvis i meget ny tid, utkrystallisert slegten *Scalpellopsis* i det indomalayiske arkipel. *Protomitella* er en Ny-Zealandsk strandform; *Mitella* har spredt sig ut langs alle tropehavenes strandpartier, mens *Ibla* holder sig samlet i det indomalayisk-østaustralske havomraades grundere partier. *Lithotrya* endelig har spredt sig ut i tropehavenes grunde regioner jorden rundt. De geografiske forhold tyder altsaa bestemt i retning av at *Scalpellidae* er opstaat i det indomalayiske omraade, hvor de ogsaa nu har sin sterkeste repræsentation, og herfra har de saa spredt sig ut mere eller mindre i forhold til sine specielle livskrav, og under en mere eller mindre livlig artsdannelse paa grund av de tillempninger som det enkelte livsomraade har fremtvunget.

Trykt 24. oktober 1921.

BIDRAG TIL KJENDSKAPET TIL TRØNDELAGENS RUSTFLORA

AV

IVAR JØRSTAD

(VIDENSKAPSSELSKAPETS SKRIFTER. I. MAT.-NATURV. KLASSE. 1921. NO. 14)

KRISTIANIA
I KOMMISSION HOS JACOB DYBWAD
1921

Fremlagt i den mat.-naturv. klasses møte den 3dje juni 1921 ved prof. H. H. GRAN.

A. W. BRØGGERS BOKTRYKKERI A/S

Nedenfor har jeg forsøkt at gi en oversigt over de hittil kjendte findesteder for rustsopper i Trøndelagen, dog saaledes at i nord Namdalen (saavel indre som ytre) og i syd Opdal med Dovretrakten ikke er tat med. Angivelsene er for den aller største del basert paa mine egne indsamlinger, som især er foretat i 1918, for en mindre del ogsaa i 1917 og 1920. Hvor i teksten intet andet er angit, er vedkommende materiale indsamlet av mig. Det befinder sig nu i Universitetets botaniske samlinger.

De steder hvor jeg har hat anledning til at gjøre mere grundige indsamlinger, er følgende: Trondhjems nærmeste omegn, Tydalen, Frosta, Leksviken, Verran og Aafjorden. Noget har jeg endvidere samlet i Aalen, Holtaalen, Meraker, Hegre, Stjørdalen, Hommelvik, Levanger, Inderøen, Rissen, Skjørn, Ørlandet, Bjugn og Jøssund.

Det lille der ellers er indsamlet av rustsopper inden distriktet, er likeledes for det meste opbevaret ved Universitetets samlinger, hvor jeg har hat anledning til at undersøke det. Det materiale der er ældre end 1896, og som væsentlig er indsamlet av R. T. Nissen og H. Bryn, er tat med i Blytt's: Bidrag til kundskaben om Norges soparter IV. Her nævnes i alt voksesteder inden distriktet for 30 rustarter, mot 96 i nærværende fortegnelse. I litteraturen er det forøvrig meget litet at finde om trønderske rustsopper, men det som foreligger er for fuldstændighetens skyld tat med i denne oversigt.

Det er klart at nærværende arbeide bare gir et yderst ufuldkomment billede av rustfloraen i Trøndelagen. Naar jeg desuagtet gaar til offentliggjørelse av det, saa er det fordi jeg antar at der neppe foreløbig vil bli gjort yderligere indsamlinger av rustsopper i Trøndelagen, og fordi ikke alene det søndenfjeldske Norge, men ogsaa Nordland og Finmarken hittil har været betydelig bedre undersøkt med hensyn paa sin rustflora end Trøndelagen. Denne landsdel har derfor dannet en lakune i vort kjendskap til rustsoppenes utbredelse i Norge.

Omtrent en tredjedel av de nedenfor opførte 96 arter, i alt 33, har sin hittil kjendte nordgrænse inden distriktet. I fortegnelsen er disse merket med *. Sandsynligvis vil dog ved nærmere undersøkelse de fleste av disse vise sig at gaa endnu længere mot nord.

Baade med hensyn til nomenklatur og rækkefølge har jeg i det væsentlige fulgt SYDOW's Monographia Uredinearum.

Puccinia PERS.

1. *P. carduorum* JACKY.

Carduus crispus. Ladehammeren ved Trondhjem, Brekstad paa Ørlandet, Frosta.

*2. *P. centaureae* MART.

Centaurea scabiosa. Loksteinhaugen paa Frosta

*3. *P. cirsii lanceolati* SCHROET.

Cirsium lanceolatum. Munken ved Trondhjem og Selbu (H. BRYN 1886), Frosta, Verran mell. Voldset og Skjelstad, Salberg st. i Inderøen; paa Frosta fandtes i 1918 pyknider 26. juni og et andet sted æcidium sammen med uredo 27. juni.

4. *P. suaveolens* (PERS.) ROSTR.

Cirsium arvense. Frosta. Nær Sakshaug paa Inderøen.

5. *P. cirsii* LASCH.

Cirsium palustre. Nær Monstad i Aafjorden. Hoven i Verran

C. heterophyllum. Trondhjems omegn (iflg. SCHROETER 1886 sub *P. hieracii* (SCHUM.) MART.), Trollaveien ved Trondhjem, Hilmo i Tydalen, O + II 10. juli 1918, Meraker, Frosta, Tun i Verran, Leksviken, Aarnes og Amunddalen i Aafjorden.

6. *P. major* DIET.

Crepis paludosa. Tydalen: Hilmo samt mell. Skarpdalsvolden og Øivolden, Verran: Tun, Grande, mell. Sollien og Verrabotn samt mell. Røstjernet og Voldset, Aafjorden: Aarnes og Amunddalen.

7. *P. hieracii* (SCHUM.) MART.

Hieracium auricula. Frosta, Aarnes i Aafjorden.

H. pilosella. Asenø i Jøssund.

Hieracium sp. Nær Gilsaa i Meraker, Hommelvik i Malvik, ved Grønsjøen i Leksviken, Tun i Verran, Aafjorden: Aarnes og Amunddalen, Uthaug paa Ørlandet, Froøene (R. NORDHAGEN 1915).

Hieracium cfr. murorum. Ved Liavandet paa Frosta, O + II 4. juli 1918, Tun i Verran, O + II 29. juni 1918.

*8. *P. lampsanae* (SCHULTZ) FUCK.

Lampsana communis. Vaagen paa Frosta.

9. *P. leontodontis* JACKY.

Leontodon autumnale. Frosta, Aarnes i Aafjorden.

10. *P. mulgedii* SYDOW.

Mulgedium alpinum Vaarvik i Modalen ved Trondhjem (H. BRYN 1886), Halsjøfjeld i Meraker, Leksviken, Verran: Tun samt mell. Røstjernet og Voldset, Langløfta i Aafjorden.

*11. *P. virgaureae* (D. C.) LIB.

Solidago virgaurea. Trollaveien ved Trondhjem, Frønes i Aafjorden, Valdersund og Asenø i Jøssund.

12. *P. variabilis* GREV.

Taraxacum officinale. Inderøen: Salberg samt mell. Norum og Sakshaug, Ørlandet: Østraat samt mell. Uthaug og Grande, Sæter i Bjugn, Aarnes i Aafjorden, Valdersund i Jøssund.

13. *P. taraxaci* (REBENT.) PLOWR.

Taraxacum officinale. Meraker, Frosta, ved Grønsjøen i Leksviken, Aarnes og Amunddalen i Aafjorden.

T. croceum. Ved Skarpdalsvolden i Tydalen, O + II 8. juli 1918, Meraker: mell. Gilsaa grube og Skarpdalsvolden.

14. *P. campanulae* CARM.

Campanula rotundifolia. Loksteinhaugen paa Frosta. Søndenfor Saltdalen er denne art ellers kun fundet i Granvin i Hardanger.

*15. *P. punctata* LINK.

Galium verum. Ladehammeren ved Trondhjem, O + I 20. juni 1918, Ørlandet, I 24. juni 1918.

*16. *P. deminuta* VLEUGEL.

Galium uliginosum. Frosta, II + III 31. aug. 1917.

*17. *P. rubefaciens* JOHANS.

Galium boreale. Svartdalsbækken ved Tun i Verran. Er nærmest en alpin form, som tidligere ikke var kjendt nordenfor Dovre.

18. *P. Porteri* PECK.

Veronica alpina. Ved Skarpdalsvolden i Tydalen.

*19. *P. menthae* PERS.

Calamintha acinos. Frosta, bl. a. I + II 26. juni 1918, Oldervik i Verran.

20. *P. chaerophylli* Purt.

Anthriscus silvestris. Lein paa Frosta, Ørlandet, I + II + III 24. juni 1918, Frønes i Aafjorden.

21. *P. pimpinellae* (Strauss) Link.

Pimpinella saxifraga. Ladehammeren ved Trondhjem, Asenø i Jøssund, Aarnes i Aafjorden, Agle i Snaasen (A. Notø 1916).

*22. *P. epilobii tetragoni* (D. C.) Wint.

Epilobium montanum. Trondhjem (R. T. Nissen 1893), Lensviken (H. Bryn), Frosta, Aarnes i Aafjorden.

23. *P. epilobii* D. C.

Epilobium montanum. Ladehammeren ved Trondhjem.

E. Hornemanni. Nord-Aune i Holtaalen.

24. *P. violae* (Schum.) D. C.

Viola riviniana. Ladehammeren ved Trondhjem, Hilmo i Tydalen, Frosta, Verran: Tun og Snertvik, Salberg st. i Inderøen.

V. canina. Beian paa Ørlandet, Aarnes i Aafjorden, Tun i Verran.

25. *P. alpina* Fuck.

Viola biflora. Trondhjem (Rostrup iflg. Blytt 1896 p. 57).

26. *P. Fergussoni* Berk. & Br.

Viola palustris. Tydalen, Frosta, Verran: Tun samt paa fjeldet mell. Aafjorden og Røstjernet, Aafjorden: Aarnes og Amunddalen.

27. *P. geranii silvatici* Karst.

Geranium silvaticum. Tydalen: Hilmo samt mell. Skarpdalsvolden og Øivolden, Leksviken, Grande i Verran. Synes væsentlig at optræde subalpint.

28. *P. Morthieri* Koern.

Geranium silvaticum. Nord-Aune i Holtaalen, Hilmo i Tydalen, Trollaveien ved Trondhjem, Frosta, ved Grønsjøen i Leksviken, Salberg st. i Inderøen, Verran: Tun, mell. Røstjernet og Voldset samt mell. Verrabotn og Sollien, Aafjorden: Aarnes, Amunddalen og paa fjeldet mell. Amunddalen og Verran.

29. *P. ribis* D. C.

Ribes rubrum (culta). Rennebu (iflg. T. H. Schøyen 1918 p. 62), Trondhjem (Lagerheim 1893), Rotvold paa Strinna, »herjet meget voldsomt« (W. M. Schøyen 1892 samt iflg. do. 1891 p. 24 og 1892 p. 32), Malvik (iflg. T. H. Schøyen 1915 p. 80), Stenkjær (iflg. W. M. Schøyen 1907 p. 33), Aafjorden: Aarnes og prestegaarden.

30. *P. saxifragae* SCHLECHT.

Saxifraga stellaris. Ved Lillefjeld grube i Meraker.

31. *P. Holboelli* (HORNEM.) ROSTR.

Arabis hirsuta. Ramsø i Modalen ved Trondhjem (H. BRYN 1886), Snaasen (R. T. NISSEN 1893).

32 *P. fusca* (PERS.) WINT

Anemone nemorosa. Frosta, nær Gilsaa i Meraker, Snertvik i Verran, Aafjorden: Fjeldet mell. Amunddalen og Verran, Stod (R. T. NISSEN 1893).

*33. *P. Zopfii* WINT.

Caltha palustris. Prestegaarden paa Frosta, III 21. aug. 1917, I + II 26. juni 1918 og II + III 15. juli 1918, Amunddalen i Aafjorden, II + III 29. juli 1918.

Paa Ørlandet fandt jeg 24. juni 1918 paa Caltha et isolert æcidium, som muligens tilhører enten *Pucc. calthae* LINK eller *Pucc. Zopfii.* Iflg. LIRO (1908 p. 250) er der forresten en mulighet for at *Pucc. Magnusiana* KOERN. paa Phragmites ikke alene danner æcidier paa Ranunculus repens, men ogsaa paa Caltha palustris. Jeg har selv i Borre gjort iagttagelser som tyder paa det samme, idet 1.—2. juni 1918 æcidier paa Caltha blev paatruffet i umiddelbar nærhet av gammel III av *Pucc. Magnusiana*, mens ingen saaes paa Ran. repens.

34. *P. arenariae* (SCHUM.) WINT.

Stellaria nemorum. Mell. Røstjernet og Voldset i Verran, Frønes i Aafjorden.

35. *P. bistortae* (STRAUSS) D. C.

Angelica silvestris. Østraat paa Ørlandet.

Polygonum viviparum. Trondhjem (H. LANGBERG 1879), Ladehammeren ved Trondhjem, Tydalen, Meraker nær smelteverket samt mell. Gilsaa grube og Skarpdalsvolden, Frosta, Tun i Verran, Rissen (H. BRYN), Høibakken i Skjørn, Ørlandet og Bjugn, Valdersund i Jøssund, Aafjorden: Aarnes og Amunddalen.

36. *P. septentrionalis* JUEL.

Thalictrum alpinum. Røros (J. HOLMBOE 1906), Tydalen: Fjeldet ovenfor Hilmo samt ved Skarpdalsvolden, Meraker: ved Gilsaa samt mell. Gilsaa grube og Lodølja, Rissen (H. BRYN), Ervik i Bjugn (O. A. HOFFSTAD 1897).

Polygonum viviparum. Rissen (H. BRYN).

*37. *P. acetosae* (SCHUM.) KOERN.

Rumex acetosa. Trollaveien ved Trondhjem, Uthaug paa Ørlandet, ved Monstad i Aafjorden. Kun uredo iagttat.

*38. *P. obscura* SCHROET.

Luzula campestris. Frosta, II.

39. *P. caricis* REBENT. Syn. *P. Pringsheimiana* KLEB.

Urtica dioica. Trondhjem (ROSTRUP iflg. BLYTT 1896 p. 45), Frosta, Norum i Inderoen, Bjugn, Valdersund i Jøssund.

Ribes grossularia. Trondhjem (iflg. W. M. SCHØYEN 1910 p. 34 og 1911 p. 47 samt T. H. SCHØYEN 1913 p. 53), Frosta: Hernesøren og Vikaleret, Høibakken i Skjørn, Ørlandet, Valdersund i Jøssund. Kan optræde ganske ondartet paa bærene av de kultiverte stikkelsbærbusker.

Ribes rubrum (culta). Kroen i Leksviken, Ørlandet.

Carex Goodenoughii. Frosta, prestegaarden i Aafjorden.

C. panicea. Munken ved Trondhjem (H. BRYN 1886), Frosta.

Det lar sig ikke avgjøre om ovenanførte eks. paa Carex Goodenoughii og C. panicea virkelig tilhører *Pucc. caricis* eller muligens en anden av de paa Carex forekommende rustarter.

40. *P. dioicae* P. MAGNUS.

Cirsium palustre. Frosta: Valbergskogen og Prestegaardsskogen.

Carex dioica. Frosta: Valbergskogen, II + III 13. juli 1918 sammen med æcidier paa Cirsium palustre.

41. *P. silvatica* SCHROET.

Taraxacum officinale. Frosta, Inderøen: Rol samt mell. Norum og Sakshaug, Ørlandet: Østraat samt mell. Uthaug og Grande, Sæter i Bjugn, Valdersund i Jøssund, Aarnes i Aafjorden.

Carex leporina. Frosta, II + III 30 aug. 1917.

42. *P. vaginatae* JUEL.

Saussurea alpina. Døsvik paa Ørlandet, I 23. juni 1918 med Carex panicea voksende i umiddelbar nærhet, Trevassheia i Verran, pyknider 30. juli 1918, Sulunesset i Aafjorden, gammel I 22. juli 1918, med rustbefængt Carex panicea i umiddelbar nærhet.

Carex panicea. Sulunesset i Aafjorden, II + III 22. juli 1918.

*43. *P. paludosa* PLOWR.

Pedicularis palustris. Svedjan i Meraker, pyknider 7. juli 1918.

*44. *P. graminis* PERS.

Berberis vulgaris. »Ikke kjendt længer nord end Trondhjem« (W. M. SCHØYEN iflg. HENNING 1915 p. 11), Ladehammeren ved Trondhjem, Korsnesset paa Frosta, Nesset ved Levanger, æcidier 11. sept. (A. NOTØ 1910).

Avena sativa. Prestegaarden paa Frosta.

Agropyrum repens. Lademoen i Trondhjem (H. LANGBERG 1879).

*45. *P. coronata* CDA.

Rhamnus frangula. Frosta, Snaasen (A. NOTØ 1916).

Agrostis vulgaris. Frosta: Lokstein og Valbergskogen, Askjærholmen i Aafjorden. Kun uredo iagttat.

*46. *P. glumarum* (SCHMIDT) ERIKSS. & HENN.

Hordeum sativum. Iflg. W. M. SCHØYEN (1892 p. 16) gjorde i 1890 *Pucc. rubigo vera* skade paa bygaakrene især i Leinstranden og Børsen, tildels ogsaa i Strinna og Buviken. Rusten viste sig igjen i 1892, men syntes da ikke at optræde saa voldsomt. Prøve paa angrepne bygaks fra Langørjan i Buviken, indsendt 1. okt. 1892 av foged Petersen og nu i Universitetets botaniske samlinger, viser at angjældende rust er *Pucc. glumarum*. Kun uredo fandtes paa denne prøve. — Høsten 1921 optraadte *Pucc. glumarum* atter paa byg i Trøndelagen. Sterkt angrepne prøver blev nemlig indsendt 16. aug. av fylkesgartner Håve i Stjørdalen, og mindre sterkt angrepne 19. sept. av B. Holan i Værdalen. Ogsaa paa disse prøver saaes kun uredo.

Lolium sp. Iflg. J. BRUNCHORST (1888 p. 12) var der i 1887 et meget sterkt angrep av *Pucc. straminis* paa Lolium paa en enkelt eng i Rennebu. Hvilken rustart dette gjælder, er uklart, skjønt det sandsynligste er at det har været *Pucc. glumarum*. Denne er ellers ikke fundet paa Lolium-arter i Norge.

*47. *P. holcina* ERIKSS.

Holcus lanatus. Froøene: Bogø, 11 aug. 1915 (R. NORDHAGEN).

*48. *P. agrostidis* PLOWR.

Aquilegia vulgaris. Holmberget paa Frosta.

49. *P. poarum* NIELS.

Tussilago farfara. Trondhjem (ROSTRUP iflg. BLYTT 1896 p. 45), Ladehammeren ved Trondhjem, Meraker, Frosta, Leksviken, Verran: Tun samt mell. Verrabotn og Sollien, Inderøen, Hasselviken i Rissen. Ørlandet og Bjugn, Aarnes i Aafjorden.

Poa nemoralis. Ladehammeren ved Trondhjem, Frosta, Tun i Verran, Rol i Inderøen. Kun uredo iagttat.

Poa pratensis. Aarnes i Aafjorden, II.

Poa glauca. Frosta, II.

Poa jemtlandica. Meraker: Lillefjeld og Kluken, II (O. A. HOFFSTAD 1895).

Poa annua. Frosta, II.

Anthoxanthum odoratum. Ladehammeren og Trollaveien ved Trondhjem, Frosta, Leksviken, Asenø i Jøssund. Formen paa Anthoxanthum (*Uredo anthoxanthina* Bubak) er kun kjendt i uredostadiet, men da dette ikke lar sig skille morfologisk fra det tilsvarende stadium av *Pucc. poarum,* tør det være rigtigst at forene de to former.

50. *P. actaeae agropyri* ED. FISCHER.

Actaea spicata. Frosta.

51. *P. subalpina* LAGERH.

Aconitum septentrionale. »Trondhjems stift« (H. BRYN), ved Grønsjøen i Leksviken, mell. Verrabotn og Sollien i Verran.

Uromyces LINK.

52. *U. solidaginis* (SOMMERF.) NIESSL.

Solidago virgaurea. Hommelvik i Malvik, ved Grønsjøen i Leksviken, Verran: Tun samt fjeldet mell. Aafjorden og Røstjernet, Aafjorden: Mælanakken og Amunddalen. Synes væsentlig at optræde subalpint og alpint.

*53. *U. valerianae* (SCHUM.) FUCK.

Valeriana excelsa. Trondhjems omegn (iflg. SCHROETER 1886).

*54. *U. anthyllidis* (GREV.) SCHROET.

Anthyllis vulneraria. Frosta fl. st., II, Snertvik i Verran, II, Valdersund og Asenø i Jøssund, II, Aarnes i Aafjorden, II + III 24. juli 1918.

55. *U. fabae* (PERS.) DE BY.

Vicia sepium. Tun i Verran, II.

*56. *U. loti* BLYTT.

Lotus corniculatus. Lokstein paa Frosta, II 2. sept. 1917 og 2. aug. 1918.

57. *U. trifolii repentis* (CAST.) LIRO.

Trifolium repens. Frosta, II + III 30. aug. 1917 og I + II + III 13. juli 1918, Aarnes i Aafjorden, I + II + III 23. juli 1918.

*57. *U. flectens* LAGERH.

Trifolium repens. Loktu paa Frosta, Aarnes i Aafjorden.

*58. *U. trifolii* (HEDW. F.) LEV.

Trifolium pratense. Frosta, Sakshaug i Inderøen, Jøssund: Valdersund og Asenø, Monstadmoen i Aafjorden. Kun uredo iagttat.

59. *U. geranii* (D. C.) OTTH. & WARTM.

Geranium silvaticum. Trondhjem (R. T. NISSEN 1893), Trollaveien og Ladehammeren ved Trondhjem, Hommelvik i Malvik, Hilmo i Tydalen, ved Grønsjøen i Leksviken, Tun i Verran, Østraat paa Ørlandet, Amunddalen i Aafjorden.

60. *U. alchemillae* (PERS.) LEV.

Alchemilla vulgaris. Trondhjem (ROSTRUP iflg. BLYTT 1896 p. 38). Ladehammeren og Trollaveien ved Trondhjem, Aune i Holtaalen, ved Skarpdalsvolden i Tydalen, Meraker, Frosta, Leksviken, Inderøen, Verran: Tun samt mell. Vestvik og Venneshavn, Høibakken i Skjørn, Ørlandet, Ærvik i Bjugn, Aarnes i Aafjorden.

61. *U. aconiti lycoctoni* (D. C.) WINT.

Aconitum septentrionale. Trondhjems omegn, I + III 3.—4. aug. 1885 (iflg. SCHROETER 1886), Meraker I 2. juli 1887 (ERIKSSON fung. paras. scand. no. 307 a), ved Liavandet paa Frosta, I 4. juli 1918, ved Grønsjøen i Leksviken, I 17. juli 1918, Strømmen paa Inderøen, I 1. juli 1918, Tun i Verran, I 29. juni 1918.

62. *U. ficariae* (SCHUM.) LEV.

Ranunculus ficaria. Frosta, III.

63. *U. polygoni* (PERS.) FUCK.

Polygonum aviculare. Prestegaarden paa Frosta, Salberg i Inderøen, Ørlandet.

63. *U. acetosae* SCHROET.

Rumex arifolius. Sulunesset i Aafjorden, II + III 22. juli 1918

*64. *U. festucae* SYDOW.

Festuca ovina. Frosta, Frønes i Aafjorden.

F. rubra. Frosta, Leksviken.

Aira flexuosa. Asenø i Jøssund.

Saavel paa Festuca-artene som paa Aira flexuosa er kun uredo fundet her i landet, svarende henholdsvis til *Uredo festucae* D. C. og *Uredo airae flexuosae* LIRO. Disse lar sig imidlertid ikke skille morfologisk fra uredostadiet tilhørende *Uromyces festucae* SYD. og bør derfor neppe opretholdes som egne arter.

Gymnosporangium Hedw. f.

65. *G. juniperi* Link.

Sorbus aucuparia. Trondhjem (R. T. Nissen 1893), Ladehammeren og Trollaveien ved Trondhjem, Holtaalen, Eidet i Aalen, Tydalen, Frosta, Leksviken, Levanger, Inderøen, Tun i Verran, Hasselviken i Rissen, Ørlandet, Bjugn, Valdersund i Jøssund, Aarnes og Amunddalen i Aafjorden. Øiensynlig alm. overalt.

S. fennica. Ladehammeren ved Trondhjem, pyknider 20. juni 1918, Holmberget paa Frosta, pyknider 28. juni 1918. I sidstnævnte tilfælde var et asaldtræ meget svakt angrepet, mens en rogn i umiddelbar nærhet hadde bladene bokstavelig dækket av pyknider. Dette tyder paa at asald er forholdsvis motstandsdygtig mot denne rust.

Juniperus communis. Frosta: Rygg 4. april 1920 og Holmberget 6. april 1920. I begge tilfælder vokste vedkommende enerbusker i umiddelbar nærhet av rogn.

*66. *G. tremelloides* Hartig.

Pirus malus. Frosta: prestegaarden 3. juli 1918 og Berg 14. juli 1918, pyknider, prestegaarden i Aafjorden, pyknider 27. juli 1918. Det er muligens ikke usandsynlig at disse pyknider paa eple i virkeligheten tilhører *Gymnosp. juniperi*, som iflg. Eriksson (1919 p. 76) kan frembringe pyknider paa Pirus malus, skjønt rigtignok meget sjelden.

Juniperus communis. Lillevik paa Frosta, 29. mai 1919 (Hj. Moksnes). Iflg. meddelelse fra hr. Moksnes var senere paa sommeren epletrærne i nærheten sterkt befængt med rust.

Phragmidium Link.

*67. *Ph. potentillae* (Pers.) Karst.

Potentilla argentea. Ladehammeren ved Trondhjem (H. Langberg 1879).

P. maculata. Prestegaarden paa Frosta.

68. *Ph. tuberculatum* J. Muell.

Rosa canina (coll.). Trollaveien ved Trondhjem, Frosta, Leksviken, Salberg i Inderøen, Tun i Verran, Aarnes i Aafjorden.

R. villosa (coll.). Venneshavn i Verran (A. CARLSEN 1915), Vanvik (H. BRYN 1886)[1], Valdersund i Jøssund.

R. cinnamomea. Frosta alm., Rol i Inderøen.

Rosa sp. (culta). Aarnes i Aafjorden.

69. *Ph.* **subcorticium** (SCHRANK.) WINT.

Rosa villosa (coll.). Ladehammeren ved Trondhjem, Frosta, Inderøen, Hasselviken i Rissen.

Rosa sp. (culta). Aarnes i Aafjorden.

Kun cæomastadiet blev iagttat.

T. H. SCHØYEN (1914 p. 85) angir *Ph. rosae* paa dyrket rose fra Inderøen. Hvilken av de to Phragmidium-arter paa Rosa som menes hermed, er usikkert.

*70. *Ph.* **perforans** (DIETR.) LIRO.

Rubus saxatilis. Eidet i Aalen, I 11. juli 1918, Korsnesset paa Frosta, I 27. juni 1918, Østraat paa Ørlandet. I 24 juni 1918, Frønes i Aafjorden, I + II + III 25. juli 1918.

71. *Ph.* **rubi idaei** (D. C.) KARST.

Rubus idaeus. Trondhjem (R. T. NISSEN 1893), Trollaveien ved Trondhjem, Rotvold paa Strinna (W. M. SCHØYEN 1892), Hommelvik i Malvik, Frosta alm., Rol i Inderøen, mell. Røstjernet og Voldset i Verran, Aarnes i Aafjorden.

Triphragmium LINK.

72. *T.* **ulmariae** (SCHUM.) LINK.

Ulmaria pentapetala. Trollaveien ved Trondhjem, Hilmo i Tydalen, Frosta, Inderøen, Verran: Grande og Tun samt mell Røstjernet og Voldset, Lysøen i Jøssund (O A. HOFFSTAD 1896), Sulunesset og Amunddalen i Aafjorden. Som oftest manglet den sekundære uredo.

Melampsora CAST.

73. *M.* **tremulae** TUL. (coll.).

Populus tremula. Trondhjem (R. T. NISSEN 1893), Trollaveien ved Trondhjem, Værnes i Stjørdalen, Frosta.

Som cæoma-vert vil formentlig i Trøndelagen væsentlig Pinus silvestris komme i betragtning, desuten sandsynligvis i nogen grad Larix, kanske ogsaa Corydalis fabacea.

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[1] Hos BLYTT (1896 p. 62) opført under *Phr. subcorticium*

74. *M. salicina* Desm. (coll.).

Salix caprea. Trollaveien ved Trondhjem, Frosta, Leksviken.

S. aurita. Trollaveien ved Trondhjem.

S. nigricans. Trollaveien ved Trondhjem, Hommelvik i Malvik, II + III 27. aug. 1917, Tun i Verran.

S. glauca. Leksviken, Amunddalen i Aafjorden.

S. lapponum. Eidet i Aalen, Tydalen: ved Gammelvoldsjøen og ved Usmesjøsæteren, Meraker, Leksviken, ved Røstjernelven i Verran, Amunddalen i Aafjorden.

Med undtagelse av eksemplaret paa Salix nigricans fra Hommelvik henviser ovenstaaende til ikke nærmere bestembar uredo paa Salix-arter. Øiensynlig blir ofte teleutosporer overhodet ikke dannet, og rusten holder sig da fra aar til aar ved hjælp av overvintrende uredomycel i knoppene. I Meraker og Tydalen saaes saaledes i begyndelsen av juli 1918 flere steder sterke rustangrep paa netop utsprungne skud av Salix lapponum, og samtlige blade paa disse skud pleiet da at være rustbefængt.

Formen paa S. nigricans fra Hommelvik har amfigene og subepidermale teleutohoper og turde derfor tilhøre enten *M. larici epitea* Kleb. eller *M. ribesii purpureae* Kleb.

*75. *M. larici caprearum* Kleb.

Salix caprea. Trondhjem, II + III aug. 1893 (R. T. Nissen).

Teleutohoper epifylle og subkutikulare med teleutosporer i toppen sterkt fortykket og forsynt med tydelig spirepore.

Melampsora sp. Syn. *Caeoma laricis* Hartig.

Larix decidua. Trollaveien ved Trondhjem 6. aug. 1918.

Tilhører utvilsomt en Melampsora enten paa Salix eller Populus tremula. I nærheten fandtes ikke nærmere bestembar uredo paa Salix caprea, S. aurita, S. nigricans og Populus tremula (se ovenfor). Følgende arter kunde komme i betragtning: *Melampsora larici caprearum* Kleb., *M. larici epitea* Kleb. og *M. larici tremulae* Kleb.

76. *M. alpina* Juel.

Salix herbacea. Storlifjeld i Meraker, II + III aug. 1895 (O. A. Hoffstad), Mefjeldet i Verran og Grønfjeldet i Aafjorden, II 30. juli 1918.

77. *M. reticulatae* Blytt.

Saxifraga aizoides. Tveraa sæter i Holtaalen 11. juli 1918, ved Skarpdalsvolden i Tydalen 8. juli 1918.

78. *M. lapponum* Lindf.

Viola palustris. Mell. Gilsaa og Lillefjeld gruber i Meraker, 7. juli 1918.

Salix lapponum. Prestegaarden paa Frosta, II + III 29. aug. 1917.

79. *M. lini* (Ehrenb.) Lev.

Linum catharticum. Trondhjem (M. N. Blytt 1826), Frosta, Trangsundet og Oldervik i Verran, Agle i Snaasen (A. Noto 1916), Beian paa Ørlandet (J. Koren), Valdersund og Asenø i Jøssund.

*80. *M. hypericorum* Wint.

Hypericum quadrangulum. Frosta, I 4. aug. 1918.

Melampsoridium Klebahn.

81. *M. betulinum* (Tul.) Kleb.

Betula odorata. Trollaveien ved Trondhjem, Trondhjem, II + III aug. 1893 (R. T. Nisssen), Orkedalen (J. Brunchorst 1887), Hommelvik i Malvik, Frosta, bl. a. II + III 31. aug. 1917. Teleutostadiet synes at optræde forholdsvis sjelden.

Melampsorella Schroet.

82. *M. caryophyllacearum* Schroet.

Stellaria graminea. Guldberget paa Frosta, II 13. juli 1918.

Pucciniastrum Otth.

83. *P. epilobii* Otth.

Epilobium davuricum. Valbergskogen paa Frosta, II 13. juli 1918. Epilobium palustre, som vokste sammen med E. davuricum paa vedkommende sted, var ikke angrepet.

84. *P. pirolae* (Karst.) Schroet.

Pirola minor. Mell. Usmesjøsæteren og Bukkhammeren i Tydalen, Loktumyrene paa Frosta.

P. rotundifolia. Loktumyrene paa Frosta.

P. secunda. Tydalen, Meraker, Tun i Verran.

Kun uredo iagttat.

Thecopsora P. Magnus.

85. *T. areolata* (Fr.) P. Magn.

Picea excelsa. Orkladalføret, sterke angrep i 1913 (iflg. T. H. Schøyen skog 1913 p. 143), Frosta alm., Hegre, Rol i Inderøen, Stenkjær (iflg. W. M. Schøyen 1901 p. 36 sub *Acidium strobilinum* Rees.).

Prunus padus. Trondhjem (Rostrup iflg. Blytt 1896 p. 69 samt R. T. Nissen 1893), Trollaveien ved Trondhjem, Frosta, ved Rol i Inderøen, Tun i Verran, Aarnes og Amunddalen i Aafjorden.

86. *T. vacciniorum* Karst.

Vaccinium uliginosum. Trollaveien ved Trondhjem, Frosta, Tun i Verran, Aafjorden: Mælanakken og Amunddalen.

V. myrtillus. Trondhjem (R. T. Nissen 1893), Trollaveien ved Trondhjem, Tydalen, Frosta, Tun i Verran, Aafjorden: Aarnes og Amunddalen.

V. vitis idaea. Eidet i Aalen, Tydalen, Meraker, Frosta, Tun i Verran.

Kun uredo iagttat.

Milesina P. Magnus.

*87. *M. blechni* Syd.

Blechnum spicant. Geværstenen i Leksviken, II 17. juli 1918.

Hyalopsora P. Magnus.

88. *H. aspidiotus* P. Magn.

Phegopteris dryopteris. Trondhjem (Rostrup iflg. Blytt 1896 p. 68), Trollaveien ved Trondhjem, Eidet i Aalen, Tydalen, Meraker, Inderøen, Verran: Tun samt mell. Røstjernet og Voldset, Ørlandet, Aafjorden: Aarnes og Amunddalen.

Ph. Robertiana. Ved Liavandet paa Frosta.

Kun uredo iagttat.

*89. *H. polypodii* P. Magn.

Cystopteris fragilis. Guldberget paa Frosta, Leksviken.

Kun uredo iagttat.

Chrysomyxa Unger

90. ***C. empetri*** Schroet.

Empetrum nigrum. Trollaveien ved Trondhjem, Eidet i Aalen, Tydalen, Meraker, Frosta, Tun i Verran, Aafjorden: Sulunesset og Amunddalen. Kun uredo iagttat.

91. ***C. pirolae*** Rostr.

Picea excelsa. Strinna og Høilandet 1894, desuten sterke angrep i det trondhjemske 1892 (iflg. W. M. Schøyen 1894 p. 35 sub *Aecidium conorum* Thuem.). I det trondhjemske 1913 (iflg. T. H. Schøyen 1913 p. 143). Trakten om Stenkjær (Haakon Lie 1921).

Pirola minor. Mell. Skarpdalsvolden og Øivolden i Tydalen, II + III 8. juli 1918.

*92. ***C. abietis*** (Wallr.) Unger.

Picea excelsa. Herjer ofte voldsomt i granskogene: I 1908 i sterk grad i det trondhjemske (iflg. W. M. Schøyen skog 1908 p. 161). I 1909 meget utbredt over store deler av Sør-Trøndelag, bl a. i Soknedalen (iflg. do. 1909 p. 206). I 1918 meget utbredt i Trøndelagen (iflg. T. H. Schøyen skog 1918 p 110). Eidet i Aalen, Tydalen, Skjelstadmarken i Hegre, Frosta alm , Tun i Verran. Gjævran ved Stenkjær og Fosnes i Beitstaden (iflg. W. M. Schøyen skog 1907 p. 139).

Cronartium Fries.

93. ***Cronartium sp.*** Syn *Peridermium pini* Willd. forma *corticola*. *Pinus silvestris.* Vestvik i Verran.

Coleosporium Lev.

*94. ***C. tussilaginis*** (Pers.) Lev.

Tussilago farfara. Trondhjem (Lagerheim iflg. Blytt 1896 p. 71), Trollaveien ved Trondhjem.

95. ***C. campanulae*** (Pers.) Lev.

Campanula rotundifolia. Frosta, Leksviken, Asenø i Jøssund, Aarnes i Aafjorden. Kun uredo iagttat.

Ochropsora DIETEL.

96. *O. ariae* (FUCK.) SYD.

Anemone nemorosa. Trondhjem (ROSTRUP iflg. BLYTT 1896 p. 73 sub *Aecidium leucospermum* D. C.), Ladehammeren ved Trondhjem, Frosta, Leksviken, Levanger, Inderøen, Stod (R. T. NISSEN 1893). Østraat paa Ørlandet.

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—[1] Om skadeinsekter og snyltesopp paa skogtrærne. Indberetning 1913.

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—[1] Indberetning om skadeinsekter og sygdomme paa skogtrærne, 1907, 1908 og 1909.

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[1] I teksten benævnt henholdsvis T. H. SCHØYEN skog og W. M. SCHØYEN skog.

Trykt 29. oktober 1921.

LICHENS FROM THE GJOA EXPEDITION

BY

BERNT LYNGE

(VIDENSKAPSSELSKAPETS SKRIFTER. I. MAT.-NATURV. KLASSE. 1921. No. 15)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
IN COMMISSION BY JACOB DYBWAD
1921

Fremlagt i den mat.-naturv. klasses møte den 3dje juni 1921.

A. W. BRØGGERS BOKTRYKKERI A/S

During the Gjøa Expedition under the command of ROALD AMUNDSEN (The North West Passage) also some lichens were collected by the indefatigeable Arctic explorer HENRIK ADOLF LINDSTRÖM. Mr. LINDSTRÖM was not a botanist, and the collection of lichens is not large. But every collection from this almost inaccessible part of the earth is of great interest.

It contained a *Lecidea* n. sp. which I have taken great pleasure in naming after Mr. LINDSTRÖM.

The greatest part of the plants was collected at Gjøa Harbour and at Herschel Island, a few also at King Point.

For geographical particulars see AMUNDSEN, ROALD: The North-West Passage: Being the record of a voyage of exploration of the ship 'Gjøa' 1903—1907. London (Constable) I—II, 1908.

Alectoria ACH.

divergens (ACH.) NYL. Herschel Island, very abundant. Dark decumbent plants are easily mistaken for *A. jubata*, but the positive medullary reaction with $CaCl_2O_2$ is very intense in *A. divergens*.

jubata (L.) NYL. Gjøa Harbour, poor specimens. Better represented from Herschel Island.

nigricans (ACH.) NYL. Gjøa Harbour, and Herschel Island. There are relatively few specimens of this species which in Northern Norway is much more general than *A. divergens*, and the specimens are poorly developed.

ochroleuca (EHRH.) NYL. Herschel Island, well developed.

Bacidia (DE NOTRS.) A. ZAHLBR.

abbrevians (NYL.) TH. FR. Herschel Island, on a dead *Polytrichum*. Low hymenium (50 μ), short, three-septate spores (16—18.5 $\times$ 2.5 μ).

Blastenia (MASS.) TH. FR.

ferruginea var. *cinnamomea* TH. FR. Gjøa Harbour, several small specimens. Concave or plane apothecia, and narrower spores than *B. leucoraea* (*ferruginea*: 16—21 $\times$ 8 μ).

leucoraea. Two small plants from Gjøa Harbour. Apothecia convex, spores rather broad: 18 – 21 × 10 – 11 μ.

This species was recorded from Ellesmereland: Goosefjord, Sec. Norw. Arct. Exp. Fram (1909) p. 30. The plant from Ellesmereland has plane disc and albopruinose margin *(Caloplaca stillicidiorum)*.

Buellia De Notrs

papillata (Somrft.) Arn. Wain. Pitlekai p. 83, ubi syn. Herschel Island, very common, with *Cetraria nivalis, Thamnolia vermicularis, Physcia muscigena,* the two *Caloplacae, Lecanora epibrya* and *Lecanora verrucosa.*

Thallus albissimus, crassus, verrucosus vel etiam papillatus. Apothecia primo plana, margine tenui circumdata, dein mox convexa, margine evanescente. Hymenium 80—100 μ, J. e caeruleo sordide vinosum; hypothecium obscurum, paraphyses facile discretae, apice nigro-capitatae, asci octospori, sporae — saepe angustae — ellipsoideae vel subfarinaceae, 17—26 × 8—10 μ.

These specimens agree well with Sommerfelt's authentic specimens in our herb. The white colour and the thick papillate thallus distinguish it from the *(parasema) muscorum.*

Caloplaca Th. Fr.

jungermanniae (Vahl) Th. Fr. Gjøa Harbour, and Herschel Island, almost everywhere.

Apothecia small, diam. 0.3—0.5 (0.7) mm. — indicating the var. *subolivacea* Th. Fr. Scand. I p. 180 — plane, hymenium 65—90 μ, paraphyses cohaerent only at the adsperse tips, asci 60 – 65 × 25 μ, membrane only slightly incrassate towards the tips, spores 14.5—18.5 × 8 – 11 μ, cell-rooms larger than in *C. stillicidiorum.*

stillicidiorum (Hornem.). Gjøa Harbour, and Herschel Island, on moss, earth, and decayed plants, with the former species, and very common.

Hymenium 50 up to 70 μ, paraphyses cohaerent only at the adsperse tips, asci ovale, membrane very incrassate at the upper end, spores 12 – 16 × 7—9.3, μ somewhat rhomboid, cell-rooms small, polar, with distinct canal.

Spores well developed in either species.

Cetraria Ach.

crispa Ach. Herschel Island.

cucullata (Bell.) Ach. King Point, and Herschel Island, many well developed specimens.

juniperina var. *terrestris* Schaer. Gjøa Harbour, well developed. The plants are densely caespitose, laciniae ± narrow — some of them approach to *C. alvarensis*, but this species is tubulose and more ramose.

The pycnides are but sparingly developed and often sterile, pycnoconidia straight or slightly curvate, cylindrical or somewhat apiculate, 4—6 μ long.

C. juniperina from Ellesmereland (Sec. Arct. Exp. Fram p. 37) is var. *terrestris*.

nivalis (L.) Ach. Gjøa Harbour, King Point, and Herschel Island. Well developed, but sterile.

tenuissima (Schreb.) Fr. A few poorly developed specimens from Gjøa Harbour.

Cladonia (Hill) Wain.

deformis (L.) Hoffm. Station not indicated.

pyxidata var. *neglecta* (Flk.) Schaer. Herschel Island.

Candelariella Müll. Arg.

vitellina (Ehrh.) Müll. Arg. A poor specimen from Gjøa Harbour, on moss. Typically developed, asci multisporous, spores 11—14 × 4—6 μ.

Dactylina Nyl.

arctica (Hook.) Nyl. King Point.

Dufourea (Ach.) Nyl.

ramulosa Hook. A poor specimen from Gjøa Harbour.

Lecanora Ach.

epibrya (Ach.) Nyl. Gjøa Harbour and Herschel Island, very common.

verrucosa (Ach.) Laur. Herschel Island.

Pertusaria glomerata from Ellesmereland: Harbour Fjord and Isaachsen Fjord (Sec. Norw. Arct. Exp. Fram (1909) p. 28) is *Lecanora verrucosa*.

Lecidea (Ach.) Th. Fr.

assimilata Nyl. Gjoa Harbour and Herschel Island.

Berengeriana (Mass.) Th. Fr. Herschel Island.

glomerulosa var. *Wulfenii* (Hepp) Wain. Syn. *elaeochroma* var. *muscorum* (Wulf.) Th. Fr. Scand. p. 545. Gjøa Harbour and Herschel Island, very common.

Lindströmii n. sp.

Crusta *tenuissima* vel subnulla, albida vel pallide cinerea, apothecia *minutissima*, diam. 0.1—0.15 mm., discus *ater*, convexus vel subplanus, epruinosus, margo exclusus.

Hypothecium *omnino incoloratum*. Infra hypothecio gonidia sparsa adsunt, margo thallinus tamen non evolutus. Hymenium angustum, 35—40 μ, paraphyses distinctae, crassae, apice obscure capitatae. Asci pyriformes, octospori. Sporae *minutae* vel *parvae*, 5—6.5 (9) $\times$ 2.5—3.5 μ.

Pycnides non visae.

Gjøa Harbour, at the tips of dead *Saxifraga oppositifolia* tufts, with *Caloplaca stillicidiorum* and *C. jungermanniae*.

The few gonidia under the hypothecium might indicate a *Lecanora*. But the habitus is Lecideine or Biatorine. The structure of the apothecia calls to mind *Lecidea (Biatora) septentrionalis* Th. Fries Scand. p. 475, which, however, has a better developed darker thallus and much larger apothecia (ca. 1 mm.).

Leptogium (Ach.) S. Gray.

saturninum (Dicks.) Nyl. Herschel Island, well developed.

Ochrolechia.

tartarea (L.) Mass. Gjøa Harbour, abundant.

The reaction is K ÷ in some specimens, in others a reddish colour is visible, and a few plants take an intense red colour.

Parmelia (Ach.) De Notrs

vittata (Ach.) A dark brown specimen from Herschel Island. Plants from Ellesmereland: Beitstadfjord and King Oscar Land: Harbourfjord and Goosefjord, named *Parmelia physodes* (Sec. Norw. Arct. Exp. Fram (1909) p. 36) are *P. vittata*.

Peltigera WILLD.

erumpens (TAYL.) WAIN. A few plants from Herschel Island.

Physcia (SCHREB.) WAIN.

muscigena (ACH.) NYL. Gjøa Harbour and Herschel Island, very abundant. Well developed, also fertile specimens, agreeing entirely with Norwegian plants (spores 24—32 × 12—15 μ). The two *Caloplaca* species often grow on the thallus of this lichen; a parasite is common on the thallus. (3-septate dark spores, 16—18.5 × 9 μ)

Ramalina ACH.

Almquistii WAIN. Pitlekai p. 17. Herschel Island.

My plants agree entirely with WAINIOS authentic specimens. This indicates a very wide distribution.

Rinodina (MASS.) STIZ.

roscida (SOMRFT.) One small plant from Herschel Island.

Stereocaulon SCHREB.

alpinum LAUR. King Point, and Herschel Island, very common. The plants from King Point have more incise phyllocladia and approach to *S. paschale*.

Toninia (MASS.) TH. FR.

syncomista (FLK.) TH. FR. Gjøa Harbour and Herschel Island. The former plant with typical 3 septate spores, the latter has quite as frequently one- or two-septate spores, cfr. TH FR. Scand. p. 336.

Thamnolia ACH.

vermicularis (SW.) ACH. Gjøa Harbour, King Point, and very plentifully from Herschel Island.

Printed October 26th, 1921.

UEBER DEN THUESCHEN SATZ

VON

CARL SIEGEL

(Videnskapsselskapets Skrifter. I. Mat.-naturv. Klasse. 1921. No. 16)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
IN KOMMISSION BEI JACOB DYBWAD
1922

Fremlagt i den mat.-naturv. klasses møte den 24de sept. 1920 ved prof. Thue.

A. W. BRØGGERS BOKTRYKKERI A/S

In meiner Inaugural-Dissertation (Göttingen 1920) habe ich den Satz von Thue über die Annäherung an algebraische Zahlen durch rationale verschärft und andererseits die Untersuchung auf Approximation durch beliebige algebraische (anstatt rationale) Zahlen ausgedehnt. Diese Verallgemeinerung auf beliebige Zahlkörper erfordert jedoch längere Hilfsbetrachtungen, welche beim Körper der rationalen Zahlen wegfallen; daher möchte ich hier den kürzeren Beweis für letzteren Fall ausführen.

Meine Verschärfung des Thueschen Satzes lautet:

Für jede reelle ganze algebraische Zahl ξ vom Grade $n \geqq 2$ hat die Ungleichung [1]

$$\left|\xi - \frac{x}{y}\right| \leqq \frac{1}{y^{2\sqrt{n}}}$$

nur endlich viele Lösungen in ganzen rationalen Zahlen x, y $(y > 0)$.

Dem Beweis gehen drei Hilfssätze voraus:

Hilfssatz 1.

Es sei ξ eine reelle ganze algebraische Zahl des Grades $n \geqq 2$; es seien r und s zwei natürliche Zahlen, und zwar $s \leqq n-1$; es sei $0 < \vartheta < 1$. Dann gibt es

1) zwei von ξ, r, s, ϑ abhängige Polynome $F(x, y)$ und $G(x, y)$ von den Graden [2]

(1) $$m = \left[\left(\frac{n+\vartheta}{s+1} - 1\right) r\right]$$

---

[1] Ich werde den Satz sogar für den Exponenten $\min\limits_{\lambda = 1, \ldots n} \left(\frac{n}{\lambda+1} + \lambda\right) + \theta$ (anstatt $2\sqrt{n}$) mit beliebigem festen $\theta > 0$ beweisen; — diese Zahl ist $\leqq \sqrt{4n+1} - 1 + \theta$, also $< 2\sqrt{n}$ für hinreichend kleines θ, und kleiner als der Thuesche Exponent $\frac{n}{2} + 1 + \theta$ für $n \geqq 7$.

[2] Grad bedeutet bei Polynomen nicht den »genauen« Grad. Für reelles x bedeutet $[x]$ die größte ganze rationale Zahl $\leqq x$. Die durch (1) erklärte ganze rationale Zahl m ist $\geqq 0$.

in x, s in y, und $m+r$ in x, $s-1$ in y, mit ganzen Coefficienten aus dem durch ξ erzeugten Körper K,

2) ein ebenfalls von ξ, r, s, ϑ abhängiges nicht identisch verschwindendes Polynom $R(x, y)$ vom Grade $m+r$ in x, s in y mit ganzen rationalen Coefficienten,

3) zwei nur von ξ, ϑ und nicht von r, s abhängige positive Zahlen c_1, c_2

mit folgenden Eigenschaften:

I) Es gilt identisch in x, y

(2) $$(x-\xi)^r F(x, y) + (y-\xi)\, G(x, y) = R(x, y),$$

II) jeder Coefficient von $R(x, y)$ ist absolut $< c_1^r$,

III) wird für jede Zahl ϱ der Reihe $0, 1, \ldots r-1$

(3) $$F_\varrho(x, y) = \sum_{\lambda=0}^{\varrho} \binom{r}{\varrho-\lambda} (x-\xi)^\lambda \frac{\partial^\lambda F(x, y)}{\lambda!\, \partial x^\lambda},$$

(4) $$G_\varrho(x, y) = \frac{\partial^\varrho G(x, y)}{\varrho!\, \partial x^\varrho},$$

(5) $$R_\varrho(x, y) = \frac{\partial^\varrho R(x, y)}{\varrho!\, \partial x^\varrho}$$

gesetzt, so ist

(6) $$(x-\xi)^{r-\varrho} F_\varrho(x, y) + (y-\xi)\, G_\varrho(x, y) = R_\varrho(x, y),$$

(7) $$\begin{cases} |F_\varrho(x, y)| < c_2^r (1+|x|)^m (1+|y|)^s \leqq c_2^r (1+|x|)^{m+r} (1+|y|)^s, \\ |G_\varrho(x, y)| < c_2^r (1+|x|)^{r-\varrho-1} (1+|y|)^{s-1} \leqq c_2^r (1+|x|)^{m+r} (1+|y|)^s. \end{cases}$$

Beweis:

Es sei a eine natürliche Zahl. Es gibt genau

(8) $$N = (2a+1)^{(m+r+1)(s+1)}$$

verschiedene Polynome $P(x, y)$ vom Grade $m+r$ in x, s in y, mit ganzen rationalen Coefficienten vom absoluten Betrage $\leqq a$. Ich setze

$$\frac{\partial^\lambda P(x, y)}{\lambda!\, \partial x^\lambda} = P_\lambda(x, y) \qquad (\lambda = 0, \ldots r-1);$$

dann ist jeder Coefficient von $P_\lambda(x, y)$ absolut

$$\leqq \binom{m+r}{\lambda} a < \sum_{\nu=0}^{m+r} \binom{m+r}{\nu} a = 2^{m+r} a.$$

Im Folgenden bedeuten $c_3, c_4, \ldots$ natürliche, nur von ξ, ϑ abhängige Zahlen; mit dieser Bezeichnung gilt für die Zahl $P_\lambda(\xi, \xi)$ und alle Conjugierten

$$|P_\lambda(\xi, \xi)| < 2^{m+r} a (1 + c_3 + \ldots + c_3^{m+r-\lambda})(1 + c_3 + \ldots + c_3^s) < c_4^{m+r+s} a,$$

oder, da nach (1)

$$m + r + s \leqq \frac{n+\vartheta}{s+1} r + s < \frac{n+1}{2} r + n < c_5^r,$$

(9) $$|P_\lambda(\xi, \xi)| < c_6^r a = t.$$

Nun sei speciell $a = \left[\left(\frac{3}{2} c_6^r\right)^{\frac{n}{\vartheta}}\right]$. Dann ist wegen (1) und (8)

(10) $$N = (2a+1)^{\left(\left[\frac{n+\vartheta}{s+1} r\right]+1\right)(s+1)} > (2a)^{(n+\vartheta)r} > (2a)^{nr} \left(\frac{3}{2} c_6^r\right)^{\frac{n}{\vartheta}\vartheta r} =$$
$$= (3 c_6^r a)^{nr} = (3t)^{nr}.$$

Von den zu K conjugierten Körpern seien $K^{(1)}, \ldots K^{(r_1)}$ reell und die Paare $K^{(r_1+\nu)}, K^{(r_1+r_2+\nu)}$ ($\nu = 1, \ldots r_2$; $r_1 + 2r_2 = n$) conjugiert complex[1]. Bedeutet α eine der r ganzen algebraischen Zahlen $P_\lambda(\xi, \xi)$ ($\lambda = 0, \ldots r-1$), so wird durch die Gleichungen

(11) $\alpha_\nu = \alpha^{(\nu)}$ für $\nu = 1, \ldots r_1$; $\alpha_\nu + i\alpha_{r_2+\nu} = \alpha^{(\nu)}$ für $\nu = r_1+1, \ldots r_1 + r_2$

diesem α ein System von n reellen Zahlen $\alpha_1, \ldots \alpha_n$ zugeordnet. Für jedes Polynom $P(x, y)$ entsprechen daher den r Zahlen $P_\lambda(\xi, \xi)$ insgesamt nr reelle Zahlen, also ein Punkt eines nr-dimensionalen Raumes; und zwar liegt nach (9) jeder der N Punkte, die den N Polynomen zugeordnet sind, in einem festen Würfel der Kantenlänge $2t$. Diesen Würfel zertrenne ich in $(3t)^{nr}$ congruente Teilwürfel von der Kantenlänge $\frac{2}{3}$; dann ist wegen (10) für mindestens zwei Polynome P^* und P^{**} der zugehörige Punkt in oder auf demselben Teilwürfel gelegen. Mit Rücksicht auf die Definition (11) der Coordinaten gilt also

$$|P_\lambda^*(\xi, \xi) - P_\lambda^{**}(\xi, \xi)| \leqq \tfrac{2}{3}\sqrt{2} < 1 \qquad (\lambda = 0, \ldots r-1)$$

[1] r_1 oder r_2 kann auch 0 sein.

für sämtliche Conjugierten von $P_\lambda^*(\xi,\xi) - P_\lambda^{**}(\xi,\xi)$. Die Norm dieser ganzen algebraischen Zahl ist demnach absolut <1, und daher ist sie 0. Folglich fehlen in der Taylorschen Entwicklung von $P^* - P^{**} = R$ nach Potenzen von $x-\xi$ und $y-\xi$ die Glieder mit $(x-\xi)^\lambda (y-\xi)^0$ für $\lambda = 0, \ldots r-1$. — Setzt man also

$$F(x,y) = \sum_{\varkappa=0}^{m} \sum_{\lambda=0}^{s} (x-\xi)^\varkappa (y-\xi)^\lambda \left(\frac{\partial^{\varkappa+r+\lambda} R(x,y)}{(\varkappa+r)!\,\lambda!\,\partial x^{\varkappa+r}\,\partial y^\lambda}\right)_{x=\xi,\,y=\xi}$$

$$G(x,y) = \sum_{\varkappa=0}^{r-1} \sum_{\lambda=0}^{s-1} (x-\xi)^\varkappa (y-\xi)^\lambda \left(\frac{\partial^{\varkappa+\lambda+1} R(x,y)}{\varkappa!\,(\lambda+1)!\,\partial x^\varkappa\,\partial y^{\lambda+1}}\right)_{x=\xi,\,y=\xi},$$

so gilt die Identität (2). Ferner ist für ein gewisses positives $c_1 = c_1(\xi,\vartheta)$ jeder Coefficient von $R(x,y)$ absolut $\leqq 2a \cdot 2\left[\left(\frac{3}{2}c_6^r\right)^{\frac{n}{\vartheta}}\right] < c_1^r$. Damit sind die Behauptungen I) und II) bewiesen.

Ich differentiiere (2) ϱ-mal nach x und erhalte wegen (3), (4), (5)

$$\sum_{\lambda=0}^{\varrho} \binom{\varrho}{\lambda}\binom{r}{\varrho-\lambda}(\varrho-\lambda)!\,(x-\xi)^{r-\varrho+\lambda}\,\lambda!\,\frac{\partial^\lambda F(x,y)}{\lambda!\,\partial x^\lambda} +$$
$$+ (y-\xi)\,\varrho!\,G_\varrho(x,y) = \varrho!\,R_\varrho(x,y),$$

$$(x-\xi)^{r-\varrho}\sum_{\lambda=0}^{\varrho}\binom{r}{\varrho-\lambda}\binom{\varrho}{\lambda}\frac{\lambda!\,(\varrho-\lambda)!}{\varrho!}(x-\xi)^\lambda\frac{\partial^\lambda F(x,y)}{\lambda!\,\partial x^\lambda} +$$
$$+ (y-\xi)\,G_\varrho(x,y) = R_\varrho(x,y),$$

also (6), wegen $\binom{\varrho}{\lambda} = \frac{\varrho!}{\lambda!\,(\varrho-\lambda)!}$.

Nun ist jeder Coefficient von $\frac{\partial^{\alpha+\beta} R(x,y)}{\alpha!\,\beta!\,\partial x^\alpha\,\partial y^\beta}$ $(\alpha \leqq m+r,\ \beta \leqq s)$ absolut $\leqq \binom{m+r}{\alpha}\binom{s}{\beta} 2a < 2^{m+r+s} c_1^r < c_7^r$ und folglich

$$\left|\left(\frac{\partial^{\alpha+\beta} R(x,y)}{\alpha!\,\beta!\,\partial x^\alpha\,\partial y^\beta}\right)_{x=\xi,\,y=\xi}\right| < c_7^r(1 + c_8 + \ldots + c_8^{m+r}) \cdot$$
$$\cdot (1 + c_8 + \ldots + c_8^s) < c_9^r,$$

(12) $$\left|G_\varrho(x,y)\right| < \binom{r-1}{\varrho} rs\,c_9^r\,(|x| + c_8)^{r-\varrho-1}(|y| + c_8)^{s-1} <$$
$$< c_{10}^r (1 + |x|)^{r-\varrho-1}(1 + |y|)^{s-1};$$

$$\left| \frac{\partial^\lambda F(x, y)}{\lambda!\, \partial x^\lambda} \right| < c_{11}{}^r (1 + |x|)^{m-\lambda} (1 + |y|)^s \qquad (\lambda = 0, \ldots \varrho),$$

also nach (3)

(13) $$| F_\varrho (x, y) | < (\varrho + 1)\, 2^r c_{11}{}^r (|x| + c_8)^m (1 + |y|)^s < \\ < c_{12}{}^r (1 + |x|)^m (1 + |y|)^s.$$

Setze ich noch $c_2 = \max(c_{10}, c_{12})$, so folgt (7) aus (12) und (13), und auch III) ist vollständig bewiesen.

Hilfssatz 2.

Es mögen ξ, n, r, s, ϑ, $R(x, y)$ die Bedeutung des Hilfssatzes 1 haben; außerdem sei

(14) $$r \geqq 2\, n^2,$$

(15) $$\vartheta \leqq \tfrac{1}{2}.$$

In

(16) $$R(x, y) = \sum_{\mu=0}^{s} f_\mu(x)\, y^\mu$$

seien von den $s + 1$ Polynomen $f_\mu(x)$ genau $s' + 1$ linear unabhängig in Bezug auf den Körper der rationalen Zahlen. s' ist $\geqq 0$, da nicht alle $s + 1$ Polynome identisch 0 sind. Ich wähle die Zahlen $\lambda_0, \ldots \lambda_{s'}$ aus der Reihe $0, 1, \ldots s$ derart, daß $f\lambda_0(x), \ldots f\lambda_{s'}(x)$ im Körper der rationalen Zahlen linear unabhängig sind, und setze die Determinante

$$| f\lambda_\beta{}^{(\alpha)}(x) | = \varDelta(x) \qquad (\alpha = 0, \ldots s';\ \beta = 0, \ldots s').$$

Dann gibt es zu jeder Zahl η, die von den zu ξ Conjugierten verschieden ist, eine nicht negative ganze Zahl $\gamma \leqq \vartheta r + n(n-1)$, so daß

$$\varDelta^\gamma(\eta) = \left(\frac{d^\gamma \varDelta(x)}{d x^\gamma} \right)_{x = \eta}$$

nicht 0 ist.

Beweis:

Wenn ich alle $f_\mu(x)$ $(\mu = 0, \ldots s)$ durch $f\lambda_0(x), \ldots f\lambda_{s'}(x)$ ausdrücke, so gehe (16) über in

(17) $$R(x, y) = \sum_{\beta=0}^{s'} f\lambda_\beta(x)\, U_\beta(y),$$

wo $U_\beta(y)$ ein rationalzahliges Polynom s^{ten} Grades in y bedeutet, das nicht identisch verschwindet. Wegen der linearen Unabhängigkeit[1] der $f_{\lambda_\beta}(x)$ ist ferner $\Delta(x)$ nicht identisch 0. Nach (2) und (17) gilt

$$\sum_{\beta=0}^{s'} f_{\lambda_\beta}^{(\alpha)}(x)\, U_\beta(\xi) = \frac{d^\alpha}{dx^\alpha}\{(x-\xi)^r F(x, \xi)\} \qquad (\alpha = 0, \ldots s').$$

Die Unterdeterminante von $f_{\lambda_0}^{(\alpha)}(x)$ in $\Delta(x)$ nenne ich $\Delta_\alpha(x)$; dann folgt

(18) $$\Delta(x)\, U_0(\xi) = \sum_{\alpha=0}^{s'} \Delta_\alpha(x) \frac{d^\alpha}{dx^\alpha}\{(x-\xi)^r F(x, \xi)\}.$$

$U_0(y)$ ist vom Grade $s < n$, und daher ist $U_0(\xi) \neq 0$. Nach (18) ist $\Delta(x)$ teilbar durch $(x-\xi)^{r-s'}$; hierbei ist der Exponent $r-s' > 0$ nach (14). Bedeutet $\varphi(x) = 0$ die irreducible Gleichung n^{ten} Grades für ξ, so ist das rationalzahlige Polynom $\Delta(x)$ teilbar durch $\varphi(x)^{r-s'}$:

(19) $$\Delta(x)\, U_0(\xi) = \varphi(x)^{r-s'} D(x),$$

wo $D(x)$ nicht identisch 0 ist. Die Elemente der $s'+1$-reihigen Determinante $\Delta(x)$ sind vom Grade $\leqq m + r$; der Grad von $\Delta(x)$ ist also $\leqq (s'+1)(m+r)$. Bedeutet δ den wahren Grad von $D(x)$, so ist nach (19)

$$\delta \leqq (s'+1)(m+r) - n(r-s') \leqq (s+1)(m+r) - n(r-s).$$

Nach Voraussetzung ist $\varphi(\eta) \neq 0$; das Polynom $\Delta(x)$ verschwindet also für $x = \eta$ höchstens von der Ordnung δ. Daher gibt es in der Reihe $0, 1, \ldots \delta$ eine Zahl γ, so daß $\Delta^{(\gamma)}(\eta) \neq 0$ ist, und für dieses γ gilt nach (1)

$$\gamma \leqq \delta \leqq (s+1)\frac{n+\vartheta}{s+1} r - nr + ns \leqq \vartheta r + n(n-1).$$

---

[1] Besteht zwischen mehreren rationalzahligen Polynomen $p_1(x), \ldots p_\nu(x)$ eine homogene lineare Gleichung mit constanten Coefficienten, so ist die aus den Coefficienten von $p_1(x), \ldots p_\nu(x)$ gebildete Matrix vom Range $< \nu$; da aber ein auflösbares System linearer rationalzahliger Gleichungen stets durch rationale Werte der Unbekannten befriedigt werden kann, so sind dann auch die ν Polynome im Körper der rationalen Zahlen linear abhängig. Sind also andererseits $p_1(x), \ldots p_\nu(x)$ im Körper der rationalen Zahlen linear unabhängig, so gilt dies auch für den Körper aller Zahlen. Folglich ist dann die Wronkische Determinante der ν Polynome nicht identisch 0.

Hilfssatz 3.

Es mögen $\xi, m, n, r, s, c_1, \vartheta$ die Bedeutung des Hilfssatzes 1 haben; für r und ϑ seien (14) und (15) erfüllt. Es seien $\frac{p_1}{q_1}$ und $\frac{p_2}{q_2}$ zwei reducierte rationale Brüche mit positiven Nennern, von denen $q_2 \geqq c_1^r$ ist. Dann gibt es eine nicht negative ganze Zahl $\varrho < \vartheta r + n^2$, also nach (14) und (15) $\leqq r - 1$, und ein natürliches $c_{13} = c_{13}(\xi, \vartheta)$, so daß mindestens eine der Zahlen

$$(20) \qquad E_1 = c_{13}^r\, q_1^{m+r}\, q_2^s \left| \xi - \frac{p_1}{q_1} \right|^{r-\varrho}, \qquad E_2 = c_{13}^r\, q_1^{m+r}\, q_2^s \left| \xi - \frac{p_2}{q_2} \right|$$

größer als 1 ist.

Beweis:

Das Polynom $R(x, y)$ des Hilfssatzes 1 verschwindet für $y = \frac{p_2}{q_2}$ nicht identisch. Denn sonst würde in der Entwicklung von $R(x, y)$ nach Potenzen von x,

$$R(x, y) = \sum_{\nu=0}^{m+r} g_\nu(y)\, x^\nu,$$

jedes $g_\nu(y)$ durch das primitive Polynom $q_2 y - p_2$ teilbar sein. Die Coefficienten von $g_\nu(y)$ sind nun ganze rationale Zahlen und absolut $< c_1^r$; nach einem bekannten Gaußschen Satze hätten dann auch die Polynome $\frac{g_\nu(y)}{q_2 y - p_2}$ ganze rationale Coefficienten, insbesondere ginge q_2 in dem Coefficienten des höchsten Gliedes jedes $g_\nu(y)$ auf. Da aber mindestens ein $g_\nu(y)$ nicht identisch 0 ist, so wäre dies ein Widerspruch zur Voraussetzung $q_2 \geqq c_1^r$.

Nach (17) ist also eine der Zahlen $U_\beta\left(\frac{p_2}{q_2}\right) \neq 0$. Die Bezeichnung sei so gewählt, daß dies für $\beta = 0$ zutrifft. Die Auflösung der $s'+1$ Gleichungen

$$\alpha!\, R_\alpha\left(x, \frac{p_2}{q_2}\right) = \sum_{\beta=0}^{s'} f_{\lambda\beta}^{(\alpha)}(x)\, U_\beta\left(\frac{p_2}{q_2}\right) \qquad (\alpha = 0, \ldots, s')$$

nach $U_0\left(\frac{p_2}{q_2}\right)$ lautet

$$(21) \qquad \Delta(x)\, U_0\left(\frac{p_2}{q_2}\right) = \sum_{\alpha=0}^{s'} \Delta_\alpha(x)\, \alpha!\, R_\alpha\left(x, \frac{p_2}{q_2}\right).$$

Die rationale Zahl $\frac{p_1}{q_1}$ ist sicherlich von den zu ξ Conjugierten verschieden. Folglich existiert nach Hilfssatz 2 ein nichts negatives $\gamma \leqq \vartheta r + n(n-1)$, so daß $\Delta^{(\gamma)}\left(\frac{p_1}{q_1}\right) \neq 0$ ist. Nun ist aber nach (21) die von 0 verschiedene Zahl $\Delta^{(\gamma)}\left(\frac{p_1}{q_1}\right) U_0\left(\frac{p_2}{q_2}\right)$ eine homogene lineare Verbindung der Zahlen $R_\varkappa\left(\frac{p_1}{q_1}, \frac{p_2}{q_2}\right) (\varkappa = 0, \ldots \gamma + s')$. Unter diesen $\gamma + s' + 1$ Zahlen ist also mindestens eine $\neq 0$; und für den zugehörigen Index $\varkappa = \varrho$ gilt

$$\varrho \leqq \gamma + s' < \vartheta r + n(n-1) + n = \vartheta r + n^2. \tag{22}$$

Das Polynom $R_\varrho(x, y)$ vom Grade $m + r - \varrho$ in x, s in y, hat ganze rationale Coefficienten. Daher ist die Zahl $q_1^{m+r-\varrho} q_2^s R_\varrho\left(\frac{p_1}{q_1}, \frac{p_2}{q_2}\right)$ ganz rational und $\neq 0$, also absolut genommen $\geqq 1$. Folglich ist nach (6)

$$q_1^{m+r-\varrho} q_2^s \left| \left(\frac{p_1}{q_1} - \xi\right)^{r-\varrho} F_\varrho\left(\frac{p_1}{q_1}, \frac{p_2}{q_2}\right) + \left(\frac{p_2}{q_2} - \xi\right) G_\varrho\left(\frac{p_1}{q_1}, \frac{p_2}{q_2}\right)\right| \geqq 1,$$

also wegen (7) a fortiori

$$c_2^r\left(1 + \frac{|p_1|}{q_1}\right)^{m+r}\left(1 + \frac{|p_2|}{q_2}\right)^s q_1^{m+r-\varrho} q_2^s \left(\left|\xi - \frac{p_1}{q_1}\right|^{r-\varrho} + \right.$$
$$\left. + \left|\xi - \frac{p_2}{q_2}\right|\right) > 1. \tag{23}$$

Offenbar braucht Hilfssatz 3 nur für den Fall bewiesen zu werden, daß die Zahlen $\left|\xi - \frac{p_1}{q_1}\right|$ und $\left|\xi - \frac{p_2}{q_2}\right|$ beide < 1 sind. Dann ist aber

$$1 + \frac{|p_1|}{q_1} < 2 + |\xi| < c_{14}, \quad 1 + \frac{|p_2|}{q_2} < c_{14};$$

und es gibt nach (23) ein positives nur von ξ und ϑ abhängiges c_{13}, so daß

$$c_{13}^r q_1^{m+r-\varrho} q_2^s \left(\left|\xi - \frac{p_1}{q_1}\right|^{r-\varrho} + \left|\xi - \frac{p_2}{q_2}\right|\right) > 2$$

ist. Hieraus folgt die Behauptung.

Ich komme jetzt zum Beweis des Satzes.

Es sei $0 < \theta < 1$ und s eine natürliche Zahl $\leqq n-1$. Ich setze

$$\frac{n}{s+1} + s + \theta = \beta \tag{24}$$

und nehme per absurdum an, die Ungleichung

(25) $$\left|\xi - \frac{x}{y}\right| \leqq \frac{1}{y^\beta} \qquad (y > 0)$$

habe unendlich viele Lösungen in ganzen rationalen x, y. Die Constante ϑ des Hilfssatzes 1 werde durch

(26) $$\vartheta = \frac{\theta}{8n}$$

definiert; die Zahlen c_1 und c_{13} der Hilfssätze 1 und 3 mögen die zu diesem ϑ gehörige Bedeutung haben. Dann wähle ich aus den unendlich vielen Lösungen von (25) eine solche Lösung $x = p_1$, $y = q_1$ in teilerfremden Zahlen, welche der Bedingung

(27) $$q_1 > \max\left(c_1, c_{13}^{\frac{4}{\theta}}\right)$$

genügen. Hierauf nehme ich eine zweite Lösung $x = p_2$, $y = q_2$ in teilerfremden Zahlen, so daß

(28) $$q_2 > q_1^{\frac{8n^3}{\theta} + 1}$$

ist, und setze

(29) $$r = \left[\frac{\log q_2}{\log q_1}\right].$$

Für dieses r ist nach (28) und (29)

(30) $$r \geqq \left[\frac{8n^3}{\theta} + 1\right] > \frac{8n^3}{\theta} > 2n^2,$$

nach (27) und (29) $q_2 > c_1^r$; ferner ist nach (26) $\vartheta < \frac{1}{2}$. Die Voraussetzungen des Hilfssatzes 3 sind also sämtlich erfüllt; folglich ist eine der beiden Zahlen E_1, E_2 aus (20) größer als 1. Für das zugehörige ϱ gilt $\varrho < \vartheta r + n^2$, also nach (26) und (30)

$$\frac{\varrho}{r} < \vartheta + \frac{n^2}{r} < \frac{\theta}{8n} + \frac{n^2\theta}{8n^3} = \frac{\theta}{4n};$$

ferner ist nach (24)

$$\beta = \frac{n}{s+1} + s + \theta < \frac{n}{s+1} + s + 1 \leqq \max_{\lambda = 2, \ldots n}\left(\frac{n}{\lambda} + \lambda\right) \leqq \frac{3}{2}n;$$

setzt man also noch zur Abkürzung

$$\theta - \frac{\vartheta}{s+1} - \beta\frac{\varrho}{r} - \frac{\log c_{13}}{\log q_1} = \varepsilon,$$

so ist mit Rücksicht auf (26) und (27)

(31) $$\varepsilon > \theta - \frac{\theta}{8n} - \frac{3}{2} n \frac{\theta}{4n} - \frac{\theta}{4} > \frac{\theta}{4} > 0.$$

Wegen $\log c_{13} \geqq 0$ ist

(32) $$0 < \frac{n+\vartheta}{s+1} + \frac{\log c_{13}}{\log q_1} = \beta + \frac{\vartheta}{s+1} - s - \theta + \frac{\log c_{13}}{\log q_1} = \beta\left(1 - \frac{\varrho}{r}\right) - s - \varepsilon,$$

und folglich nach (29) und (31)

(33) $$r \leqq \frac{\log q_2}{\log q_1} < \frac{\log q_2}{\log q_1} \cdot \frac{\beta - s}{\beta\left(1 - \frac{\varrho}{r}\right) - s - \varepsilon} = \frac{(\beta - s)\log q_2}{\frac{n+\vartheta}{s+1}\log q_1 + \log c_{13}}.$$

Ferner ist nach (31) und (32)

$$\beta\left(1 - \frac{\varrho}{r}\right) - \frac{n+\vartheta}{s+1} - \frac{\log c_{13}}{\log q_1} = s + \varepsilon > 0,$$

also nach (29), (30), (31)

$$r > \frac{\log q_2}{\log q_1} - 1 = \frac{\log q_2}{\log q_1} \cdot \frac{s}{s + \frac{\theta}{4}} + \frac{\log q_2}{\log q_1} \cdot \frac{\frac{\theta}{4}}{s + \frac{\theta}{4}} - 1 >$$

$$> \frac{\log q_2}{\log q_1} \frac{s}{s+\varepsilon} + \frac{8n^3}{\theta} \cdot \frac{\theta}{4n} - 1,$$

(34) $$r > \frac{\log q_2}{\log q_1} \cdot \frac{s}{s+\varepsilon} = \frac{s \log q_2}{\left(\beta\left(1 - \frac{\varrho}{r}\right) - \frac{n+\vartheta}{s+1}\right)\log q_1 - \log c_{13}}.$$

Aus (33) und (34) folgt mit Rücksicht auf (1)

$$s \log q_2 < \{\beta(r - \varrho) - (m + r)\} \log q_1 - r \log c_{13}$$

und

$$(m + r) \log q_1 + r \log c_{13} < (\beta - s) \log q_2,$$

oder, da p_1, q_1 und p_2, q_2 Lösungen von (25) sind, a fortiori nach (20)

$$E_1 < 1 \text{ und } E_2 < 1,$$

was ein Widerspruch ist. Folglich hat (25) nur endlich viele Lösungen.

Göttingen, 1920 August 7.

Gedruckt 29. Mai 1922.

UNTERSUCHUNGEN ÜBER DIE MÖGLICHEN VERTEILUNGEN GANZZAHLIGER LÖSUNGEN GEWISSER GLEICHUNGEN

VON

TH. SKOLEM

(Videnskapsselskapets Skrifter. I. Mat.-naturv. Klasse. 1921. No. 17)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
IN KOMMISSION BEI JACOB DYBWAD
1921

Fremlagt i den mat.-naturv. klasses møte den 4de mai 1921.

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§ I.

Über Verteilungsdichten.

Es sei K eine Klasse ganzer positiver Zahlen. Wir können durch $N(\nu)$ die Anzahl der Zahlen in K bezeichnen, welche $\geqq 1$ und $\leqq \nu$ sind, und betrachten die Werte des Quotienten

$$\frac{N(\nu)}{\nu}.$$

Es wird dann oft geschehen, daß dieser Quotient sich einer Grenze g nähert, wenn ν ins Unendliche wächst. Dann nenne ich *g die durchschnittliche Verteilungsdichte der Zahlen der Klasse K.*

Es kann aber auch geschehen, daß kein eindeutig bestimmter Grenzwert existiert; da indessen die Zahlen $\frac{N(\nu)}{\nu}$ alle zwischen 0 und 1 liegen, müssen Häufungswerte für $\nu = \infty$ existieren. Ist γ ein solcher Häufungswert, so gibt es also eine unendliche Reihe von Werten von ν, $\nu_1 < \nu_2 < \ldots$, so beschaffen, daß $\frac{N(\nu_r)}{\nu_r}$ gegen γ konvergiert, wenn r ins Unendliche wächst. Ich sage dann, daß γ *eine* durchschnittliche Verteilungsdichte der Zahlen in K ist[1].

Satz 1. *Ist die Klasse K die Summe einer endlichen Zahl von Klassen $K_1, K_2, \ldots, K_n$, so hat jede Teilklasse K_r nur die Verteilungsdichte Null, wenn K selbst nur die Verteilungsdichte Null hat, und umgekehrt.*

Beweis: Die erste Behauptung des Satzes ist unmittelbar einleuchtend und beruht nur darauf, daß eine Unterklasse K' von K nur die Verteilungsdichte Null haben kann, falls K selbst nur eine solche hat. Die Richtigkeit der Umkehrung sieht man auch äußerst leicht so:

Es sei $N_r(\nu)$ die Anzahl der Zahlen in K_r und $N(\nu)$ die Anzahl der Zahlen in K, welche $\leqq \nu$ sind. Es ist also $N(\nu) \leqq \sum_{r=1}^{n} N_r(\nu)$. Dann konvergiert nach der Voraussetzung jeder der Quotienten

[1] Statt von Verteilungsdichten zu reden, könnte man die bekannten Symbole $O(n)$ und $o(n)$ benutzen. Ich glaube aber, daß der Begriff der Verteilungsdichte hier mehr anschaulich ist.

$$\frac{N_1(\nu)}{\nu}, \frac{N_2(\nu)}{\nu}, \ldots, \frac{N_n(\nu)}{\nu}$$

für unendlich wachsendes ν gegen Null. Folglich konvergiert auch die Summe

$$\sum_{r=1}^{n} \frac{N_r(\nu)}{\nu} \geqq \frac{N(\nu)}{\nu}$$

gegen Null.

Man kann dies auch so ausdrücken: Gibt es für die Klasse K eine Verteilungsdichte > 0, so gibt es eine solche auch für mindestens eine der Klassen $K_1, \ldots, K_n$.

Satz 2. *Ist die Klasse K die Summe der n Klassen $K_1, \ldots K_n$, und hat K eine Verteilungsdichte $> \frac{1}{m}$, so hat mindestens eine der Klassen $K_1 \ldots K_n$ eine Verteilungsdichte $> \frac{1}{mn}$.*

Beweis: Hat nämlich jede Klasse K_r ($r = 1, 2, \ldots, n$) nur Verteilungsdichten $\leqq \frac{1}{mn}$, so muß eine so große positive Zahl ν_r existieren, daß

$$\frac{N_r(\nu)}{\nu} < \frac{1}{mn} + \frac{\varepsilon}{n},$$

wenn ε eine beliebig kleine positive Größe ist, für alle $\nu > \nu_r$. Es sei $\nu^1 =$ Max $(\nu_1, \nu_2, \ldots \nu_n)$. So bald $\nu > \nu^1$ ist, wird dann für alle r

$$\frac{N_r(\nu)}{\nu} < \frac{1}{mn} + \frac{\varepsilon}{n},$$

wodurch man erhält

$$\frac{N(\nu)}{\nu} \leqq \sum_{r=1}^{n} \frac{N_r(\nu)}{\nu} < \frac{1}{m} + \varepsilon.$$

Es können somit die Zahlen $\frac{N(\nu)}{\nu}$ keine Häufungsstelle $> \frac{1}{m}$ haben.

Satz 3. *Gibt es für K eine durchschnittliche Verteilungsdichte $> \frac{1}{m}$, und wird die Zahlenreihe in Intervalle, von welchen jedes aus $m\mu$ Zahlen besteht, eingeteilt, so gibt es in unendlich vielen dieser Intervalle mindestens μ Zahlen aus K.*

Beweis: Im entgegengesetzen Falle müßte die Klasse K innerhalb jedes Intervalles von dem $(l+1)^{\text{ten}}$ an, wo l eine ganze positive Zahl ist, höchstens $\mu - 1$ Zahlen besitzen. Es sei t die Anzahl der Zahlen in K, welche $\leqq m\mu l$ sind. Weiter sei

$$m\mu k \leqq \nu < m\mu(k+1),$$

und folglich

$$N(\nu) \leqq t + (\mu - 1)(k - l + 1),$$

woraus

$$\frac{N(\nu)}{\nu} \leqq \frac{t + (\mu - 1)(k - l + 1)}{m \mu k} = \frac{\mu - 1}{m \mu} + \frac{t - (\mu - 1)(l - 1)}{m \mu k}.$$

Wäre nun erstens $t \leqq (\mu - 1)(k - 1)$, so müßte immer

$$\frac{N(\nu)}{\nu} \leqq \frac{1}{m} - \frac{1}{m \mu},$$

so daß eine durchschnittliche Verteilungsdiche $> \frac{1}{m}$ unmöglich wäre. Wäre zweitens $t > (\mu - 1)(l - 1)$, so würde für alle k, für welche

$$k > t - (\mu - 1)(l - 1),$$

augenscheinlich

$$\frac{N(\nu)}{\nu} < \frac{\mu - 1}{m \mu} + \frac{1}{m \mu} = \frac{1}{m},$$

so daß wieder eine Verteilungsdichte $> \frac{1}{m}$ unmöglich wäre.

In dieser Abhandlung werden wir oft Klassen K von Paaren ganzer Zahlen (x, y) zu betrachten haben, die von folgender Beschaffenheit sind.

Es sei k die Klasse der Zahlen x, die überhaupt in den Paaren von K vorkommen. Weiter sei $k(x)$ für jedes x in k die Klasse der Zahlen y, die mit diesem x in den Paaren von K auftreten. Dann sollen:

1) Die Klasse k eine Verteilungsdichte > 0 haben.

2) Die Klassen $k(x)$ *gleichmäßig* Verteilungsdichten > 0 haben, d. h. jede Klasse $k(x)$ hat eine Verteilungsdichte $> \frac{1}{m}$, wobei m eine von x unabhängige ganze positive Zahl ist.

So oft im folgenden eine solche Klasse K von Paaren betrachtet wird, werde ich kurz sagen, daß sie die Eigenschaften 1) und 2) haben.

Weiter werden auch Klassen von Tripeln zur Anwendung kommen, die von folgender Art sind:

Es sei k die Klasse der x, welche überhaupt in den Tripeln von K vorkommen. Für jedes x in k sei $k(x)$ die Klasse der y, die überhaupt in irgend einem der Tripel in K mit dem betreffenden x zusammen vorkommen. Weiter sei $k(x, y)$ für jedes x in k und jedes y in $k(x)$ die Klasse der z, welche mit x und y zusammen in den Tripeln in K vorkommen. Dann sollen:

1) k eine Verteilungsdichte > 0 haben;

2) die Klassen $k(x)$ *gleichmäßig* eine Verteilungsdichte $> \frac{1}{m_1}$ haben;

3) die Klassen $k(x, y)$ *gleichmäßig* eine Verteilungsdichte $> \frac{1}{m_2}$ haben.

Die Forderung 3) bedeutet natürlich, daß für die Klassen $k(x, y)$ Verteilungsdichten gefunden werden können, die alle $> \frac{1}{m_2}$ sind, wobei m_2 eine ganze positive und von x und y unabhängige Zahl ist.

So oft im folgenden eine solche Klasse K von Tripeln betrachtet wird, werde ich sagen, daß sie die Eigenschaften 1), 2) und 3) haben.

Man kann natürlich weiter gehen und entsprechende Klassen von Quadrupeln usw. bilden.

Satz 4. *Es sei K eine Klasse von Paaren mit den Eigenschaften 1) und 2). Ist dann K die Summe einer endlichen Zahl von Klassen $K_1 \ldots K_n$, so hat mindestens einer dieser Teile eine Unterklasse mit den Eigenschaften 1) und 2).*

Beweis: Es sei x eine Zahl in k. Für jedes r ($r = 1, 2, \ldots, n$) sei $k_r(x)$ die Klasse der y, welche mit x Paare in K_r bilden. Dann zerfällt also $k(x)$, welche eine Verteilungsdichte $> \frac{1}{m}$ hat, in die n Teile $k_1(x), \ldots, k_n(x)$ und folglich muß nach Satz 2 mindestens eine dieser Teilklassen, $k\, r_x\, (x)$, eine Verteilungsdichte $> \frac{1}{m\, n}$ haben. Da m von x unabhängig ist, so ist auch $m\, n$ von x unabhängig. Nun braucht aber nicht r_x dieselbe Zahl für alle x in k zu sein. Es seien deshalb $k_1, k_2, \ldots, k_n$ die Teile von k, für welche bezw. $r_x = 1, 2, \ldots, n$ ist. Nach Satz 1 muß mindestens einer der Teile $k_1 \ldots k_n$ eine nichtverschwindende Verteilungsdichte haben. Ist k_λ ein solcher Teil, so hat also k_λ eine Verteilungsdichte > 0 und für jedes x in k_λ die Klasse $k_\lambda(x)$ eine Verteilungsdichte $> \frac{1}{m\, n}$.

Satz 5. *Es sei K eine Klasse von Tripeln mit den Eigenschaften 1), 2) und 3). Ist dann K die Summe einer endlichen Zahl von Klassen $K_1 \ldots, K_n$, so hat mindestens eine der letzteren Klassen eine Unterklasse mit den Eigenschaften 1), 2) und 3).*

Beweis: Es sei $k_r(x, y)$ für jedes x und jedes y in $k(x)$ die Klasse der z, welche mit x und y zusammen Tripel in K_r bilden. Mindestens eine der Klassen $k_1(x, y), \ldots, k_n(x, y)$ hat dann nach Satz 2, eine Verteilungsdichte $> \frac{1}{m_2\, n}$. Falls mehrere solche für gegebene x und y vorhanden sind, können wir z. B. die mit dem kleinsten Index wählen; dieser durch x und y eindeutig bestimmte Index heiße $r_{x,y}$. Es seien nun $k_1(x), \ldots, k_n(x)$ die Klassen der y für gegebenes x in k, für welche bezw. $r_{x,y} = 1, 2 \ldots, n$ ist. Mindestens eine der Klassen $k_1(x), \ldots, k_n(x)$ muß dann eine

Verteilungsdichte $> \frac{1}{m_1 n}$ haben (Satz 2). Falls mehrere solche für gegebenes x vorhanden sind, wählen wir z. B. die mit kleinstem Index; der Index sei r_x. Weiter seien $k_1 \ldots k_n$ die Teile von k_1 für welche bezw. $r_x = 1, 2, \ldots, n$ ist. Dann hat nach Satz 1 mindestens einer dieser Teile eine Verteilungsdichte > 0. Ist k_λ diese Teilklasse, so hat also k_λ eine Verteilungsdichte > 0; für jedes x in k_λ hat die Klasse $k_\lambda(x)$ eine Verteilungsdichte $> \frac{1}{m_1 n}$, und für jedes x in k_λ und jedes y in $k_\lambda(x)$ hat die Klasse $k_\lambda(x, y)$ eine Verteilungsdichte $> \frac{1}{m_2 n}$. Der Satz ist hierdurch bewiesen.

Es ist klar, daß analoge Sätze für die entsprechenden Klassen von Quadrupeln usw. aufgestellt werden können.

§ 2.

Ein Paar Hilfssätze über unendliche Reihen.

Es sei die Reihe

$$f(x) = \frac{a_1}{x} + \frac{a_2}{x^2} + \cdots$$

konvergent, wenn $|x| > R$. Auf dem Kreise um den Nullpunkt mit dem Radius R gibt es dann notwendig Singularitäten für $f(x)$. Es seien weiter

$$r_1 < r_2 < r_3 < \cdots < r_\varkappa$$

positive Konstanten. Die Reihen

$$f(x + r_1) = \frac{a_1}{x + r_1} + \frac{a_2}{(x + r_1)^2} + \cdots$$

$$\cdots\cdots\cdots\cdots\cdots$$

$$f(x + r_\varkappa) = \frac{a_1}{x + r_\varkappa} + \frac{a_2}{(x + r_\varkappa)^2} + \cdots$$

konvergieren dann außerhalb Kreise mit Radius R und bezw. den Punkten $-r_1, -r_2, \ldots, -r_\varkappa$ als Zentra.

Ich behaupte, daß entweder *die Funktion $f(x + r_\varkappa)$ mindestens eine Singularität besitzt, welche eine reguläre Stelle für jede der Funktionen $f(x), \ldots, f(x + r_{\varkappa-1})$ ist, oder $f(x)$ eine Singularität, die eine reguläre Stelle der Funktionen $f(x + r_1) \ldots f(x + r_\varkappa)$ ist.*

Hat $f(x)$ eine Singularität $\zeta = \xi + \eta i$ auf dem Kreise um den Nullpunkt mit Radius R, so beschaffen, daß $\xi \geq 0$ ist, so muß ζ eine reguläre Stelle sein für die anderen Funktionen f. Hat dagegen $f(x)$ eine Singularität

$\zeta = \xi + \eta\, i$ auf demselben Kreise, so daß $\xi < 0$ ist, so hat $f(x + r_\varkappa)$ dieselbe Singularität $\zeta' = \xi - r_\varkappa + \eta\, i$ auf dem Kreise um den Punkt $- r_\varkappa$, und ζ' ist dann eine reguläre Stelle der anderen Funktionen f.

Anmerkung: Ich verstehe unter Singularität für $f(x)$ ein Punkt, über welchen die Reihe für $f(x)$ nicht analytisch fortsetzbar ist. Falls $f(x)$ ein Element einer mehrdeutigen Funktion ist, können ja Zweige existieren, die Singularitäten außerhalb des Kreises mit Radius R um den Nullpunkt haben.

Der Fall $R = 0$ macht keine Ausnahme; denn dann ist $x = 0$ die einzige Singularität für $f(x)$ und entsprechend $x = -r_1, -r_2, \ldots -r_\varkappa$ für bezw. $f(x + r_1), \ldots f(x + r_\varkappa)$.

Sind deshalb $A, \ldots, A_\varkappa$ Konstanten, wobei A und $A_\varkappa \neq 0$ sind, so muß die Summe

$$A\, f(x) + A_1\, f(x + r_1) + \cdots + A_\varkappa\, f(x + r_\varkappa)$$

notwendig Singularitäten im Endlichen haben. Hieraus folgt umgekehrt:

Satz 6. *Im Falle diese Summe überall im Endlichen regulär ist (z. B. eine Konstante, speziell identisch Null), so muß $f(x)$ identisch verschwinden, d. h. alle Koeffizienten $a_1, a_2, \ldots$ sind Null.*

Wir können auch in einer mehr rechnenden Weise zeigen, daß $f(x)$ identisch verschwinden muß, falls die erwähnte Summe identisch Null ist. Es sei wieder

$$f(x) = \frac{a_1}{x} + \frac{a_2}{x^2} + \cdots$$

$$f(x + r_i) = \frac{a_1}{x + r_i} + \frac{a_2}{(x + r_i)^2} + \cdots \qquad = \frac{a_1}{x}\left(1 - \frac{r_i}{x} + \frac{r_i^2}{x^2} - \cdots\right)$$
$$+ \frac{a_2}{x^2}\left(1 - \frac{2\, r_i}{x} + \frac{3\, r_i^2}{x^2} - \cdots\right)$$
$$+ \frac{a_2}{x^3}\left(1 - \frac{3\, r_i}{x} + \frac{6\, r_i^2}{x^2} - \cdots\right)$$
$$+ \cdots\cdots\cdots\cdots$$

Es sei $r_0 = 0$ und $\sum_{i=0}^{\varkappa} A_i f(x + r_i) = 0$ identisch, wobei A_0 und $A_\varkappa$ von Null verschieden sind. Die Koeffizienten der Entwicklung von $\sum_{i=0}^{\varkappa} A_i f(x + r_i)$ nach fallenden Potenzen von x werden

$$a_1 \cdot \Sigma A_i$$
$$- a_1 \cdot \Sigma A_i r_i + a_2 \cdot \Sigma A_i$$
$$a_1 \cdot \Sigma A_i r_i^2 - 2\, a_2 \cdot \Sigma A_i r_i + a_3 \cdot \Sigma A_i$$
$$- a_1 \cdot \Sigma A_i r_i^3 + 3\, a_2\, \Sigma A_i r_i^2 - 3\, a_3 \cdot \Sigma A_i\, r_i + a_4\, \Sigma A_i$$
$$\cdots\cdots\cdots\cdots\cdots\cdots$$

In der Reihe der Zahlen

$$\Sigma A_i,\ \Sigma A_i r_i,\ \Sigma A_i r_i^2, \cdots$$

können die $\varkappa + 1$ ersten Glieder nicht alle verschwinden; denn aus den Gleichungen

$$\Sigma A_i = 0\,,\ \Sigma A_i r_i = 0\,, \cdots,\ \Sigma A_i r_i^{\varkappa} = 0$$

würde folgen

$$A_0 = 0\,,\ A_1 = 0\,,\ \cdots,\ A_{\varkappa} = 0\,,$$

weil die Determinante

$$\begin{vmatrix} 1 & 1 & \cdots & 1 \\ r_0 & r_1 & \cdots & r_{\varkappa} \\ \cdot & \cdot & \cdot & \cdot \\ r_0^{\varkappa} & r_1^{\varkappa} & \cdots & r_{\varkappa}^{\varkappa} \end{vmatrix} = \pm (r_1 - r_0) \cdots (r_{\varkappa} - r_{\varkappa - 1})$$

$\neq 0$ ist.

Sind nun ΣA_i, $\Sigma A_i r_i, \ldots, \Sigma A_i r_i^p$ alle Null, während $\Sigma A_i r_i^{p+1} \neq 0$ ist, bekommt man aus dem Ausdruck für den $(p+2)^{ten}$ Koeffizienten in der obigen Entwicklung von $\Sigma A_i f(x + r_i)$, daß $a_1 = 0$ ist. Weiter folgen dann aus den Ausdrücken für die folgenden Koeffizienten $a_2 = 0$, $a_3 = 0$, ... in.inf.

Es genügt übrigens augenscheinlich vorauszusetzen, daß nicht alle Zahlen A verschwinden.

Weiter betrachten wir die Reihen

$$f(x) = \frac{a_1}{x^{\frac{1}{q}}} + \frac{a_2}{x^{\frac{2}{q}}} + \cdots \qquad q \text{ ganze positive Zahl.}$$

$$f(x + r_1) = \frac{a_1}{(x + r_1)^{\frac{1}{q}}} + \frac{a_2}{(x + r_1)^{\frac{2}{q}}} + \cdots$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$f(x + r_{\varkappa}) = \frac{a_1}{(x + r_{\varkappa})^{\frac{1}{q}}} + \frac{a_2}{(x + r_{\varkappa})^{\frac{2}{q}}} + \cdots$$

$$g_1(x) = \frac{l_{1,1}}{x^{\frac{1}{q}}} + \frac{l_{2,1}}{x^{\frac{2}{q}}} + \cdots$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$g_{\varkappa}(x) = \frac{l_{1,\varkappa}}{x^{\frac{1}{q}}} + \frac{l_{2,\varkappa}}{x^{\frac{2}{q}}} + \cdots,$$

wobei die Reihe für $f(x)$ außerhalb eines Kreises um den Nullpunkt mit dem Radius R konvergiert, während $g_i(x)$ $(i = 1, 2, \ldots, \varkappa)$ nur zwei singuläre Stellen hat, falls sie nicht identisch verschwindet, nämlich $x = -r_i$ und $x = 0$. Diese sollen Verzweigungsstellen, aber nicht Unendlichkeitsstellen[1], sein.

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[1] D. h. es sollen alle Zweige von $|g_i(x)|$ innerhalb Kreise mit Radius ε um die Punkte $x = 0$ und $x = -r_i$ beschränkt sein.

Die Ebene soll längs der negativen reellen Axe aufgeschnitten gedacht werden, so daß $x^{\frac{1}{q}}$ eine bestimmte der q^{ten} Wurzeln von x bedeutet. Die Funktionen g werden dabei eindeutig. $f(x)$ ist augenscheinlich ein eindeutig bestimmtes Funktionselement einer mehrdeutigen Funktion. (Weiter soll $f(x+r_i)$ für $x=a$ der Wert von $f(x)$ für $x=a+r_i$ sein, so daß auch alle Funktionselemente $f(x+r_i)$ eindeutig bestimmt sind.

Hat nun $f(x)$ eine solche Singularität $\zeta = \xi + \eta i$ auf dem Kreise mit R um den Nullpunkt, daß $\xi \geqq 0$ ist, so ist ζ eine reguläre Stelle für alle g und alle anderen f. Hat aber $f(x)$ auf demselben Kreise eine singuläre Stelle $\zeta = \xi + \eta i$, so daß $\xi < 0$ ist, so hat $f(x+r_\varkappa)$ auf dem Kreise mit Radius R um den Punkt $-r_\varkappa$ eine solche Singularität $\zeta' = \xi' + \eta' i$, wobei $\xi' = \xi - r_\varkappa < -r_\varkappa$ ist, und dann ist ζ' eine reguläre Stelle für alle g und alle anderen f.

Im Falle $R=0$ ist $f(x)$ eine ganze transcendente Funktion von $x^{\frac{1}{q}}$ und dann ist, falls $f(x)$ nicht identisch verschwindet, $x=0$ eine solche singuläre Stelle für $f(x)$, daß sie auch eine Singularität sein muß für jede lineare Kombination von f mit den Funktionen g. Zugleich ist $x=0$ regulär für die anderen f.

Man hat also:

Satz 7. *Sind $A_1 \ldots, A_\varkappa$ von Null verschiedene Konstanten, muß die Summe*

$$A\, f(x) + A_1 (f(x+r_1) + g_1(x)) + \cdots + A_\varkappa (f(x+r_\varkappa) + g_\varkappa(x)),$$

notwendig Singuläriteten im Endlichen haben, falls nicht $f(x)$ und auch alle Funktionen g identisch verschwinden.

§ 3.

Funktionen einer Variabeln x, welche ganzzahlige Werte haben für unendlich viele ganze Werte von x.

Satz 8. *Ist $x=\infty$ entweder eine reguläre Stelle oder ein Pol für die eindeutige analytische Funktion $f(x)$, und im letzteren Falle die Koeffizienten des zugehörigen Hauptteiles rationale Zahlen sind, so kann $f(x)$ nicht eine ganze Zahl sein für unendlich viele ganze Zahlen x, ohne daß $f(x)$ ein Polynom ist mit rationalen Koeffizienten*[1].

Beweis: Es sei die Reihe

$$f(x) = a_0' x^n + a_1' x^{n-1} + \cdots + a_n' + \frac{a_{n+1}'}{x} + \cdots,$$

[1] Ich gebe hier den Beweis dieses ziemlich trivialen Satzes, weil er eine passende Einleitung zu den folgenden Sätzen bildet.

konvergent, wenn $|x| > R$, wobei $a'_0, \cdots, a'_{n-1}$ rationale Zahlen sind. Diese haben dann einen gemeinsamen Nenner N.

Folglich wird

$$N f(x) = a_0 x^n + a_1 x^{n-1} + a_{n-1} x + a_n + \frac{a_{n+1}}{x} + \cdots,$$

wo jetzt $a_0, a_1, \ldots, a_{n-1}$ ganze Zahlen sind. Außerdem ist $N f(x)$ immer eine ganze Zahl, wenn $f(x)$ eine solche ist, und dies also der Voraussetzung zufolge für unendlich viele ganze Werte von x. Folglich wird die Differenz

$$\varphi(x) = N f(x) - a_0 x^n - a_1 x^{n-1} - \cdots - a_{n-1} x = a_n + \frac{a_{n+1}}{x} + \frac{a_{n+2}}{x^2} + \cdots$$

auch eine ganze Zahl für dieselben unendlich vielen ganzen x. Wenn x ins Unendliche wächst, konvergiert $\varphi(x)$ gegen a_n. Es muß also a_n eine ganze Zahl sein, und außerdem muß für alle betreffenden ganzen Zahlen x, welche $>$ eine gewisse Zahl M sind, $\varphi(x) = a_n$ sein. Da indessen $x = \infty$ eine reguläre Stelle der Funktion $\varphi(x)$ ist, so kann die Gleichung $\varphi(x) = a_n$ nicht unendlich viele Wurzeln, die sich um $x = \infty$ häufen, haben, ohne eine Identität zu sein. $\varphi(x)$ ist also identisch $= a_n$, und wir erhalten

$$N f(x) = a_0 x^n + \cdots + a_n,$$

wodurch der Satz bewiesen ist..

Satz 9. *Es sei $x = \infty$ entweder eine reguläre Stelle oder ein Pol einer eindeutigen analytischen Funktion $f(x)$. Weiter sei $f(x)$ eine ganze Zahl für unendlich viele ganze Werte von x, welche eine Verteilungsdichte > 0 haben. Dann ist $f(x)$ ein Polynom mit rationalen Koeffizienten.*

Beweis: Es sei die Reihe

$$f(x) = a_0 x^n + \cdots + a_{n-1} x + a_n + \frac{a_{n+1}}{x} + \cdots,$$

konvergent, wenn $|x| > R$, und es sei K die Klasse der ganzen Zahlen x, für welche $f(x)$ eine ganze Zahl ist.

Besitzen die Zahlen in K eine Verteilungsdichte > 0, so haben sie auch eine, welche $> \frac{1}{m}$ ist, wenn m eine hinreichend große ganze positive Zahl ist. Teilt man nun die Zahlenreihe in Intervalle, jedes aus $m(\mu + 1)$ Zahlen bestehend, so gibt es zufolge Satz 3 in unendlich vielen der Intervalle mindestens $\mu + 1$ Zahlen, die zu K gehören. Es seien $x_1 < x_2 < \cdots, < x_{\mu+1}$ die $\mu + 1$ (kleinsten dieser) Zahlen innerhalb eines beliebigen dieser Intervalle. Bildet man die Differenzen

$$x_2 - x_1,\ x_3 - x_2, \cdots, x_\mu - x_{\mu-1},\ x_{\mu+1} - x_\mu,$$

so hat man eine Reihe von μ Zahlen, die alle > 0 und $< m(\mu + 1)$ sind. Von solchen Reihen gibt es aber nur eine endliche Zahl. Es muß folglich unendlich oft, d. h. für unendlich viele Intervalle, geschehen, daß eine solche Reihe wiederholt wird. Dies bedeutet aber, daß man in unendlich vielen der Intervalle $\mu + 1$ zu K gehörende Zahlen finden kann, die in der Form

$$x, x + r_1, \cdots, x + r_\mu$$

geschrieben werden können, wobei die Zahl x von Intervall zu Intervall variiert, während die Zahlen $r_1, \ldots, r_\mu$ konstant sind. Diese x bilden eine Unterklasse K^1 von K.

Man kann nun die Gleichungen bilden:

$$f(x) = a_0 x^n + a_1 x^{n-1} + \cdots$$

$$f(x + r_1) = a_0 (x + r_1)^n + a_1 (x + r_1)^{n-1} + \cdots + a_n + \frac{a_{n+1}}{x + r_1} + \cdots$$

$$= a_0 x^n + a_1^1 x^{n-1} + \cdots + a_n^1 + \frac{a_{n+1}}{x + r_1} + \cdots$$

. . . .

$$f(x + r_\mu) = a_0 (x + r_\mu)^n + a_1 (x + r_\mu)^{n-1} + \cdots + a_n + \frac{a_{n+1}}{x + r_\mu} + \cdots$$

$$= a_0 x^n + a_1^\mu x^{n-1} + \cdots + a_n^\mu + \frac{a_{n-1}}{x + r_\mu} + \cdots$$

Hier sind die Zahlen $a_1^1 \cdots a_n^1$, $a_1^2 \cdots a_n^2$, $\cdots$, $a_1^\mu \cdots a_n^\mu$ lineare homogene Funktionen von $a_0, \cdots, a_n$, deren Koeffizienten ganze Zahlen sind, welche nur von $r_1 \cdots r_\mu$ abhängen.

Die Zahl μ ist noch nicht bestimmt; wir können sie jetzt so groß wählen, daß die Größen

$a_0 x^n$; $a_0 x^{n-1}, a_1 x^{n-1}$; $a_0 x^{n-2}, a_1 x^{n-2}, a_2 x^{n-2}$; $\cdots$; $a_0 x, a_1 x, \cdots a_{n-1} x$;

die ja alle linear mit ganzen Koeffizienten vorkommen, zwischen den Gleichungen eliminiert werden können. Das Eliminationsresultat ist von der Form:

$$\begin{aligned} A f(x) + A_1 f(x + r_1) + \cdots + A_\mu f(x + r_\mu) = B + {} & A \left(\frac{a_{n+1}}{x} + \frac{a_{n+2}}{x^2} + \cdots \right). \\ & + A_1 \left(\frac{a_{n-1}}{x + r_1} + \frac{a_{n+2}}{(x + r_1)^2} + \cdots \right) \\ & + \cdots \cdots \\ & + A_\mu \left(\frac{a_{n+1}}{x + r_\mu} + \frac{a_{n+2}}{(x + r_\mu)^2} + \cdots \right), \end{aligned}$$

wobei $A, A_1, \ldots, A_\mu$ ganze Zahlen sind, die nicht alle verschwinden, während $B = A a_n + A_1 a_n^1 + \ldots + A_\mu a_n^\mu$ eine Konstante ist.

Für jedes x in K^1 nehmen $f(x)$, $f(x+r_1), \ldots, f(x+r_\mu)$ gleichzeitig ganze Werte an, wodurch auch $A\, f(x) + A_1\, f(x+r_1) + \ldots + A_\mu\, f(x+r_\mu)$ eine ganze Zahl wird. Da die rechte Seite der letzten Gleichung für unendliches x gegen B konvergiert, muß B eine ganze Zahl sein, und für alle x in K^1, welche $>$ eine gewisse Zahl M sind, muß die Summe der übrigen Glieder rechts verschwinden. Da aber $x = \infty$ eine reguläre Stelle dieser Summe ist, muß sie identisch Null sein. Dies bewirkt aber nach § 1 (Satz 6), daß die Koeffizienten a_{n+1}, a_{n+2}, ... alle Null sein müssen.

Es ist also $f(x)$ ein Polynom in x, und daß die Koeffizienten rational sein müssen folgt sofort daraus, daß es für unendlich viele rationale (nämlich ganze) Werte von x einen rationalen (nämlich ganzen) Wert hat. In der Tat müssen ja die Koeffizienten eines Polynoms n^{ten} Grades rational sein, falls es einen rationalen Wert hat für $n+1$ verschiedene Werte von x.

Anmerkung: Die Voraussetzung des Satzes, daß $f(x)$ eindeutig sein soll ist nicht nötig, wenn man nur weiß, im Falle sie mehrdeutig ist, daß *derselbe Zweig* eine ganze Zahl ist für eine Klasse K ganzer x mit einer Verteilungsdichte > 0. Dies folgt sofort daraus, daß der Satz 6 auch in diesem Falle anwendbar ist.

Satz 10. *Es sei die Reihe*

$$f(x) = a_0\, x^{\frac{p}{q}} + a_1\, x^{\frac{p-1}{q}} + \cdots + a_p + \frac{a_{p+1}}{x^{\frac{1}{q}}} + \cdots$$

gegeben. Die Reihe sei konvergent für $|x| > R$; *p und q seien zwei ganze positive Zahlen. Die Ebene soll längs der negativen reellen Axe aufgeschnitten sein, so daß* $x^{\frac{1}{q}}$ *eine bestimmte der* q^{ten} *Wurzeln von* x *bedeutet. Gibt es dann unendlich viele ganze Werte von* x, *wobei* $|x| > R$ *ist, mit einer Verteilungsdichte* > 0, *für welche* $f(x)$ *eine ganze Zahl ist, so ist* $f(x)$ *ein Polynom mit rationalen Koeffizienten.*

Beweis: Es sei K die Klasse der ganzen x, für welche $f(x)$ ganz ist. Da K eine nicht verschwindende Verteilungsdichte hat, so gibt es auch eine solche $> \frac{1}{m}$, wenn m eine hinreichend große ganze positive Zahl ist. Denken wir uns wieder die Zahlenreihe in Intervalle, jedes aus $m\,(\mu+1)$ Zahlen bestehend geteilt, so gibt es in unendlich vielen unter ihnen $\mu+1$ zu K gehörige Zahlen und dann wie wir früher gesehen haben auch in unendlich vielen $\mu+1$ zu K gehörige Zahlen mit denselben Differenzen. Für unendlich viele ganze x, die eine Unterklasse K^1 von K bilden, gehören also die $\mu+1$ Zahlen

$$x,\ x+r_1,\ \cdots,\ x+r_\mu$$

zu K, wobei $r_1, \cdots, r_\mu$ von x unabhängige ganze Zahlen sind, so daß

$$0 < r_1 < r_2 < \cdots < r_\mu .$$

Es ist nun (r ist positiv reel gedacht)

$$f(x+r) = a_0 (x+r)^{\frac{p}{q}} + a_1 (x+r)^{\frac{p-1}{q}} + \cdots + a_p + \frac{a_{p+1}}{(x+r)^{\frac{1}{q}}} + \cdots$$

Hier können wir aber jedes Glied, das einen positiven Exponenten hat, nach fallenden Potenzen von x entwickeln. Wir haben ja die Entwicklung

$$(x+r)^{\frac{p_1}{q}} = x^{\frac{p_1}{q}}\left(1+\frac{r}{x}\right)^{\frac{p_1}{q}} = x^{\frac{p_1}{q}}\left(1 + \frac{p_1}{q}\cdot\frac{r}{x} + \frac{\frac{p_1}{q}\left(\frac{p_1}{q}-1\right)}{1\cdot 2}\cdot\frac{r^2}{x^2} + \cdots\right), \text{ für } |x| > r,$$

wodurch für alle x, für welche $|x| > R$ und $> r$ ist,

$$f(x+r) = a_0 x^{\frac{p}{q}} + b_1 x^{\frac{p-1}{q}} + \cdots + b_{p-1} + \frac{a_{p+1}}{(x+r)^{\frac{1}{q}}} + \frac{a_{p+2}}{(x+r)^{\frac{2}{q}}} + \cdots$$
$$+ \frac{b_{p+1}}{x^{\frac{1}{q}}} + \frac{b_{p+2}}{x^{\frac{2}{q}}} + \cdots,$$

wobei $b_1, b_2, \ldots$ lineare homogene Funktionen von $a_0 \ldots a_p$ sind mit rationalen Zahlen als Koeffizienten. In dieser Weise erhalten wir folgendes System von Gleichungen:

$$f(x) = a_0 x^{\frac{p}{q}} + a_1 x^{\frac{p-1}{q}} + \cdots + a_p + \varphi_0(x)$$

$$f(x+r_1) = a_0 x^{\frac{p}{q}} + a_1^1 x^{\frac{p-1}{q}} + \cdots + a_p^1 + \varphi_1(x) + \psi_1(x)$$

. . . .

$$f(x+r_\mu) = a_0 x^{\frac{p}{q}} + a_1^\mu x^{\frac{p-1}{q}} + \cdots + a_p^\mu + \varphi_\mu(x) + \psi_\mu(x),$$

wobei hier

$$\varphi_0(x) = \frac{a_{p+1}}{x^{\frac{1}{q}}} + \frac{a_{p+2}}{x^{\frac{2}{q}}} + \cdots$$

$$\varphi_1(x) = \varphi_0(x+r_1)$$

. . . .

$$\varphi_\mu(x) = \varphi_0(x+r_\mu)$$

$$\psi_1(x) = \frac{a^1_{p+1}}{x^{\frac{1}{q}}} + \frac{a^1_{p+2}}{x^{\frac{2}{q}}} + \cdots$$

. . . .

$$\psi_\mu(x) = \frac{a^\mu_{p+1}}{x^{\frac{1}{q}}} + \frac{a^\mu_{p+2}}{x^{\frac{2}{q}}} + \cdots$$

gesetzt ist.

Hier sind $a_1^1, \ldots, a_p^\mu$ lineare homogene Funktionen von $a_0, \ldots, a_p$ mit rationalen Koeffizienten.

Wählt man jetzt μ hinreichend groß, können hieraus wieder alle die linear vorkommenden Größen

$$a_0\, x^{\frac{p}{q}},\; a_1\, x^{\frac{p-1}{q}},\; \cdots,\; a_{q-1}\, x^{\frac{p-q+1}{q}},\; a_0\, x^{\frac{p-q}{q}},\; \cdots,\; a_{p-1}\, x^{\frac{1}{q}},$$

deren Zahl ja endlich und von μ unabhängig ist, eliminiert werden. Das Eliminationsresultat ist von der Form

$$A\, f(x) + A_1\, f(x+r_1) + \cdots + A_\mu\, f(x+r_\mu) = B + A\, \varphi_0(x) + A_1\,(\varphi_1(x) + \psi_1(x)) + \cdots + A_\mu\,(\varphi_\mu(x) + \psi_\mu(x))$$

wo $A, A_1, \ldots, A_\mu$ ganze Zahlen sind, die nicht alle verschwinden, und $B = A\, a_p + A_1\, a_p^1 + \cdots + A_\mu\, a_p^\mu$ eine Konstante ist.

Nun sind $f(x), f(x+r_1), \ldots, f(x+r_\mu)$ alle gleichzeitig ganz für alle x in K^1. Da die rechte Seite der letzten Gleichung für unendliches x gegen B konvergiert, muß B eine ganze Zahl sein, und weiter muß für alle Zahlen x in K^1, welche $>$ eine Zahl M sind, die Summe der übrigen Glieder rechts verschwinden.

Weiter läßt sich jede der Funktionen

$$\varphi_0(x),\; \varphi_1(x), \cdots \varphi_\mu(x),\; \psi_1(x), \cdots \psi_\mu(x)$$

in eine Reihe nach fallenden Potenzen von $x^{\frac{1}{q}}$ entwickeln, die mit einem Konstanten mal $x^{-\frac{1}{q}}$ anfängt, und alle diese Reihen haben ein gemeinsames Konvergenzgebiet $|x| > \varrho$ wobei $\varrho \gtreqless R + r_\mu$ ist. Setzen wir

$$\varphi(x) = A\, \varphi_0(x) + A_1\,(\varphi_1(x) + \psi_1(x)) + \cdots + A_\mu\,(\varphi_\mu(x) + \psi_\mu(x)),$$

so läßt sich also auch $\varphi(x)$ in eine Reihe nach fallenden Potenzen von $x^{\frac{1}{q}}$ entwickeln, wo $x^{-\frac{1}{q}}$ die erste auftretende Potenz ist, und welche für $|x| > \varrho$ konvergent ist.

Nun ist $\varphi(x) = 0$ für alle x in K^1, für welche $|x| > M$ ist. Setzt man also weiter $x^{\frac{1}{q}} = z$ und $\varphi(x) = X(z)$, so muß $X(z)$ für eine q^{te} Wurzel von jedem derselben unendlich vielen x in K^1 verschwinden, und außerdem ist $X(z)$ eine gewöhnliche Potenzreihe von $\frac{1}{z}$. Nach einem bekannten Satz über Potenzreihen muß deshalb $X(z)$ und also auch $\varphi(x)$ identisch verschwinden.

Da die Reihen $\psi_1(x), \psi_2(x), \cdots, \psi_\mu(x)$, wie man aus ihrer Entstehung oben leicht sehen kann, ganze rationale Funktionen sind von $x^{\frac{1}{q}}$ und bezw. $(x+r_1)^{\frac{1}{q}}, (x+r_2)^{\frac{1}{q}}, \cdots, (x+r_\mu)^{\frac{1}{q}}$, können wir Satz 7 anwenden. Sowohl diese μ Reihen wie auch die Reihe $\frac{a_{p-1}}{x^{\frac{1}{q}}} + \frac{a_{p+2}}{x^{\frac{2}{q}}} + \cdots$ müssen also identisch verschwinden. Dies ist aber nur möglich, wenn $f(x)$ ein Polynom ist.

Denn da $a_{p+1}, a_{p+2}, \ldots$ alle Null sind, so ist jedenfalls

$$f(x) = a_0 x^{\frac{p}{q}} + a_1 x^{\frac{p-1}{q}} + \cdots + a_p,$$

und falls $f(x)$ nicht ein Polynom ist, ist $x = 0$ die einzige singuläre Stelle im Endlichen. Dann müßte aber $f(x+r_1)$ (nur) die (einzige) Singularität $x = -r_1$ im Endlichen haben und könnte also nicht zugleich die Form

$$a_0 x^{\frac{p}{q}} + a_1^1 x^{\frac{p-1}{q}} + \cdots + a_p^1$$

besitzen.

Die Koeffizienten des Polynoms müssen natürlich aus demselben Grunde wie früher rational sein.

Satz 11. *Es sei die Gleichung gegeben:*

$$A_0(x) y^n + A_1(x) y^{n-1} + \cdots + A_n(x) = 0,$$

worin $A_0(x), \ldots, A_n(x)$ eindeutige analytische Funktionen sind, für welche $x = \infty$ entweder eine reguläre Stelle oder ein Pol ist[1]. *Es sei K eine Klasse ganzer Zahlen x mit einer Verteilungsdichte > 0, so daß für jedes x in K eine solche ganze Zahl y existiert, daß die Gleichung befriedigt wird. Dann wird die Gleichung identisch in bezug auf x befriedigt, wenn man statt y ein gewisses Polynom $P(x)$ mit rationalen Koeffizienten setzt.*

Beweis: Die Diskriminante der Gleichung (in bezug auf y) ist augenscheinlich eine eindeutige analytische Funktion $D(x)$ von x, für welche $x = \infty$ höchstens ein Pol ist. Ist $D(x)$ identisch $= 0$, so hat die gegebene Gleichung eine Doppelwurzel y for alle x. In jedem solchen Falle läßt sich aber bekanntlich durch rationale Rechnungen eine Gleichung finden, welche dieselben Funktionen y von x als einfache Wurzeln hat wie die gegebene Gleichung, während die Koeffizienten der neuen Gleichung Funktionen derselben Natur sind wie die Koeffizienten der gegebenen

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[1] $A_0(x)$ kann übrigens offenbar ohne Einschränkung der Allgemeinheit gleich 1 gesetzt werden. Die Quotienten $\frac{A_1(x)}{A_0(x)}, \cdots, \frac{A_n(x)}{A_0(x)}$ sind ja Funktionen derselben Natur.

Gleichung. Es wird deshalb hinreichend sein den Satz in dem Falle zu beweisen, da $D(x)$ nicht identisch verschwindet.

Dann kann die Gleichung $D(x) = 0$ nur eine endliche Zahl von Wurzeln haben, deren absoluter Betrag eine gewisse positive Größe überschreitet. Es gibt also eine positive Zahl M_1, so daß $D(x)$ nie verschwindet, wenn $|x| > M_1$ ist. Außerhalb des Kreises um den Nullpunkt mit Radius M_1 gibt es dann, $x = \infty$ eventuell ausgenommen, kein Punkt, wo zwei oder mehr der Wurzeln der gegebenen Gleichung gleich sein können (Verzweigungsstelle der mehrdeutigen Funktion y, welche durch die gegebene Gleichung definiert ist), d. h. die n Wurzeln können in diesem Gebiete als n distinkte Funktionen von x betrachtet werden, wenn außerdem die Ebene längs der negativen reellen Axe aufgeschnitten wird; wir können sie durch $y_1, y_2, \ldots, y_n$ bezeichnen.

Da $x = \infty$ höchstens ein Pol für die Funktionen $\frac{A_1(x)}{A_0(x)}, \ldots, \frac{A_n(x)}{A_0(x)}$ ist, so sind diese alle immer endlich für endliche x, absolut $>$ eine gewisse Zahl M_2. Dann bleiben also auch $y_1 \ldots y_n$ endlich, wenn $|x| > M_2$. Es sei $M = \text{Max}\,(M_1, M_2)$.

Die Zahlen x in K, die $> M$ sind, bilden eine Unterklasse K_M von K. Weiter sei K_i $(i = 1, 2, \ldots, n)$ die Unterklasse von K_M, für welche y_i eine ganze Zahl ist. Dann muß mindestens eine der Klassen K_i (Satz 1) eine Verteilungsdichte > 0 haben. Außerdem lassen sich $y_1, \ldots y_n$ in der im Satze 10 angegebenen Weise entwickeln. Zufolge Satz 10 muß aber dann das betreffende y_i eine ganze rationale Funktion von x sein mit rationalen Koeffizienten.

Der Beweis des Satzes 11 läßt sich auch etwas anders führen nämlich mit Hilfe folgender Betrachtungen, die auch sonst ein allgemeines Interesse haben.

Wir betrachten Funktionen der Form $f(x, y) = A_0(x)\, y^n + A_1(x)\, y^{n-1} + \cdots + A_n(x)$, wo $A_0 \cdots A_n$ eindeutige Funktionen von x sind, für welche $x = \infty$ höchstens ein Pol ist.

Ist eine solche Funktion $f(x, y)$ für alle x und y gleich dem Produkte $g(x, y)\, h(x, y)$ zweier solcher Funktionen $g(x, y)$ und $h(x, y)$, so kann man sagen, daß $f(x, y)$ durch $g(x, y)$ teilbar ist. Ist f nicht durch g teilbar, so gibt es zwei andere Funktionen der betrachteten Art, $k(x, y)$ und $r(x, y)$, so daß $f(x, y) = g(x, y)\, k(x, y) + r(x, y)$ ist, und außerdem $r(x, y)$ von kleinerem Grade in y ist als $g(x, y)$.

Nun gibt es für zwei Funktionen f und g immer gemeinschaftliche Teiler, da z. B. die Konstante $+1$ ein solcher ist. Weiter ist also das Euklidische Verfahren zum Aufsuchen des größten gemeinschaftlichen Teilers gültig, d. h. es gibt immer einen eindeutig bestimmten gemeinschaftlichen Teiler vom höchsten Grad, der durch alle anderen gemeinsamen Teiler teilbar ist.

Versteht man nun unter einer *irreduktiblen* Funktion eine, die nur durch sich selbst und Funktionen von x allein teilbar und nicht nur eine Funktion von x ist, während alle anderen (Funktionen von x ausgenommen) *reduktibel* genannt werden, hat man natürlich wie in der Algebra, daß *eine reduktible Funktion immer und wesentlich nur auf eine Weise das Produkt von gewissen irreduktiblen Funktionen ist*[1].

Es genügt nun augenscheinlich, wenn man Satz 1 beachtet, den Satz 11 für irreduktible Gleichungen zu beweisen. Diese können also nicht für jedes x eine Doppelwurzel haben. Dann kann die Diskriminante $D(x)$ nicht identisch verschwinden, und der Beweis wird weiter geführt wie oben angegeben.

Ich gebe jetzt einige Anwendungen auf algebraische Gleichungen.

Satz 12. *Es sei in der Gleichung*

$$H(x, y) = 0,$$

wo H ein ganzzahliges[2] *Polynom ist, für jede ganze Zahl x einer Klasse K mit einer Verteilungsdichte > 0 mindestens eine der Wurzeln y eine ganze Zahl. Dann wird die Gleichung identisch in x befriedigt, wenn man statt y ein gewisses Polynom $P(x)$ mit rationalen Koeffizienten setzt.*

Dies ist ja ein bloßes Korollar von Satz 11.

Satz 13. *Wenn für jede ganze Zahl x einer Klasse K mit einer Verteilungsdichte > 0 mindestens ν Wurzeln y der Gleichung*

$$H(x, y) = 0$$

ganz sind, so gibt es ν Polynome $P_1(x)$, $P_2(x), \ldots, P_\nu(x)$, die statt y in die Gleichung eingesetzt Identitäten in bezug auf x liefern.

Beweis durch Induktion: Nach dem vorhergehenden Satze ist diese Behauptung richtig, wenn $\nu = 1$. Ich setze die Richtigkeit für $\nu - 1$ voraus und beweise sie dann für ν.

Nach Satz 12 gibt es jedenfalls *ein* solches Polynom $P_1(x)$. Schreiben wir die gegebene Gleichung in der Form

$$y^n + A_1(x)\, y^{n-1} + \cdots + A_n(x) = 0,$$

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[1] D. h. von der Anordnung der Faktoren und von Faktoren, die Funktionen von x allein sind, abgesehen.

[2] Man brauchte natürlich nicht vorauszusetzen, daß die Koeffizienten ganze Zahlen sind. Es ist aber nur dieser Fall von Interesse, da es ja sonst ganz trivial ist, daß sogar bloß endlich viele Lösungen in ganzen Zahlen x, y vorhanden sind.

wo jetzt $A_1(x), \ldots, A_n(x)$ rationale Funktionen von x sind, so haben wir für alle x

$$y^n + A_1(x)\, y^{n-1} + \cdots + A_n(x) = (y - P_1(x))\,(y^{n-1} + A_1'(x)\, y^{n-2} + \cdots + A_{n-1}'(x)),$$

und hier sind $A_1', \cdots, A_{n-1}'$ wieder rationale Funktionen von x mit rationalen Koeffizienten. Da für jede Zahl x in K mindestens ν der Wurzeln y ganz sein sollen, so müssen augenscheinlich mindestens $\nu - 1$ der Wurzeln der Gleichung

$$y^{n-1} + A_1'(x)\, y^{n-2} + \cdots + A_{n-1}'(x) = 0$$

ganz sein für eben diese x. Hieraus folgt nach der Voraussetzung, daß $\nu - 1$ Polynome $P_2(x), \ldots, P_\nu(x)$ mit rationalen Koeffizienten existieren müssen, so daß die letzte Gleichung von $y = P_i(x)$ $(i = 2, \ldots, \nu)$ identisch in x befriedigt wird. Dann wird aber die gegebene Gleichung für alle x befriedigt, wenn man $y = P_i(x)$ $(i = 1, 2, \cdots, \nu)$ setzt.

Man kann auch folgenden Satz aufstellen, der etwas mehr aussagt als Satz 12.

Satz 14. *Es sei für jede ganze Zahl x einer Klasse K mit einer Verteilungsdichte > 0 mindestens eine Wurzel y in*

$$H(x, y) = 0$$

eine ganze Zahl. Dann gibt es μ Polynome $P_1(x), \ldots, P_\mu(x)$ (selbstverständlich $\mu \leqq n$, wenn $H(x, y)$ vom Grade n in y ist) *mit rationalen Koeffizienten, so daß $H(x, P_i(x))$ $(i = 1, 2, \ldots, \mu)$ identisch verschwindet, während außerdem für jede Zahl in K, höchstens ausgenommen eine Unterklasse K' mit der einzigen Verteilungsdichte Null, mindestens eines der μ Polynome eine ganze Zahl ist.*

Beweis: Zufolge Satz 12 muß jedenfalls ein $P_1(x)$ mit rationalen Koeffizienten existieren, so daß $H(x, P_1(x))$ identisch verschwindet. Ist $P_1(x)$ eine ganze Zahl für jede Zahl x in K oder höchstens ausgenommen die Zahlen einer Unterklasse K' mit nur verschwindender Verteilungsdichte, so ist der Satz richtig. Im entgegengesetzten Falle müssen die Zahlen einer Unterklasse K_1, welche sogar mit K identisch sein kann, ausgenommen sein, wobei K_1 eine Verteilungsdichte > 0 hat. Da aber auch für jede Zahl in K_1 mindestens eine der Wurzeln y ganz sein sollen, während $P_1(x)$ nicht ganz ist, so muß augenscheinlich mindestens eine der Wurzeln y der Gleichung $H_1(x, y) = 0$, die man aus $H(x, y)$ durch Wegdividieren des Faktors $y - P_1(x)$ erhält, ganz sein. Deshalb muß ein Polynom $P_2(x)$ mit rationalen Koeffizienten existieren, so daß $H_1(x, P_2(x))$ und folglich auch $H(x, P_2(x))$ identisch verschwindet. Ist nun $P_2(x)$ eine ganze

Zahl für alle x in K_1, höchstens ausgenommen eine Unterklasse mit nur verschwindender Verteilungsdichte, so ist wieder der Satz richtig. Die Betrachtung kann in dieser Weise fortgesetzt werden, wodurch die Richtigkeit der Behauptung einleuchtet.

Ein einfaches Beispiel hierzu ist die Gleichung

$$(2\,y + 1 - x)(2\,y - x) = 0.$$

Hier ist $\mu = 2$; K ist die ganze Zahlenreihe und $K' = 0$. Die beiden Polynome $P_1(x)$ und $P_2(x)$ sind $\frac{x}{2}$ und $\frac{x-1}{2}$. Für jede ganze Zahl x ist ja entweder $\frac{x}{2}$ oder $\frac{x-1}{2}$ eine ganze Zahl.

Satz 15. *Es sei für jede ganze Zahl x einer Klasse K mit einer Verteilungsdichte > 0 mindestens eine Wurzel y der Gleichung*

$$H(x, y) = 0$$

eine rationale Zahl. Dann gibt es eine rationale Funktion $R(x)$ mit rationalen Koeffizienten so beschaffen, daß $H(x, R(x))$ identisch $= 0$ ist.

Beweis: Die gegebene Gleichung kann in der Form

$$A_0(x)\,y^n + A_1(x)\,y^{n-1} + \cdots + A_n(x) = 0$$

geschrieben werden, wobei $A_0, \ldots, A_n$ ganzzahlige Polynome sind. Wird nun

$$A_0(x)\,y = y_1$$

gesetzt, so bekommt man

$$y_1^n + A_1(x)\,y_1^{n-1} + A_0(x)\,A_2(x)\,y_1^{n-2} + \cdots + A_0(x)^{n-1}\,A_n(x) = 0.$$

Für jede Zahl x in K ist augenscheinlich auch y_1 rational; da aber gleichzeitig alle Koeffizienten der letzteren Gleichung ganze Zahlen werden, muß y_1 ganz sein. Es ist also y_1 eine ganze Zahl für alle Zahlen der Klasse K, und folglich gibt es (Satz 12) eine ganze rationale Funktion $P(x)$ mit rationalen Koeffizienten so beschaffen, daß die letzte Gleichung identisch in x befriedigt wird, wenn man $y_1 = P(x)$ setzt. Dann muß aber $y = \frac{P(x)}{A_0(x)}$ die ursprüngliche Gleichung $H(x, y) = 0$ zu einer Identität machen.

Satz 16. *Es sei das System von Gleichungen*

$$H_1(x, y_1, \cdots, y_n) = 0,\; H_2(x, y_1, \cdots, y_n) = 0,\; \cdots\cdots,\; H_n(x, y_1, \cdots, y_n) = 0$$

gegeben, wobei $H_1 \cdots H_n$ solche ganze rationale Funktionen bedeuten, daß die n Gleichungen von einander unabhängig sind. Weiter bestehe für jede Zahl x einer Klasse K mit einer Verteilungsdichte > 0 mindestens eine der zugehörigen Wertekombinationen $y_1 \cdots y_n$ nur aus ganzen

Zahlen. Dann gibt es n Polynome mit rationalen Koeffizienten $P_1(x)$ $\cdots P_n(x)$, *so daß die n Gleichungen zu Identitäten in x werden, wenn man* $y_1 = P_1(x), \cdots, y_n = P_n(x)$ *setzt.*

Beweis: Die n Gleichungen bestimmen $y_1 \ldots y_n$ als Funktionen von x, für welche Reihenentwicklungen der Form

$$y_1 = a_{0,1}\, x^{\frac{p_1}{q_1}} + a_{1,1}\, x^{\frac{p_1-1}{q_1}} + \cdots, \; y_2 = a_{0,2}\, x^{\frac{p_2}{q_2}} + a_{1,2}\, x^{\frac{p_2-1}{q_2}} + \cdots, \cdots\cdots$$

$$\cdots, \; y_n = a_{0,n}\, x^{\frac{p_n}{q_n}} + a_{1,n}\, x^{\frac{p_n-1}{q_n}} + \cdots$$

gelten, wobei die verschiedenen Wertekombinationen teils durch verschiedene Werte der Koeffizienten a und teils durch verschiedene Werte von $\frac{p_1}{q_1}, \frac{p_2}{q_2}, \cdots$ geliefert werden. Die Zahl dieser Wurzelsysteme ist aber endlich. Nach Satz 1 muß deshalb eine Unterklasse K' von K existieren so beschaffen, daß für jedes x in K' ein bestimmtes dieser Wurzelsysteme nur aus ganzen Zahlen besteht. Dann müssen aber, wenn $y_1 \ldots y_n$ dies Wurzelsystem ist, kraft Satz 10 $y_1 \ldots y_n$ ganze rationale Funktionen von x sein mit rationalen Koeffizienten.

Man kann natürlich hier einen allgemeineren Satz aufstellen, der in einem ähnlichen Verhältnis zu Satz 11 wie Satz 16 zu Satz 12 steht, nämlich folgenden:

Satz 16'. *Es seien die n unabhängigen Gleichungen*

$$H_1 = 0, \cdots, H_n = 0$$

gegeben, worin $H_1 \ldots H_n$ *ganze rationale Funktionen von* $y_1 \ldots y_n$ *sind, deren Koeffizienten eindeutige analytische Funktionen einer Variabeln x sind, die nach fallenden ganzen Potenzen von x entwickelt werden können. Weiter sei mindestens ein Wurzelsystem* $y_1 \ldots y_n$ *ganzzahlig für jede Zahl x einer Klasse K mit einer Verteilungsdichte* > 0. *Dann gibt es n Polynome mit rationalen Koeffizienten,* $P_1(x), \ldots, P_n(x)$, *so beschaffen, daß die n Gleichungen identisch befriedigt werden, wenn man* $y_1 = P_1(x), \ldots, y_n = P_n(x)$ *setzt.*

Beweis: Da die Gleichungen unabhängig sind, kann man durch Elimination von $y_2 \ldots y_n$ eine nicht identische Gleichung in x und y_1

$$R_1(x, y_1) = 0$$

erhalten. Weiter seien

$$R_2(x, y_2) = 0, \cdots, R_n(x, y_n) = 0$$

die analogen. Die Diskriminanten der Gleichungen seien bezw. $D_1(x), \cdots, D_n(x)$. Sollte z. B. $D_1(x)$ identisch $= 0$ seien, könnte man durch rationale

Rechnungen die mehrfache(n) Wurzel(n) von $R_1(x, y_1) = 0$ wegschaffen oder m. a. W. diese Gleichung durch eine andere $R_1'(x, y_1) = 0$ ersetzen, welche dieselben Wurzeln wie $R_1(x, y_1) = 0$, aber jede einfach, hat. Deshalb können wir annehmen, daß die Gleichungen $R_1 = 0, \ldots, R_n = 0$ schon von mehrfachen Wurzeln befreit sind, oder m. a. W. daß keine der zugehörigen Diskriminanten $D_1(x), \ldots, D_n(x)$ identisch verschwindet. Nun läßt sich die Funktion $D_1(x) D_2(x) \ldots D_n(x)$ nach fallenden ganzen Potenzen von x entwickeln, und deshalb kann die Gleichung

$$D_1(x) D_2(x) \cdots D_n(x) = 0$$

nie mehr stattfinden, wenn $|x| >$ eine Zahl M_1 geworden ist. Da außerdem alle Koeffizientfunktionen von x der Funktionen H regulär sind, wenn $|x| >$ eine Zahl M_2, so verhalten sich außerhalb eines Kreises der x. Ebene um den Nullpunkt mit Radius $M = \text{Max}(M_1, M_2)$ die Funktionen $y_1 \ldots y_n$ überall regulär und eindeutig im Endlichen, während $x = \infty$ höchstens eine algebraische Singularität sein kann. Hieraus folgt, daß $y_1 \ldots y_n$ nach fallenden ganzen oder gebrochenen Potenzen von x entwickelt werden können, und für $|x| > M$ können die verschiedenen Wurzelkombinationen konsekvent unterschieden werden.

Da nun die Zahl der Wurzelkombinationen endlich ist, muß eine Unterklasse K' von K mit Dichte > 0 existieren so beschaffen, daß eine bestimmte Wurzelkombination ganzzahlig ist für alle x in K'. Nach Satz 10 sind also die betreffenden $y_1 \ldots y_n$ Polynome mit rationalen Koeffizienten.

Zusatz zu Satz 16'.

Falls mehr Gleichungen $H_{n+1} = 0$, $H_{n+2} = 0, \ldots$ zwischen $x, y_1 \ldots y_n$ hinzukommen, während noch für jede Zahl x in K mindestens ein ganzzahliges Wurzelsystem $y_1 \ldots y_n$ existiert, das alle Gleichungen befriedigt, so gibt es noch n Polynome mit rationalen Koeffizienten, welche statt $y_1 \ldots y_n$ eingesetzt alle Gleichungen identisch in x befriedigen. Denn für alle x absolut $> M$ können die verschiedenen Wurzelsysteme der Gleichungen $H_1 = 0, \ldots, H_n = 0$ konsekvent unterschieden werden, und es ist dann bestimmt, welche von ihnen auch die übrigen Gleichungen $H_{n+1} = 0$, $H_{n+2} = 0, \ldots$ befriedigen. Unter ihnen muß der Annahme zufolge mindestens eines ganzzahlig sein für ein beliebig gewähltes x in K. Es gibt also wieder eine Unterklasse K' von K mit Dichte > 0, so daß ein bestimmtes der betreffenden Wurzelsysteme ganzzahlig ist für alle x in K', woraus folgt, daß dieses System aus ganzen rationalen Funktionen von x mit rationalen Koeffizienten besteht. Diese Polynome, $P_1(x), \ldots, P_n(x)$, befriedigen dann alle Gleichungen für jedes x in K', und da K' unendlich viele Zahlen enthält, müssen sie also die Gleichungen identisch befriedigen.

Es wird später (zweiter Beweis des Satzes 24) eine Anwendung hiervon gemacht.

Satz 17. *Es sei K die Klasse der ganzen rationalen x, für welche mindestens eine Wurzel y der Gleichung*

$$H(x, y) = 0$$

eine ganze Zahl eines algebraischen Zahlkörpers R ist, wobei $H(x, y)$ ein Polynom ist, dessen Koeffizienten ganze Zahlen in R sind. Hat dann K eine Verteilungsdichte > 0, so gibt es ein Polynom $P(x)$ mit Koeffizienten, welche zu R gehören, so daß $H(x, P(x))$ identisch verschwindet.

Beweis: Es sei $\omega_1, \ldots, \omega_n$ eine Basis der ganzen Zahlen in R. Für jede Zahl x in K ist dann eine Wurzel y von der Form $y_1 \omega_1 + y_2 \omega_2 + \cdots + y_n \omega_n$, wobei $y_1 \cdots y_n$ ganze rationale Zahlen sind. Durch Einsetzung dieses Ausdrucks für y zerlegt sich bekanntlich die Gleichung $H(x, y) = 0$ in ein System von n Gleichungen

$$H_1(x, y_1, \cdots, y_n) = 0, \; H_2(x, y_1, \cdots, y_n) = 0, \cdots\cdots, H_n(x, y_1, \cdots, y_n) = 0,$$

und für jedes x in K sind diese Gleichungen von ganzen rationalen Zahlen $y_1, \ldots, y_n$ befriedigt. Nach Satz 16 müssen diese Gleichungen dann Identitäten in bezug auf x werden, wenn statt $y_1, \ldots, y_n$ gewisse Polynome $P_1(x), \ldots, P_n(x)$ mit absolut rationalen Koeffizienten gesetzt werden. Dies bedeutet aber, daß identisch in x

$$H(x, P_1(x)\,\omega_1 + P_2(x)\,\omega_2 + \cdots + P_n(x)\,\omega_n) = 0$$

ist, wodurch die Behauptung bewiesen ist.

Bei diesem Satze ist die Voraussetzung wesentlich, daß H eine ganze rationale Funktion ist nicht nur in bezug auf y, sondern auch in bezug auf x. Es ist also hier nicht möglich einen Satz aufzustellen, der den Sätzen 11 und 16′ entsprechen könnte; es genügt durchaus nicht vorauszusetzen, daß die gegebene Gleichung ganz rational in y allein ist, während die Koeffizienten der Potenzen von y beliebige eindeutige analytische Funktionen wären, die sich nach fallenden Potenzen von x mit rationalen Koeffizienten entwickeln ließen. Dies beruht darauf, daß es im allgemeinen nicht möglich ist in einem algebraischen Zahlkörper n^{ten} Grades n Zahlen zu finden, welche linear unabhängig sind in bezug auf den Zahlbereich Z, der durch die Koeffizientfunktionen für ganze rationale x und außerdem alle mögliche Verknüpfungen davon durch die vier ersten Rechnungsarten geliefert werden. In der Tat ist es nicht schwer zu sehen, daß eine passend gewählte eindeutige analytische Funktion der erwähnten Art für ein gegebenes ganzes rationales x, z. B. $x = 1$, gleich einer völlig beliebigen reellen Zahl ξ sein kann. Es wird augenscheinlich genügen zu zeigen, daß eine ganze transcendente Funktion mit rationalen Koeffizienten sich finden läßt, welche für $x = 1$ gleich ξ wird; denn durch die Transformation $x = \frac{1}{x_1}$ geht sie in eine Funktion der erwähnten Art über. In der folgenden Weise läßt sich dies zeigen:

Es seien

$$\alpha_1, \alpha_2, \alpha_3, \cdots$$

eine unendliche Reihe positiver reeller Zahlen, welche gegen 0 konvergieren. Außerdem seien die Brüche

$$\frac{p_1}{q_1} < \frac{p_2}{q_2} < \cdots < \frac{p_n}{q_n} < \frac{p_{n+1}}{q_{n+1}} < \cdots < \xi,$$

und außerdem so gewählt, daß

$$\xi - \frac{p_{n+1}}{q_{n+1}} < \alpha_n \left(\xi - \frac{p_n}{q_n}\right),$$

was augenscheinlich möglich ist. Dann ist

$$\frac{p_1}{q_1} + \sum_{n=1}^{\infty} \left(\frac{p_{n+1}}{q_{n+1}} - \frac{p_n}{q_n}\right) x^n$$

eine ganze transcendente Funktion mit rationalen Koeffizienten, welche für $x = 1$ den Wert ξ hat.

Beweis: Man hat einerseits

$$\frac{p_{n+2}}{q_{n+2}} - \frac{p_{n+1}}{q_{n+1}} < \xi - \frac{p_{n+1}}{q_{n+1}} < \alpha_n \left(\xi - \frac{p_n}{q_n}\right)$$

und andererseits

$$\frac{p_{n+1}}{q_{n+1}} - \frac{p_n}{q_n} = \xi - \frac{p_n}{q_n} - \left(\xi - \frac{p_{n+1}}{q_{n+1}}\right) > (1 - \alpha_n)\left(\xi - \frac{p_n}{q_n}\right), \text{ d. h. } \xi - \frac{p_n}{q_n} < \frac{1}{1 - \alpha_n}\left(\frac{p_{n+1}}{q_{n+1}} - \frac{p_n}{q_n}\right)$$

woraus

$$\frac{p_{n+2}}{q_{n+2}} - \frac{p_{n+1}}{q_{n+1}} < \frac{\alpha_n}{1 - \alpha_n}\left(\frac{p_{n+1}}{q_{n+1}} - \frac{p_n}{q_n}\right).$$

Da $\frac{\alpha_n}{1 - \alpha_n}$ für unendliches n gegen 0 konvergiert, muß die erwähnte Reihe für alle x konvergieren. Außerdem konvergiert $\frac{p_n}{q_n}$ gegen ξ. Hierdurch ist alles bewiesen.

Es kann deshalb in diesem allgemeineren Falle sehr wohl geschehen, daß die Zahlen des Körpers R schon im Bereiche Z enthalten sind, und die im Beweise des Satzes 17 gemachte Zerfällung in n Gleichungen wird nicht mehr möglich.

Satz 18. *Es sei ein System von m von einander unabhängigen Gleichungen*

$$H_1(x, y_1, \cdots, y_m) = 0, \cdots\cdots, H_m(x, y_1, \cdots, y_m) = 0$$

gegeben, wobei $H_1 \ldots H_n$ *ganze rationale Funktionen sind, deren Koeffizienten ganze Zahlen eines algebraischen Zahlkörpers* R *sind. Sind für jede Zahl* x *einer Klasse* K *ganzer rationaler Zahlen mit einer Verteilungsdichte* > 0 *alle* m *Zahlen* $y_1 \ldots y_m$ *eines zugehörigen Wurzelsystems ganze Zahlen in* R, *so gibt es* m *ganze rationale Funktionen von* x, $P_1(x), \ldots, P_m(x)$, *mit Koeffizienten in* R, *so daß die* m *gegebenen Gleichungen für alle Werte von* x *befriedigt werden, wenn man* $y_1 = P_1(x)$, $\ldots, y_m = P_m(x)$ *setzt.*

Beweis: Es sei $\omega_1, \omega_2, \ldots, \omega_n$ eine Basis der ganzen Zahlen des Körpers R vom Grade n. Für jede Zahl x in K sollen die m Gleichungen alle gleichzeitig befriedigt werden, wenn $y_r = y_{r,1}\omega_1 + \cdots + y_{r,n}\omega_n$ $(r = 1, \cdots, m)$ ist, wobei alle $m\,n$ Zahlen $y_{r,s}$ ganz und rational sind. Durch Einsetzung dieser Ausdrücke für y_r zerlegt sich bekanntlich jede der m Gleichungen in n Gleichungen zwischen den Zahlen $y_{r,s}$. Es entsteht in dieser Weise ein System von $m\,n$ Gleichungen zwischen x und den Zahlen $y_{r,s}$, und diese Gleichungen sind für alle x in K von ganzen rationalen Zahlen $y_{r,s}$ befriedigt. Außerdem müssen natürlich diese Gleichungen von einander unabhängig sein. Nach Satz 16 müssen sie also identisch in bezug auf x befriedigt werden, wenn man statt $y_{r,s}$ gewisse Polynome $P_{r,s}(x)$ mit absolut rationalen Koeffizienten setzt. Dadurch werden aber die m gegebenen Gleichungen identisch in x befriedigt, wenn man $y_r = P_{r,1}(x)\,\omega_1 + \cdots + P_{r,n}(x)\,\omega_n$ $(r = 1, 2, \cdots, m)$ setzt.

Satz 19. *Es sei*

$$F(x, y) = y^n + A_1(x)\, y^{n-1} + \cdots + A_n(x),$$

wo $n > 1$ *und* $A_1 \ldots A_n$ *Polynome sind mit ganzen rationalen Koeffizienten, eine irreduktible Funktion von* y *innerhalb des Rationalitätsbereiches* L, *der aus allen rationalen Funktionen von* x *mit rationalen Koeffizienten besteht. Die Klasse* K *der ganzen rationalen Zahlen* x, *für welche die übrig bleibende Funktion von* y *reduktibel im natürlichen Rationalitätsbereich ist, kann dann nur die Verteilungsdichte Null haben*[1].

Beweis: Soll $F(x, y)$ für einen Wert von x reduktibel in bezug auf y werden, so muß identisch in bezug auf y

$$y^n + A_1(x)\, y^{n-1} + \cdots + A_n(x) = (y^\nu + \alpha_1 y^{\nu-1} + \cdots + \alpha_\nu)\,(y^{n-\nu} + \\ + \beta_1 y^{n-\nu-1} + \cdots + \beta_{n-\nu}).$$

[1] Ähnliche Sätze über Irreduktibilitäten, wie die hier bewiesenen, sind von D. HILBERT im Journal für Mathematik, B. 110, aufgestellt worden. Die Beweise Hilberts sind aber komplizierter, und außerdem haben die in dieser Abhandlung bewiesenen Sätze einen größeren Inhalt.

Da $A_1 \ldots A_n$ für jede ganze Zahl x ganz sind, müssen bekanntlich für solche x auch $\alpha_1 \ldots \alpha_\nu, \beta_1 \ldots \beta_{n-\nu}$ ganz sein. Nun gibt es bloß $n-1$ mögliche Wahlen der Zahl ν, und wird deshalb mit K_ν diejenige Unterklasse von K bezeichnet, für welche eben eine Reduktibilität mit dem Werte ν stattfindet, so müßte (Satz 1) mindestens eine dieser Klassen K_ν eine Verteilungsdichte > 0 haben, falls K eine solche hätte. Weiter müßten die Gleichungen

$$\alpha_1 + \beta_1 = A_1(x),\ \alpha_1\beta_1 + \alpha_2 + \beta_2 = A_2(x), \cdots,\ \alpha_\nu\beta_{n-\nu} = A_n(x),$$

welche von der im Satze 16 erwähnten Form sind, für alle Zahlen x in K_ν von ganzen Zahlen α und β befriedigt werden. Nach Satz 16 müßten deshalb diese Gleichungen Identitäten in bezug auf x werden, wenn statt $\alpha_1 \ldots \alpha_\nu, \beta_1 \ldots \beta_{n-\nu}$ n ganze rationale Funktionen von x mit rationalen Koeffizienten eingesetzt werden. Dies würde aber augenscheinlich bedeuten, daß $F(x, y)$ innerhalb L reduktibel wäre.

Satz 20. *Es sei*

$$F(x, y) = y^n + A_1(x)\, y^{n-1} + \cdots + A_n(x),$$

wo $n > 1$ und $A_1, A_2, \ldots, A_n$ Polynome sind, deren Koeffizienten ganze Zahlen eines algebraischen Zahlkörpers R sind, eine irreduktible Funktion von y innerhalb des Funktionenkörpers L, der aus allen rationalen Funktionen von x mit Koeffizienten in R besteht. Es sei K die Klasse der ganzen rationalen x, für welche $F(x, y)$ reduktibel in R wird. Dann kann K nur die Verteilungsdichte Null haben.

Beweis: Soll $F(x, y)$ für ein x reduktibel werden, muß identisch in y eine Gleichung der Form

$$y^n + A_1(x)\, y^{n-1} + \cdots + A_n(x)$$
$$= (y^\nu + \alpha_1 y^{\nu-1} + \cdots + \alpha_\nu)(y^{n-\nu} + \beta_1 y^{n-\nu-1} + \cdots + \beta_{n-\nu})$$

bestehen, wobei $\alpha_1, \ldots, \alpha_\nu, \beta_1, \ldots, \beta_{n-\nu}$ Zahlen in R sind. Da aber $A_1 \ldots A_n$ immer ganze Zahlen in R sind, wenn x eine ganze rationale Zahl ist, so müssen auch $\alpha_1, \ldots, \alpha_\nu, \beta_1, \ldots, \beta_{n-\nu}$ ganze algebraische Zahlen sein und folglich auch ganze Zahlen in R.

Weiter müßte, falls K eine Verteilungsdichte > 0 hätte, wie früher eine Unterklasse K_ν mit nicht verschwindender Verteilungsdichte existieren, für welche ν einen bestimmten seiner $n-1$ möglichen Werte hätte. Für jede Zahl x in K_ν müßten also die Gleichungen

$$\alpha_1 + \beta_1 = A_1(x),\ \alpha_1\beta_1 + \alpha_2 + \beta_2 = A_2(x), \cdots,\ \alpha_\nu\beta_{n-\nu} = A_n(x)$$

in der Weise befriedigt werden, daß $\alpha_1 \ldots \alpha_\nu, \beta_1 \ldots \beta_{n-\nu}$ ganze Zahlen in R würden. Nach Satz 18 müßten folglich eben diese Gleichungen zu

Identitäten in bezug auf x werden, wenn statt $\alpha_1 \dots \alpha_\nu$, $\beta_1 \dots \beta_{n-\nu}$ bezw. n ganze rationale Funktionen von x mit Koeffizienten in R gesetzt würden. Das würde aber bedeuten, daß $F(x, y)$ eine reduktible Funktion von y wäre innerhalb L.

Satz 21. *Es sei die Funktion*

$$F(x, y) = A_0(x)\, y^n + A_1(x)\, y^{n-1} + \dots + A_n(x),$$

worin $A_0 \dots A_n$ Polynome sind, deren Koeffizienten ganze Zahlen in einem algebraischen Zahlkörper R sind, eine irreduktible Funktion von y in dem Körper L, der aus allen rationalen Funktionen von x mit Koeffizienten in R besteht. Dann kann die Klasse der ganzen rationalen x, für welche $F(x, y)$ eine reduktible Funktion von y im Körper R ist, nur die Verteilungsdichte Null haben.

Beweis: Gilt für ein x und alle y die Gleichung

$$A_0(x)\, y^n + A_1(x)\, y^{n-1} + \dots + A_n(x) = \left(\alpha_0\, y^\nu + \dots + \alpha_\nu\right)\left(\beta_0\, y^{n-\nu} + \dots + \beta^{n-\nu}\right),$$

so daß $A_0(x) = \alpha_0\, \beta_0$ sein muß, so bekommt man durch Multiplikation mit $A_0(x)^{n-1} = \alpha_0^{n-1}\, \beta_0^{n-1}$

$$\begin{aligned} A_0(x)^n\, y^n + A_1(x)\, A_0(x)^{n-1}\, y^{n-1} + \dots + A_n(x)\, A_0(x)^{n-1} \\ = \left(\alpha_0^\nu\, \beta_0^\nu\, y^\nu + \alpha_0^{\nu-1}\, \beta_0^\nu\, \alpha_1\, y^{\nu-1} + \dots + \alpha_0^{\nu-1}\, \beta_0^\nu\, \alpha_\nu\right) \\ \left(\alpha_0^{n-\nu}\, \beta_0^{n-\nu}\, y^{n-\nu} + \alpha_0^{n-\nu}\, \beta_0^{n-\nu-1}\, \beta_1\, y^{n-\nu-1} + \dots + \alpha_0^{n-\nu}\, \beta_0^{n-\nu-1}\, \beta_{n-\nu}\right), \end{aligned}$$

oder wenn $A_1(x)\, y = y_1$ gesetzt wird:

$$\begin{aligned} \Phi(x, y_1) = y_1^n + A_1(x)\, y_1^{n-1} + \dots + A_0(x)^{n-1}\, A_n(x) \\ = \left(y_1^\nu + \alpha_1\, \beta_0\, y_1^{\nu-1} + \dots + \alpha_0^{\nu-1}\, \beta_0^\nu\, \alpha_\nu\right) \\ \left(y_1^{n-\nu} + \alpha_0\, \beta_1\, y^{n-\nu-1} + \dots + \alpha_0^{n-\nu}\, \beta_0^{n-\nu-1}\, \beta_{n-\nu}\right). \end{aligned}$$

Hieraus sieht man, daß $F(x, y)$ für ein ganzes rationales x nicht eine reduktible Funktion von y in R sein kann, ohne daß $\Phi(x, y_1)$ reduktibel wird und mit demselben Werte von ν. Hätte also K eine Verteilungsdichte > 0, so wäre nach Satz 20 $\Phi(x, y)$ reduktibel in L. Dies würde aber bedeuten, daß identisch in x und y_1

$$\begin{aligned} \Phi(x, y_1) = y_1^n + A_1(x)\, y_1^{n-1} + \dots + A_0(x)^{n-1}\, A_n(x) \\ = \left(y_1^\nu + B_1(x)\, y^{\nu-1} + \dots + B_\nu(x)\right)\left(y_1^{n-\nu} + C_1(x)\, y_1^{n-\nu-1} + \dots + C_{n-\nu}(x)\right), \end{aligned}$$

wo $B_1, \dots B_\nu, C_1, \dots, C_{n-\nu}$ rationale Funktionen von x sind mit Koeffizienten, die zu R gehören. Hieraus würde wieder folgen

$$F(x, y) = \frac{\Phi(x, y_1)}{A_0(x)^{n-1}} = A_0(x) y^n + A_1(x) y^{n-1} + \cdots + A_n(x) = A_0(x)$$

$$\left(y^{\nu} + \frac{B_1(x)}{A_0(x)} y^{\nu-1} + \cdots + \frac{B_{\nu}(x)}{A_0(x)^{\nu}}\right)\left(y^{n-\nu} + \frac{C_1(x)}{A_0(x)} y^{n-\nu-1} + \cdots + \frac{C_{n-\nu}(x)}{A_0(x)^{n-\nu}}\right),$$

wodurch ersichtlich wird, daß $F(x, y)$ auch reduktibel in L sein müßte.

§ 4.

Funktionen zweier oder mehrerer Variabeln $x, y, \ldots$, welche ganze Werte haben für unendlich viele ganze Werte von $x, y, \ldots$

Satz 22. *Es sei*

$$f(x, y) = A_0(x) y^{\frac{p}{q}} + A_1(x) y^{\frac{p-1}{q}} + \cdots + A_p(x) + \frac{A_{p+1}(x)}{y^{\frac{1}{q}}} + \cdots,$$

wo p und q ganze positive Zahlen und $A_0, A_1, \ldots$ Funktionen von x sind, die alle in der im Satze 10 erwähnten Weise nach fallenden ganzen oder gebrochenen Potenzen von x entwickelt werden können. Es wird dabei vorausgesetzt, daß sowohl die x- wie die y-Ebene längs der negativen reellen Axe aufgeschnitten sind, so daß die vorkommenden gebrochenen Potenzen von x und y eindeutig bestimmt sind.

Die Reihen für $A_0, A_1, \ldots$ sollen alle für $|x| >$ ein positives a konvergieren, während für $|x| > a$ die Reihe für $f(x, y)$ konvergieren soll, wenn $y > Y(x)$ ist, wobei $Y(x)$ eine positive Zahl ist, die im allgemeinen von x abhängig ist.

Ist dann $f(x, y)$ eine ganze Zahl für eine Klasse K von Paaren (x, y) mit den Eigenschaften 1) und 2) (Siehe Seite 5), so muß $f(x, y)$ ein Polynom sein mit rationalen Koeffizienten[1].

Beweis: Da die Zahlen y in $k(x)$ eine Verteilungsdichte $> \frac{1}{m}$ haben, muß für jedes x in k (Satz 10) $f(x, y)$ ein Polynom in bezug auf y sein. Es sei $n = \left[\frac{p}{q}\right]$ die größte ganze Zahl $\leqq \frac{p}{q}$. Dieses Polynom kann dann in der Form $A_0(x) y^n + A_1(x) y^{n-1} + \cdots + A_n(x)$ geschrieben werden. Wir teilen dann die Zahlenreihe in Intervalle, jedes aus $m(n+1)$

[1] Außerdem sollen natürlich die Ungleichheiten $|x| > a$, $|y| > Y(x)$ für alle Paare x, y in K gültig sein, sonst würden wir ja außerhalb des Konvergenzbezirks kommen.

Zahlen bestehend; es gibt also (Satz 3) in unendlich vielen unter ihnen $n+1$ Zahlen, die zu $k(x)$ gehören. Es seien $y_1 \ldots y_{n+1}$ $n+1$ solche Werte von y in einem dieser Intervalle. Bilden wir jetzt die Gleichungen

$$A_0(x)\,y_1^n + \cdots + A_n(x) = h_1$$

$$\cdots\cdots\cdots\cdots$$

$$\cdots\cdots\cdots\cdots$$

$$A_0(x)\,y_{n+1}^n + \cdots + A_n(x) = h_{n+1}\,,$$

worin also $h_1, \ldots, h_{n+1}$ ganze Zahlen sind, so bekommen wir

$$D \cdot A_r(x) = \text{einer ganzen Zahl } (r = 0, 1, \ldots, n),$$

wobei

$$D = \begin{vmatrix} y_1^n & \cdots & 1 \\ \cdot & \cdot\;\cdot & \cdot \\ \cdot & \cdot\;\cdot & \cdot \\ y_{n+1}^n & \cdots & 1 \end{vmatrix} = \pm (y_1 - y_2)(y_1 - y_3) \cdots (y_n - y_{n+1})\,.$$

Da die Differenzen $|y_r - y_s|$ alle $< m(n+1)$ sind, wird $|D| < (m(n+1))^{\frac{(n+1)n}{2}}$, und außerdem ist $n \leqq \frac{p}{q}$.

Die Zahl D kann selbstverständlich für die verschiedenen Intervalle (oder auch eventuell verschiedenen Wahlen von $y_1 \ldots y_{n+1}$ innerhalb desselben Intervalles) verschiedene Werte haben. Jedenfalls haben aber diese Zahlen D einen größten gemeinschaftlichen Divisor d, der dann nur von x abhängt[1]. Außerdem gibt es, wenn $D_1\, D_2 \cdots D_l$ die Werte von D sind, ganze rationale Zahlen $t_1, t_2, \ldots t_l$, so daß $D_1 t_1 + D_2 t_2 + \cdots + D_l t_l = d$ ist. Es wird deshalb auch $d\, A_r(x)\,(r = 0, 1, \ldots, n)$ eine ganze Zahl. Da aber die Zahlen d, welche für die verschiedenen x auftreten, auch alle $< (m(n+1))^{\binom{n+1}{2}}$ sein müssen, haben sie alle ein gemeinsames Multiplum $\varDelta$.

Es wird dann $\varDelta \cdot A_r(x)\,(r = 0, 1, \ldots, n)$ eine ganze Zahl für jedes x in k, und da k eine Verteilungsdichte > 0 hat, muß (Satz 10) $\varDelta\, A_r(x)$ ein Polynom sein mit rationalen Koeffizienten. Es sind also auch die Funktionen $A_r(x)$ solche Polynome, wodurch die Behauptung bewiesen ist.

Satz 22'. Es sei wieder $f(x, y)$ eine Funktion, welche in der in Satz 22 erwähnten Weise entwickelt werden kann. Ist dann $f(x, y)$ eine ganze Zahl für unendlich viele Paare ganzer Zahlen x, y, so daß die Verteilungsdichte > 0 ist in bezug auf y für unendlich viele x und umgekehrt > 0

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[1] Falls der Nullpunkt $y = 0$ für jedes x als Trennungspunkt zweier Intervalle gewählt wird.

in bezug auf x für unendlich viele y, so muß $f(x, y)$ ein Polynom sein mit rationalen Koeffizienten.

Beweis: Betrachten wir einen der ganzen Werte von x, für welche solche Zahlen y mit einer Verteilungsdichte > 0 existieren soll, daß $f(x, y)$ ganz wird, so muß $f(x, y)$ nach Satz 10 für den betreffenden Wert von x eine ganze rationale Funktion von y sein, d. h. $A_{p+r}(x) = 0$ für $r = 1, 2, \ldots$ Da dies für unendlich viele ganze x gelten soll, welche also $x = \infty$ als Häufungsstelle haben, müssen die Funktionen $A_{p+r}(x)$ identisch verschwinden. Folglich ist $f(x, y)$ für alle x und y eine ganze rationale Funktion von y. Da man aber nach der Voraussetzung x und y in der ganzen Betrachtung vertauschen kann, muß $f(x, y)$ auch eine ganze rationale Funktion von x sein. Es reduziert sich also $f(x, y)$ auf ein Polynom. Die Koeffizienten dieses Polynoms müssen natürlich rational sein.

Anmerkung: Die Voraussetzungen des Satzes 22, daß k eine Verteilungsdichte > 0 und die Klassen $k(x)$ gleichmäßig Verteilungsdichten > 0 haben, sind nötig[1].

In der Tat zeigt das Beispiel $f(x, y) = \frac{y}{x}$, daß es nicht hinreicht vorauszusetzen, daß alle Klassen $k(x)$ Verteilungsdichten > 0 haben, wenn das nicht gleichmäßig geschieht, selbst wenn k eine Verteilungsdichte > 0 hat. Jede Klasse $k(x)$ hat hier die Verteilungsdichte $\frac{1}{x}$, während k die Dichte 1 hat.

Weiter zeigt das Beispiel $f(x, y) = \sqrt{2x^2 + 1} \cdot P(y)$, wo $P(y)$ ein ganzzahliges Polynom ist, daß es nicht hinreicht, daß die Klassen $k(x)$ gleichmäßig Verteilungsdichten > 0 haben, falls k nur eine verschwindende Dichte hat. Jede Klasse $k(x)$ hat ja hier die Dichte 1.

Satz 23. *Es sei*

$$f(x, y, z) = A_0(x, y) z^{\frac{p}{q}} + A_1(x, y) z^{\frac{p-1}{q}} + \cdots + A_p(x, y) + \frac{A_{p+1}(x, y)}{z^{\frac{1}{q}}} + \cdots,$$

wobei p und q ganze positive Zahlen bedeuten und $A_0, A_1, \ldots$ solche Funktionen sind, die in der im Satze 22 erwähnten Weise entwickelt werden können. Es wird hierbei vorausgesetzt, daß die x-, die y- und die z-Ebene so aufgeschnitten sind, daß die vorkommenden gebrochenen Potenzen von x, y und z eindeutig bestimmt sind. Die Reihe soll für jedes solche Tripel (x, y, z) konvergieren, daß $|x| > a$, $y > Y$ und $|z| > Z$ ist, wobei Y eine positive Größe ist, die von x, und Z eine positive Größe ist, die von x und y abhängen kann.

[1] D. h. sie können nicht vernachlässigt, vielleicht aber geschwächt, werden.

Ist dann $f(x, y, z)$ eine ganze Zahl für alle Tripel (x, y, z), die zu einer Klasse K von Tripeln mit den Eigenschaften, 1), 2) und 3) (Siehe Seite 6) gehören[1], *so muß $f(x, y, z)$ ein Polynom sein mit rationalen Koeffizienten.*

Beweis: Da die Zahlen z in $k(x, y)$ eine Verteilungsdichte $> \frac{1}{m}$ haben, muß für jedes x in k und y in $k(x)$ (Satz 10) $f(x, y, z)$ eine ganze rationale Funktion von z sein. Es sei $n = \left[\frac{p}{q}\right]$. Dann können wir $f(x, y, z)$ in der Form $A_0(x, y) z^n + \cdots + A_n(x, y)$ schreiben. Wird die Zahlenreihe in Intervalle, jedes aus $m(n+1)$ Zahlen bestehend, geteilt, so gibt es in unendlich vielen unter ihnen (Satz 3) $n+1$ Zahlen $z_1 \ldots z_{n+1}$ in $k(x, y)$. Wenn D die Determinante $\begin{vmatrix} z_1^n & \cdots & 1 \\ \cdot & \cdot & \cdot \\ z_{n+1}^n & \cdots & 1 \end{vmatrix}$ ist, erhält man wie im Satze 22, daß jede Größe $D A_r(x, y)$ $(r = 0, 1, \ldots, n)$ eine ganze Zahl sein muß. Die Zahlen D sind wieder absolut $< (m(n+1))^{\binom{n+1}{2}}$, können aber für die verschiedenen Wahlen von $z_1 \ldots z_{n+1}$ verschieden sein. Wenn d ihr größter gemeinschaftlicher Divisor bedeutet, muß wieder $d A_r(x, y)$ $(r = 0, 1, \ldots, n)$ ganz sein. Die Zahlen d können hier für die verschiedenen Paare (x, y) (x zu k und y zu $k(x)$ gehörig) verschieden sein; jedenfalls ist aber $|d| < (m(n+1))^{\binom{n+1}{2}}$, und sie haben folglich alle ein kleinstes gemeinschaftliches Multiplum Δ. Dann ist $\Delta \cdot A_r(x, y)$ $(r=0, 1, \ldots, n)$ eine ganze Zahl für jedes x in k und jedes y in $k(x)$. Da aber diese Paare eine Klasse mit den Eigenschaften 1) und 2) ist (Seite 5), müssen nach Satz 22 diese Funktionen $\Delta A_r(x, y)$ Polynome sein mit rationalen Koeffizienten. Es sind also auch die $A_r(x, y)$ solche Polynome, wodurch die Behauptung bewiesen ist.

Es ist ganz klar, wie man analoge Sätze für mehrere Variablen aufstellen kann.

Satz 24. *Es sei die Gleichung gegeben*

$$z^n + A_1(x, y) z^{n-1} + \cdots + A_n(x, y) = 0,$$

worin $A_1 \ldots A_n$ eindeutige analytische Funktionen von x und y sind, die nach fallenden ganzen Potenzen von y entwickelt werden können mit Koeffizienten, die nach fallenden ganzen Potenzen von x entwickelt werden können. Die letzteren Entwicklungen der Koeffizientfunktionen

[1] Außerdem natürlich immer $|x| > a$, $|y| > Y$ und $|z| > Z$ für alle Tripel x, y, z in K.

von $A_i(x, y)$ seien konvergent, wenn $|x| > a_i$, die Entwicklung für $A_i(x, y)$ selbst sei konvergent, wenn zugleich $|y| > Y_i(x)$ ist. Es sei weiter mindestens eine der Wurzeln z ganz, so oft das Paar (x, y) zu einer Klasse K von Paaren mit den Eigenschaften 1) und 2) gehört. Dann gibt es ein Polynom $P(x, y)$ mit rationalen Koeffizienten, so daß die Gleichung identisch in bezug auf x und y befriedigt wird, wenn man $z = P(x, y)$ setzt.

Beweis: Wenn $|x| >$ alle a_i und $|y| >$ alle $Y_i(x)$, so sind alle Funktionen $A_i(x, y)$ regulär, und jede Wurzel z der Gleichung bleibt endlich. Zwei oder mehr Wurzeln können nur dann gleich werden, wenn die Diskriminante $D(x, y)$ der Gleichung Null ist. Außerdem sieht man aus der Entwicklung von $D(x, y)$ nach fallenden Potenzen von y, daß bei gegebenem x die endlichen Wurzeln y der Gleichung $D(x, y) = 0$ ihrem absoluten Werte nach eine obere Grenze $Y'(x)$ haben müssen.

Da $D(x, y)$ nach fallenden Potenzen von y entwickelt werden kann

$$D(x, y) = D_0(x)\, y^{\nu} + D_1(x)\, y^{\nu-1} + \cdots,$$

konvergent für $|x| >$ alle a_i und $|y| >$ alle $Y_i(x)$, so sieht man, daß y nur dann unendlich werden kann in der Gleichung $D(x, y) = 0$, wenn $D_0(x) = 0$ ist, und folglich müssen die endlichen Werte von x, für welche eine Wurzel y der Gleichung $D(x, y) = 0$ unendlich wird, absolut genommen eine obere Grenze a' haben.

Es sei B der Bereich, der aus allen Paaren (x, y) besteht, worin $|x| >$ alle a_i und a' und ebenso $|y| >$ alle $Y_i(x)$ und $Y'(x)$ sind. Dann muß jede Wurzel z der gegebenen Gleichung überall regulär sein innerhalb B und auch eindeutig, wenn sowohl die x- wie die y-Ebene längs der negativen reellen Axe aufgeschnitten werden. Die Wurzel z besitzt folglich eine Entwicklung

$$z = C_0(x)\, y^{\frac{p}{q}} + C_1(x)\, y^{\frac{p-1}{q}} + \cdots,$$

wo jede der Funktionen C wieder eine Entwicklung der Form

$$C(x) = a_0\, x^{\frac{r}{s}} + a_1\, x^{\frac{r-1}{s}} + \cdots$$

hat, wobei diese Entwicklungen konvergent sein müssen für alle Paare (x, y) innerhalb B und $\sqrt[s]{x}$ und $\sqrt[q]{y}$ verhalten sich eindeutig bei der erwähnten Aufschneidung.

Die n Wurzeln z können $z_1 \ldots z_n$ heißen. Es sei K_ν $(\nu = 1, 2, \ldots, n)$ die Unterklasse von K, für deren Zahlenpaare (x, y) eben die Wurzel z_ν ganz ist. Nach Satz 4 muß dann mindestens eine der Klassen K_ν eine Unterklasse K'_ν mit den Eigenschaften 1) und 2) haben. Diejenigen Paare

x, y in $K'_{\gamma'}$, die dem Bereiche B angehören, bilden eine Unterklasse $K''_{\gamma'}$, die augenscheinlich wieder die Eigenschaften 1) und 2) hat. Nach Satz 22 muß folglich eine der Wurzeln z eine ganze rationale Funktion von x und y sein mit rationalen Koeffizienten.

Satz 24 kann auch in der folgenden einfacheren Weise bewiesen werden.

Es sei x eine Zahl der Klasse k (Siehe Seite 5). Dann hat die Klasse $k(x)$ eine Dichte > 0, und da z ganz sein soll für dieses x für jedes y in $k(x)$, so muß nach Satz 11 eine ganze rationale Funktion $P(y)$ von y existieren, so daß $z = P(y)$ die gegebene Gleichung identisch in y befriedigt, während die Koeffizienten von $P(y)$ Funktionen von x sind, die für jedes x in k rational sind. $P(y)$ hat höchstens einen Grad, den man mit Hilfe der Gleichung leicht angeben kann. Wir können deshalb für jedes x setzen

$$P(y) = u_0 y^l + u_1 y^{l-1} + \cdots + u_l,$$

wo $u_0 \ldots u_l$ Funktionen von x sind. Durch Einsetzen von $z = P(y)$ bekommt man ein System (gewöhnlich sogar eine unendliche Reihe) von Gleichungen zwischen x und $u_0, \ldots, u_l$, ganz rational in $u_0, \ldots, u_l$. Es soll weiter unten nachgewiesen werden, daß wir voraussetzen können, daß darunter $l + 1$ unabhängige vorhanden sind.

Da die Klassen $k(x)$ gleichmäßig Verteilungsdichten > 0 haben, erhalten wir genau in derselben Weise wie beim Beweise von Satz 22, daß $u_0 \ldots u_l$ für alle x in k einen endlichen Hauptnenner N haben müssen. Außerdem sind $u_0 \ldots u_l$ mit x durch $l + 1$ unabhängige Gleichungen, ganz rational in bezug auf $u_0 \ldots u_l$, verknüpft. Nach Satz 16′ müssen dann $l + 1$ Polynome $Q_0(x), \ldots, Q_l(x)$ mit rationalen Koeffizienten existieren, welche bezw. statt $u_0, \ldots, u_l$ eingesetzt alle Gleichungen zwischen $x, u_0, \ldots, u_l$ identisch in x befriedigen. Hierdurch wird aber $P(y)$ eine ganze rationale Funktion von x und y, $P(x, y)$, mit rationalen Koeffizienten, und $z = P(x, y)$ befriedigt die gegebene Gleichung identisch in x und y.

Gäbe es nicht so viele als $l + 1$ unabhängige Gleichungen zwischen $x, u_0, \ldots, u_l$, so könnte man bei beliebigem x eine oder mehrere der Größen $u_0, \ldots, u_l$ beliebig wählen, z. B. gleich Null setzen. Dann müßten aber wieder die übrigen dieser Größen rational sein für jedes x in k, und man könnte genau dieselbe Betrachtung wie oben anstellen mit demselben Ergebnis.

Satz 25. *Es sei die Gleichung gegeben*

$$u^n + A_1(x, y, z)\, u^{n-1} + \cdots + A_n(x, y, z) = 0,$$

worin $A_1 \ldots A_n$ *eindeutige analytische Funktionen von* x, y *und* z *sind, die nach fallenden Potenzen von* z *entwickelt werden können mit Koeffizienten, die Funktionen von* x *und* y *sind, welche nach fallenden Potenzen von* y *entwickelt werden können mit Koeffizienten, die Funktionen von* x *sind, welche nach fallenden Potenzen von* x *entwickelt werden können. Es seien die Entwicklungen nach* x *allein konvergent, wenn* $|x| > a_i$ *(der Index* i *bezieht sich auf* $A_i(x, y, z)$*), die Entwicklungen nach* x *und* y *konvergent, wenn zugleich* $|y| > Y_i(x)$*, und endlich die Entwicklung nach* x, y *und* z *von* $A_i(x, y, z)$ *konvergent, wenn zugleich* $|z| > Z_i(x, y)$ *ist. Es sei weiter mindestens eine der Wurzeln* u *ganz, so oft* (x, y, z) *ein Tripel einer Klasse* K *von Tripeln mit den Eigenschaften 1), 2) und 3) ist. (Seite 5). Dann gibt es ein solches Polynom* $P(x, y, z)$ *mit rationalen Koeffizienten, daß* $u = P(x, y, z)$ *die Gleichung identisch in* x, y, z *befriedigt.*

Beweis: Wenn $|x| >$ alle a_i, $|y| >$ alle $Y_i(x)$ und $|z| >$ alle $Z_i(x, y)$, so sind alle Funktionen $A_i(x, y, z)$ regulär, und jede Wurzel u bleibt endlich. Zwei oder mehr Wurzeln u können nur dann gleich werden, wenn die Diskriminante $D(x, y, z)$ der Gleichung verschwindet. Nun läßt sich jede Wurzel z der Gleichung $D(x, y, z) = 0$ nach fallenden ganzen oder gebrochenen Potenzen von y entwickeln mit Funktionen von x als Koeffizienten, die wieder nach fallenden ganzen oder gebrochenen Potenzen von x entwickelt werden können, wobei diese letzteren Entwicklungen alle konvergieren, wenn $|x| > a'$ ist. Für jedes solche x gibt es eine obere Grenze der absoluten Werte der endlichen y, für welche ein z der Gleichung $D(x, y, z) = 0$ unendlich wird; es sei $Y'(x)$ diese Grenze. Da aber auch $D(x, y, z)$ nach fallenden ganzen Potenzen von x, y, z entwickelt werden kann, müssen bei gegebenen x und y die endlichen Wurzeln z absolut genommen eine obere Grenze $Z'(x, y)$ haben. Es sei B der Bereich, der aus allen Tripeln x, y, z besteht, worin $|x| > a'$ und alle a_i', $|y| > Y'(x)$ und alle $Y_i(x)$ und $|z| > Z'(x, y)$ und alle $Z_i(x, y)$ ist. Dann ist jede Wurzel u der gegebenen Gleichung überall regulär und eindeutig innerhalb B, wenn die x-, y- und z-Ebene längs der negativen reellen Axe aufgeschnitten werden. Jede Wurzel u besitzt folglich eine Entwicklung

$$u = C_0(x, y)\, z^{\frac{p}{q}} + C_1(x, y)\, z^{\frac{p-1}{q}} + \cdots,$$

wo die Funktionen C wieder in derselben Weise wie $f(x, y)$ im Satze 22 entwickelt werden können, wobei alle diese Reihenentwicklungen für alle Tripel x, y, z in B konvergent sein müssen, und die auftretenden gebrochenen Potenzen von x, y, z verhalten sich eindeutig bei der erwähnten Aufschneidung.

Die n Wurzeln u, die also innerhalb B als n getrennte eindeutige Funktionen angesehen werden können, sollen $u_1, u_2, \ldots, u_n$ heißen. Es sei K_ν die Unterklasse von K ($\nu = 1, 2, \ldots, n$), für deren Zahlentripel x, y, z eben u_ν eine ganze Zahl ist. Nach Satz 5 muß dann mindestens eine der Klassen K_ν eine Unterklasse K'_ν mit den Eigenschaften 1), 2) und 3) haben. Diejenigen Tripel (x, y, z) in K'_ν, die dem Bereiche B angehören, bilden eine Unterklasse K''_ν, die augenscheinlich wieder die Eigenschaften 1), 2) und 3) hat. Nach Satz 23 muß folglich die Wurzel u_ν eine ganze rationale Funktion von x, y und z sein mit rationalen Koeffizienten.

Natürlich läßt sich auch für Satz 25 ein dem zweiten Beweis für Satz 24 entsprechender Beweis aufstellen.

In ganz analoger Weise können entsprechende Sätze für mehrere Variabeln bewiesen werden.

Satz 26. *Es sei die Gleichung*

$$H(x, y, z) = 0$$

gegeben, wo H ein ganzzahliges Polynom ist. Ist dann mindestens eine Wurzel z ganz für jedes Paar (x, y) in einer Klasse K mit den Eigenschaften 1) und 2), so gibt es ein Polynom $P(x, y)$ mit rationalen Koeffizienten, das statt z eingesetzt die Gleichung identisch befriedigt.

Dieser Satz ist ja ein Spezialfall von Satz 24.

Satz 27. *Es sei die Gleichung gegeben*

$$H(x, y, z, u) = 0.$$

wo H ein ganzzahliges Polynom ist. Es sei eine Wurzel u ganz für jedes Tripel einer Klasse K mit der Eigenschaften 1), 2) und 3). Dann gibt es ein Polynom $P(x, y, z)$ mit rationalen Koeffizienten, das statt u eingesetzt die Gleichung identisch befriedigt

Dies ist ja ein bloßes Korollar von Satz 25.

Genau analoge Sätze gelten natürlich für mehrere Variabeln.

Satz 28. *Es sei wieder die Gleichung*

$$H(x, y, z) = 0$$

gegeben; es werde aber jetzt vorausgesetzt, daß für jedes Paar (x, y) der Klasse K mit den Eigenschaften 1) und 2) mindesten ν der Wurzeln z ganze Zahlen sind. Dann gibt es ν Polynome $P_1(x, y), \ldots, P_\nu(x, y)$ mit rationalen Koeffizienten, die statt z eingesetzt die Gleichung identisch befriedigen.

Beweis durch Induktion: Die Behauptung ist richtig für $\nu = 1$ (Satz 26). Ich setze ihre Gültigkeit für $\nu - 1$ voraus und beweise sie für ν.

Nach Satz 26 gibt es jedenfalls ein Polynom $P_1(x, y)$ mit rationalen Koeffizienten so beschaffen, daß $H(x, y, P_1(x, y))$ identisch verschwindet. Man kann dann in $H(x, y, z)$ den vorkommenden Linearfaktor in bezug auf z, $z - P_1(x, y)$, wegdividiren, wodurch eine Gleichung

$$H_1(x, y, z) = 0$$

erhalten wird. Da für jedes Paar (x, y) in K mindestens ν der Wurzeln z der Gleichung $H = 0$ ganz sein sollen, müssen mindestens $\nu - 1$ der Wurzeln der Gleichung $H_1 = 0$ ganz sein. Es gibt also nach der Annahme $\nu - 1$ Polynome $P_2(x, y), \ldots, P_\nu(x, y)$, so daß die Gleichungen $H_1(x, y, P_2(x, y)) = 0, \ldots, H_1(x, y, P_\nu(x, y)) = 0$ Identitäten sind. Es sind also auch $H(x, y, P_2(x, y)), \ldots H(x, y, P_\nu(x, y))$ identisch Null ebenso wie $H(x, y, P_1(x, y))$.

Analoges läßt sich für mehrere Variabeln beweisen.

Satz 29. *Es sei ein System von n unabhängigen Gleichungen*

$$H_1(x, y, z_1, \cdots, z_n) = 0, \cdots, H_n(x, y, z_1, \cdots, z_n) = 0$$

gegeben, worin $H_1 \ldots H_n$ ganzzahlige Polynome sind. Es sei für alle Paare (x, y) einer Klasse K mit den Eigenschaften 1) und 2) mindestens ein Wurzelsystem $z_1 \ldots z_n$ ganzzahlig. Dann gibt es n Polynome $P_1(x,y), \ldots, P_n(x, y)$, so daß $z_1 = P_1(x, y), \ldots, z_n = P_n(x, y)$ die Gleichungen identisch befriedigen.

Beweis: Die n Gleichungen bestimmen $z_1 \ldots z_n$ als n Funktionen von x und y, für welche Reihenentwicklungen der im Satze 22 für $f(x, y)$ angegebenen Form gelten. Da nur eine endliche Zahl von Wurzelsystemen $z_1 \ldots z_n$ existieren, gibt es nach Satz 4 eine Unterklasse K' von K, die wieder die Eigenschaften 1) und 2) hat, und für deren Paare (x, y) eben ein bestimmtes der Wurzelsysteme ganzzahlig ist. Nach 22 müssen aber dann die Zahlen $z_1 \ldots z_n$ dieses Wurzelsystems Polynome $P_1(x, y), \ldots, P_n(x, y)$ mit rationalen Koeffizienten sein.

Man kann auch den folgenden allgemeineren Satz aufstellen, dem Satze 16' entsprechend.

Satz 29'. *Es seien die n unabhängigen Gleichungen*

$$H_1 = 0 \cdots H_n = 0$$

gegeben, worin $H_1 \ldots H_n$ ganze rationale Funktionen von $z_1 \ldots z_n$ sind, deren Koeffizienten eindeutige analytische Funktionen von x und y von der im Satze 24 erwähnten Art sind. Weiter sei für alle Paare x, y einer Klasse K von Paaren mit den Eigenschaften 1) und 2) mindestens eine Wurzelkombination $z_1 \ldots z_n$ ganzzahlig. Dann gibt es n Polynome mit rationalen Koeffizienten $P_1(x, y) \ldots P_n(x, y)$, welche bezw. statt $z_1 \ldots z_n$ eingesetzt die Gleichungen identisch befriedigen.

Der Beweis kann entweder analog dem Beweise für Satz 29 oder auch mit Hilfe des Satzes 16′ analog dem zweiten Beweise des Satzes 24. Ich gebe hier kurz den letzteren.

Beweis: Es sei x eine Zahl der Klasse k. Da $k(x)$ eine Dichte > 0 hat, und mindestens eine Kombination $z_1 \ldots z_n$ ganzzahlig sein soll für das gewählte x und jedes y in $k(x)$, müssen nach Satz 16′ n Polynome $P_1(y)$, ..., $P_n(y)$ existieren, deren Koeffizienten Funktionen von x sind, welche für jedes x in k rational sind, während sie bezw. statt $z_1 \ldots z_n$ eingesetzt alle n Gleichungen identisch in y befriedigen. Man kann folglich setzen

$$P_1(y) = u_{0,1}\, y^{l_1} + u_{1,1}\, y^{l_1-1} + \cdots + u_{l_1,1}, \cdots, P_n(y) = u_{0,n}\, y^{l_n} + u_{1,n}\, y^{l_n-1} + \cdots + u_{l_n,n},$$

wo $l_1 \ldots l_n$ durch die n Gleichungen bestimmte Zahlen sind. Da die Klassen $k(x)$ gleichmäßig Verteilungsdichten > 0 haben, bekommt man wie früher, daß $u_{0,i}, u_{1,i}, \ldots, u_{l_i,i}$ $(i = 1, 2, \ldots, n)$ für alle x in k einen endlichen Hauptnenner haben müssen. Durch Einsetzen von $z_1 = P_1(y) \ldots z_n = P_n(y)$ in die Gleichungen $H_1 = 0, \ldots, H_n = 0$ bekommt man eine Reihe von Gleichungen zwischen x und den Größen u, und diese Gleichungen sind ganz rational in bezug auf die u. Nach 16′ müssen folglich $l_1 + 1 + l_2 + 1 + \cdots + l_n + 1$ solche Polynome $Q_{0,1}(x), \ldots, Q_{l_1,1}(x), \ldots, Q_{0,n}(x), \ldots Q_{l_n,n}(x)$ mit rationalen Koeffizienten existieren, daß sie bezw. statt $u_{0,1} \ldots u_{l_n,n}$ eingesetzt alle zuletzt erwähnten Gleichungen identisch in x befriedigen. Es sind aber dann

$$P_1(x, y) = Q_{0,1}(x)\, y^{l_1} + \cdots + Q_{l_1,1}(x), \cdots, P_n(x, y) = Q_{0,n}\, y^{l_n} + \cdots + Q_{l_n,n}(x)$$

Polynome mit rationalen Koeffizienten, welche statt $z_1 \ldots z_n$ in die Gleichungen $H_1 = 0, \ldots, H_n = 0$ eingesetzt diese identisch in bezug auf x und y befriedigen.

Analoge Sätze können natürlich wieder für eine größere Zahl unabhängiger Variabeln bewiesen werden.

Satz 30. *Es sei die Gleichung*

$$H(x, y, z) = 0$$

gegeben, wo H ein Polynom ist mit Koeffizienten in einem algebraischen Zahlkörper R. Es sei für jedes Paar (x, y) einer Klasse K von Paaren mit den Eigenschaften 1) und 2) mindestens eine Wurzel z der Gleichung eine ganze Zahl in R. Dann gibt es ein Polynom $P(x, y)$ mit Koeffizienten in R, so daß $H(x, y, P(x, y))$ identisch Null ist.

Beweis: Es sei $\omega_1, \ldots, \omega_n$ eine Basis der ganzen Zahlen in R. Für jedes Paar (x, y) in K ist dann mindestens eine Wurzel z von der Form $z_1\omega_1 + z_2\omega_2 + \cdots + z_n\omega_n$, wo $z_1 \ldots z_n$ ganze rationale Zahlen sind.

Wird dies in die Gleichung eingesetzt, spaltet sie sich bekanntlich in n simultane Gleichungen der Form

$$H_1(x, y, z_1, \cdots, z_n) = 0, \; \cdots, \; H_n(x, y, z_1, \cdots, z_n) = 0,$$

wo $H_1, \cdots, H_n$ Polynome mit absolut rationalen Koeffizienten sind, und hier ist also ein Wurzelsystem $z_1, \ldots, z_n$ rational ganzzahlig, so oft x und y ein Paar in K bilden. Nach Satz 29 müssen deshalb n Polynome $P_1(x, y), \ldots, P_n(x, y)$ mit absolut rationalen Koeffizienten existieren, so daß die n Gleichungen zu Identitäten werden, wenn man $z_1 = P_1(x, y)$, $\ldots$, $z_n = P_n(x, y)$ setzt. Das bedeutet aber augenscheinlich, daß die gegebene Gleichung $H(x, y, z) = 0$ identisch befriedigt wird, wenn man $z = P_1(x, y)\,\omega_1 + \cdots + P_n(x, y)\,\omega_n$ setzt

Eine Verallgemeinerung hiervon ist der folgende Satz:

Satz 31. *Es sei das System von m unabhängigen Gleichungen*

$$H_1(x, y, z_1, \cdots, z_m) = 0, \; \cdots, \; H_m(x, y, z_1, \cdots, z_m) = 0$$

gegeben, worin $H_1 \ldots H_m$ Polynome sind mit Koeffizienten in einem algebraischen Zahlkörper R. Es bestehe für jedes Paar (x, y) in einer Klasse K mit den Eigenschaften 1) und 2) mindestens ein Wurzelsystem $z_1, \ldots, z_m$ nur aus ganzen Zahlen in R. Dann gibt es m Polynome $P_1(x, y), \ldots, P_m(x, y)$ mit Koeffizienten in R so beschaffen, daß die m Gleichungen identisch in x und y befriedigt werden, wenn man $z_1 = P_1(x, y), \ldots, z_m = P_m(x, y)$ setzt.

Beweis: Es sei $\omega_1, \ldots, \omega_n$ eine Basis der ganzen Zahlen in R. Wenn x und y ein Paar in K bilden, sollen die Gleichungen befriedigt werden, wenn $z_r = z_{r,1}\,\omega_1 + \cdots + z_{r,n}\,\omega_n$ $(r = 1, 2, \ldots, m)$ gesetzt wird, wobei alle $m\,n$ Größen $z_{r,s}$ ganz rational sind. Werden diese Ausdrücke für z_r in die m Gleichungen eingesetzt, spaltet sich jede von diesen in n Gleichungen, so daß man ein System von $m\,n$ Gleichungen zwischen x, y und den $m\,n$ Größen $z_{r,s}$ erhält. Da nun für jedes Paar (x, y) in K mindestens ein Wurzelsystem $z_{r,s}$ dieser Gleichungen nur aus ganzen rationalen Zahlen besteht, so gibt es nach Satz 29 $m\,n$ Polynome $P_{r,s}(x, y)$ mit absolut rationalen Koeffizienten, so daß das System der $m\,n$ Gleichungen identisch befriedigt wird, wenn man $z_{r,s} = P_{r,s}(x, y)$ setzt. Dann werden aber augenscheinlich die m gegebenen Gleichungen Identitäten in bezug auf x und y, wenn $z_r = P_{r,1}(x, y)\,\omega_1 + \cdots + P_{r,n}(x, y)\,\omega_n$ $(r = 1, 2, \ldots, m)$ gesetzt wird.

Ähnliche Sätze gelten für mehrere Variabeln.

Satz 32. *Es sei*

$$F(x, y, z) = z^n + A_1(x, y)\,z^{n-1} + \cdots + A_n(x, y),$$

wo $n > 1$ und $A_1 \dots A_n$ Polynome sind mit ganzen rationalen Koeffizienten, eine irreduktible Funktion von z innerhalb des Körpers L, der aus allen rationalen Funktionen von x und y mit rationalen Koeffizienten besteht. Die Klasse K der Paare ganzer rationaler Zahlen (x, y), für welche die übrig bleibende Funktion von z reduktibel im natürlichen Rationalitätsbereich ist, kann dann keine Unterklasse mit den Eigenschaften 1) und 2) haben. — Ich beweise die Behauptung in umgekehrter Form: Falls eine solche Klasse K mit den Eigenschaften 1) und 2) existiert, muß $F(x, y, z)$ innerhalb L reduktibel sein.

Beweis: Soll $F(x, y, z)$ für irgend ein Paar x, y reduktibel in bezug auf z werden, so muß eine Identität in z der Form

$$z^n + A_1(x, y) z^{n-1} + \cdots + A_n(x, y) = (z^\nu + \alpha_1 z^{\nu-1} + \cdots + \alpha_\nu)$$
$$(z^{n-\nu} + \beta_1 z^{n-\nu-1} + \cdots + \beta_{n-\nu})$$

stattfinden. Da $A_1 \dots A_n$ immer ganze rationale Zahlen sind, wenn x und y ganz rational sind, müssen bekanntlich auch $\alpha_1, \dots, \alpha_\nu, \beta_1, \dots, \beta_{n-\nu}$ ganze rationale Zahlen sein. Gibt es nun eine Klasse K von Paaren (x, y) mit den Eigenschaften 1) und 2), so daß für jedes dieser Paare $F(x, y, z)$ reduktibel in bezug auf z ist, so muß (Satz 4), wenn K_ν $(\nu = 2, 3, \dots, n-1)$ diejenige Unterklasse von K bezeichnet, für deren Zahlenpaare eben eine Reduktibilität in zwei Faktoren der Grade ν und $n-\nu$ stattfindet, mindestens eine der Klassen K_ν eine Unterklasse K'_ν mit den Eigenschaften 1) und 2) haben. Weiter müssen die Gleichungen

$$\alpha_1 + \beta_1 = A_1(x, y),\ \alpha_1 \beta_1 + \alpha_2 + \beta_2 = A_2(x, y), \cdots\cdot,\ \alpha_\nu \beta_{n-\nu} = A_n(x, y)$$

bestehen. Sie sind von der im Satze 29 erwähnten Form und müssen für jedes Paar (x, y) in K'_ν für ein System ganzer Zahlen $\alpha_1 \dots \alpha_\nu \beta_1 \dots \beta_{n-\nu}$ erfüllt sein. Nach Satz 29 gibt es dann n Polynome mit rationalen Koeffizienten $P_1(x, y), \dots, P_n(x, y)$, so daß die n Gleichungen identisch befriedigt werden, wenn $\alpha_1 = P_1(x, y), \dots, \alpha_\nu = P_\nu(x, y)$, $\beta_1 = P_{\nu+1}(x, y), \dots$, $\beta_{n-\nu} = P_n(x, y)$ gesetzt werden. Dadurch wird aber die Gleichung

$$z^n + A_1(x, y) z^{n-1} + \cdots + A_n(x, y) = (z^\nu + P_1(x, y) z^{\nu-1} + \cdots + P_\nu(x, y))$$
$$(z^{n-\nu} + P_{\nu+1}(x, y) z^{n-\nu-1} + \cdots + P_n(x, y))$$

eine Identität in x, y und z; d. h. $F(x, y, z)$ ist eine reduktible Funktion von z innerhalb L.

Satz 33. *Es sei K_0 die Klasse der Paare ganzer rationaler Zahlen x, y, für welche das Polynom*

$$F(x, y, z) = z^n + A_1(x, y) z^{n-1} + \cdots + A_n(x, y),$$

dessen Koeffizienten ganze Zahlen eines algebraischen Zahlkörpers R sind, reduktibel in bezug auf z im Körper R wird. Hat dann K_0 eine Unterklasse K mit den Eigenschaften 1) und 2), so muß $F(x, y, z)$ eine reduktible Funktion von z sein innerhalb des Körpers L, der aus allen rationalen Funktionen von x und y mit Koeffizienten in R besteht.

Beweis: Wenn $F(x, y, z)$ für ein Paar (x, y) reduktibel in bezug auf z ist, gibt es eine Identität in z der Form

$$z^n + A_1(x, y) z^{n-1} + \cdots + A_n(x, y) = (z^\nu + \alpha_1 z^{\nu-1} + \cdots + \alpha_\nu)$$
$$(z^{n-\nu} + \beta_1 z^{n-\nu-1} + \cdots + \beta_{n-\nu}).$$

Da $A_1 \ldots A_n$ immer ganze Zahlen in R sind, wenn x und y ganz rational sind, so müssen bekanntlich auch $\alpha_1 \ldots \alpha_\nu$, $\beta_1 \ldots \beta_{n-\nu}$ ganze algebraische Zahlen sein und folglich auch ganze Zahlen in R. Es sei K_ν die Unterklasse von K, für deren Paare (x, y) eine Reduktibilität mit den Graden ν und $n-\nu$ der Faktoren stattfindet. Nach Satz 4 muß dann mindestens eine der Klassen K_ν eine Unterklasse K'_ν mit den Eigenschaften 1) und 2) haben. Außerdem gelten die Gleichungen

$$\alpha_1 + \beta_1 = A_1(x, y), \quad \alpha_1 \beta_1 + \alpha_2 + \beta_2 = A_2(x, y), \cdots, \quad \alpha_\nu \beta_{n-\nu} = A_n(x, y),$$

welche von der im Satze 31 erwähnten Form sind. Da sie für jedes Paar (x, y) in K'_ν erfüllt sind, wenn $\alpha_1 \ldots \alpha_\nu$, $\beta_1 \ldots \beta_{n-\nu}$ gewisse ganze Zahlen in R sind, gibt es nach Satz 31 n Polynome $P_1(x, y), \ldots, P_n(x, y)$ mit Koeffizienten in R, so daß die n Gleichungen identisch befriedigt werden, wenn man $\alpha_1 = P_1(x, y), \ldots, \alpha_\nu = P_\nu(x, y)$, $\beta_1 = P_{\nu+1}(x, y), \ldots, \beta_{n-\nu} = P_n(x, y)$ setzt. Dadurch wird aber wieder $F(x, y, z)$ augenscheinlich reduktibel im Körper L.

In genau derselben Weise wie wir früher Satz 21 mit Hilfe von Satz 20 bewiesen haben, läßt sich hier der folgende Satz mit Hilfe von Satz 33 beweisen:

Satz 34. *Es sei K_0 die Klasse der Paare ganzer rationaler Zahlen (x, y), für welche die ganze rationale Funktion*

$$F(x, y, z) = A_0(x, y) z^n + A_1(x, y) z^{n-1} + \cdots + A_n(x, y),$$

deren Koeffizienten ganze Zahlen eines Körpers R sind, reduktibel in bezug auf z im Körper R ist. Hat dann K_0 eine Unterklasse K mit den Eigenschaften 1) und 2), so ist $F(x, y, z)$ reduktibel in bezug auf z im Körper L, der aus allen rationalen Funktionen von x und y mit Koeffizienten in R besteht.

Analoge Sätze lassen sich natürlich für mehrere unabhängige Variabeln beweisen.

Satz 35. *Es sei K die Klasse der ganzen rationalen Zahlen x, für welche das Polynom $F(x, y, z)$, das ganze Koeffizienten in einem algebraischen Körper R hat, eine reduktible Funktion von z ist im Körper L_y, der aus allen rationalen Funktionen von y mit Koeffizienten in R besteht. Hat dann K eine Verteilungsdichte > 0, muß $F(x, y, z)$ eine reduktible Funktion von z sein im Körper L_{xy}, der aus allen rationalen Funktionen von x und y besteht mit Koeffizienten in R.*

Beweis: Hat nämlich K eine Verteilungsdichte > 0, so hat die Klasse $\overline{K}$ von Paaren, die aus allen Paaren (x, y), wo x eine Zahl in K und y eine beliebige ganze rationale Zahl ist, besteht, die Eigenschaften 1) und 2). Außerdem wird augenscheinlich $F(x, y, z)$ eine reduktible Funktion von z im Körper R für jedes Paar (x, y) in $\overline{K}$. Nach Satz 34 muß also $F(x, y, z)$ eine reduktible Funktion von z sein innerhalb L_{xy}.

Auch dieser Satz läßt sich natürlich verallgemeinern. Der allgemeinste Satz über Reduktibilitäten, den man in dieser Weise gewinnen kann, lautet folgendermaßen:

Es sei K eine Klasse von Komplexen ganzer rationaler Zahlen, jedes aus m Zahlen $x_1 \ldots x_m$ bestehend. Es sei k die Klasse der in diesen Komplexen vorhandenen Zahlen x_1, $k(x_1)$ die Klasse der x_2, welche mit x_1 zusammen in den Komplexen vorkommen, $k(x_1, x_2)$ die Klasse der x_3, welche mit x_1 und x_2 zusammen in den Komplexen vorkommen, usw. Außerdem habe k eine Verteilungsdichte > 0, die Klassen $k(x_1)$ gleichmäßig Verteilungsdichten > 0, ebenso die $k(x_1, x_2)$ gleichmäßig Verteilungsdichten > 0, usw. Weiter sei $F(x_1 \ldots x_m, y_1 \ldots y_{n-1}, y_n)$ eine ganze rationale Funktion von $m + n$ Variabeln mit Koeffizienten in einem algebraischen Zahlkörper R. Ist dann für jedes Zahlenkomplex $(x_1 \ldots x_m)$ in K die Funktion F reduktibel in bezug auf y_n im Körper $L(y_1, \ldots, y_{n-1})$, der aus allen rationalen Funktionen von $y_1 \ldots y_{n-1}$ mit Koeffizienten in R besteht, so ist F eine reduktible Funktion von y_n im Körper $L(x_1 \ldots x_m, y_1 \ldots y_{n-1})$, der aus allen rationalen Funktionen von $x_1 \ldots x_m$, $y_1 \ldots y_{n-1}$ mit Koeffizienten in R besteht.

Der Satz ist in der Tat für $n = 1$ nur eine Verallgemeinerung des Satzes 34, und wenn soviel bewiesen ist, läßt sich der Fall $n > 1$ darauf zurückführen mit Hilfe einer genau analogen Betrachtung wie die oben beim Beweise des Satzes 35 angestellte.

§ 5.

Über einige Verschärfungen der im Vorhergehenden bewiesenen Sätze, u. a. eine Klasse von Gleichungen mit zwei Unbekannten, welche nur endlich viele Lösungen in ganzen rationalen Zahlen haben.

Die in den vorhergehenden Paragraphen bewiesenen Sätze gestatten unzweifelhaft in ausgedehntem Maße Verschärfungen. Solche verschärften Sätze werden wohl aber größtenteils bedeutend schwerer zu beweisen sein. Es gibt aber einige ziemlich umfassende Fälle, da ein solche Verschärfung leicht gelingt. Ich will im folgenden ein Paar solche Fälle zeigen.

Satz 36. *Es sei die Reihe*

$$y = a_0 x + a_1 + \frac{a_2}{x} + \cdots$$

konvergent, wenn $|x| > R$, *während nicht alle Koeffizienten* $a_2, a_3, \ldots$ *verschwinden. Falls* y *eine ganze Zahl ist für unendlich viele ganze Werte* (die augenscheinlich alle positiv vorausgesetzt werden können)

$$x_1 < x_2 < x_3 \cdots$$

von x, *können die Quotienten*

$$\frac{(x_{t+1} - x_t)\,(x_{t+2} - x_t)\,(x_{t+2} - x_{t+1})}{x_t\, x_{t+1}\, x_{t+2}}$$

nicht Null als Häufungsstelle haben, oder m. a. W. für alle $t > T$ *sind sie* $> a$, *wo* a *eine positive von* t *unabhängige Zahl ist.*

Beweis: Aus den Gleichungen

$$y_{t+1} - y_t = a_0 (x_{t+1} - x_t) + a_2 \frac{(x_t - x_{t+1})}{x_t x_{t+1}} + a_3 \frac{(x_t^2 - x_{t+1}^2)}{x_t^2\, x_{t+1}^2} + \cdots$$

$$y_{t+2} - y_{t+1} = a_0 (x_{t+2} - x_{t+1}) + a_2 \frac{(x_{t+1} - x_{t+2})}{x_{t+1}\, x_{t+2}} + a_3 \frac{(x_{t+1}^2 - x_{t+2}^2)}{x_{t+1}^2\, x_{t+2}^2} + \cdots$$

bekommt man durch Elimination von a_0

$$(x_{t+1} - x_t)(y_{t+2} - y_{t+1}) - (x_{t+2} - x_{t+1})(y_{t+1} - y_t) = a_2 X_2 + a_3 X_3 + \cdots,$$

wo

$$X_m = (x_{t+1} - x_t)\frac{(x_{t+1}^{m-1} - x_{t+2}^{m-1})}{x_{t+1}^{m-1}\, x_{t+2}^{m-1}} - (x_{t+2} - x_{t+1})\frac{(x_t^{m-1} - x_{t+1}^{m-1})}{x_t^{m-1}\, x_{t+1}^{m-1}} =$$

$$= \frac{(x_{t+2} - x_{t+1})(x_{t+1} - x_t)}{x_t^{m-1}\, x_{t+1}^{m-1}\, x_{t+2}^{m-1}} \cdot \Big[(x_{t+2}^{m-1} - x_t^{m-1})\, x_{t+1}^{m-2} + (x_{t+2}^{m-2} - x_t^{m-2})\, x_t\, x_{t+1}^{m-3}\, x_{t+2}$$

$$+ \cdots + (x_{t+2} - x_t)\, x_t^{m-2}\, x_{t+2}^{m-2}\Big].$$

Hieraus

$$\frac{X_{m+1}}{X_m} = \frac{1}{x_t\, x_{t+1}\, x_{t+2}} \cdot \frac{T_1 + T_2 + \cdots + T_{m-1} + T_m}{N_1 + N_2 + \cdots + N_{m-1}},$$

wo

$$T_r = (x_{t+2}^{m-r+1} - x_t^{m-r+1})\, x_t^{r-1}\, x_{t+1}^{m-r}\, x_{t+2}^{r-1}$$

und

$$N_r = (x_{t+2}^{m-r} - x_t^{m-r})\, x_t^{r-1}\, x_{t+1}^{m-r-1}\, x_{t+2}^{r-1}$$

gesetzt ist. Es wird dann

$$\frac{1}{x_t\, x_{t+1}\, x_{t+2}} \cdot \frac{T_r}{N_r} = \frac{(x_{t+2}^{m-r+1} - x_t^{m-r+1})}{(x_{t+2}^{m-r} - x_t^{m-r})\, x_t\, x_{t+2}} =$$

$$= \frac{(x_{t+2}^{m-r} + x_{t+2}^{m-r-1}\, x_t + \cdots + x_t^{m-r})}{(x_{t+2}^{m-r-1} + x_{t+2}^{m-r-2}\, x_t + \cdots + x_t^{m-r-1})\, x_t\, x_{t+2}} =$$

$$= \frac{(x_{t+2}^{m-r} + x_{t+2}^{m-r-1}\, x_t + \cdots + x_{t+2}\, x_t^{m-r-1})}{(x_{t+2}^{m-r} + x_{t+2}^{m-r-1}\, x_t + \cdots + x_{t+2}\, x_t^{m-r-1})\, x_t}$$

$$+ \frac{x_t^{m-r-1}}{(x_{t+2}^{m-r-1} + x_{t+2}^{m-r-2}\, x_t + \cdots + x_t^{m-r-1})\, x_{t+2}} < \frac{1}{x_t} + \frac{1}{x_{t+2}} < \frac{2}{x_t},$$

und weiter

$$\frac{1}{x_t\, x_{t+1}\, x_{t+2}} \cdot \frac{T_m}{N_{m-1}} = \frac{1}{x^{t+1}} < \frac{1}{x_t}.$$

Da aber alle Größen $T_1 \ldots T_m$, $N_1 \ldots N_{m-1}$ positiv sind, folgt hieraus

$$\frac{X_{m+1}}{X_m} = \frac{T_1 + \cdots + T_{m-1}}{x_t\, x_{t+1}\, x_{t+2}\, (N_1 + \cdots + N_{m-1})} + \frac{T_m}{x_t\, x_{t+1}\, x_{t+2}\, (N_1 + \cdots + N_{m-1})}$$

$$< \frac{2}{x_t} + \frac{1}{x_t} = \frac{3}{x_t}.$$

Es sei nun unter den Koeffizienten

$$a_2,\ a_3,\ \cdots$$

a_μ der erste, welcher $\neq 0$ ist. Dann ist

$$z = (x_{t+1} - x_t)(y_{t+2} - y_{t+1}) - (x_{t+2} - x_{t+1})(y_{t+1} - y_t) =$$
$$= X_\mu \left(a_\mu + a_{\mu+1} \frac{X_{\mu+1}}{X_\mu} + a_{\mu+2} \frac{X_{\mu+2}}{X_\mu} + \cdots \right),$$

und außerdem

$$\left| a_{\mu+1} \frac{X_{\mu+1}}{X_\mu} + \cdots \right| \leq |a_{\mu+1}| \frac{X_{\mu+1}}{X_\mu} + \cdots < |a_{\mu+1}| \cdot \frac{3}{x_t} + |a_{\mu+2}| \cdot \frac{9}{x_t^2} + \cdots$$

Da aber die Reihe $\Sigma a_{r+1} x^{-r}$ konvergent sein soll, wenn $|x| > R$, so bekommen wir für alle $t >$ ein gewisses T

$$|a_{\mu+1}| \frac{3}{x_t} + |a_{\mu+2}| \cdot \frac{9}{x_t^2} + \cdots < \frac{1}{2} |a_\mu|,$$

so daß

$$\frac{1}{2} |a_\mu| X_\mu < |z| < \frac{3}{2} |a_\mu| X_\mu$$

sein muß. Es kann also die Zahl z nie mehr Null werden, wenn $t > T$. Man erhält also auch, da z immer ganz sein soll

$$\frac{3}{2} |a_\mu| X_\mu > 1 \text{ oder } X_\mu > \frac{2}{3} \frac{1}{|a_\mu|}$$

für alle $t > T$. Folglich kann X_μ nicht Null als Häufungsstelle haben, und à fortiori gilt dies für X_2, da ja $\frac{X_\mu}{X_2} < \left(\frac{3}{x_t}\right)^{\mu-2}$ und $x_t > 3$ ist für alle hinreichend große t.

Da also für alle $t > T$

$$\frac{(x_{t+1} - x_t)(x_{t+2} - x_t)(x_{t+2} - x_{t+1})}{x_t \, x_{t+1} \, x_{t+2}} > a,$$

wo a eine positive von t unabhängige Größe ist, so bekommt man

$$\frac{x_{t+1} - x_t}{x_t} \cdot \frac{x_{t+2} - x_{t+1}}{x_{t+1}} > a \frac{x_{t+2}}{x_{t+2} - x_t} > a$$

oder

$$\frac{x_{t+2}}{x_t} - \frac{x_{t+1}}{x_t} - \frac{x_{t+2}}{x_{t+1}} + 1 > a$$

oder, da $x_t < x_{t+1} < x_{t+2}$,

$$\frac{x_{t+2}}{x_t} > a + 1.$$

Sowohl die x mit geradem als die x mit ungeradem Index müssen also am wenigsten so zerstreut liegen wie die Glieder einer geometrischen Reihe. Es ist klar, daß dies weit mehr aussagt, als der Satz 9 nebst Anmerkung, nach welchem man nur weiß, daß die x eine verschwindende Verteilungsdichte haben müssen.

Satz 37. *Es seien die Variabeln x und y durch eine Gleichung der Form*

$$y^n + \left(a_1 x + a_2 + \frac{a_3}{x} + \cdots\right) y^{n-1} + (b_1 x^2 + b_2 x + b_3 + \cdots) y^{n-2} + \cdots \\ + (k_1 x^n + k_2 x^{n-1} + \cdots) = 0$$

verknüpft, wo die Reihen in x konvergent sind für hinreichend große x, während die Gleichung

$$z^n + a_1 z^{n-1} + b_1 z^{n-2} + \cdots + k_1 = 0$$

keine mehrfache Wurzel hat. Gibt es dann kein Polynom in x mit rationalen Koeffizienten, das statt y eingesetzt die Gleichung identisch befriedigt[1]*, so müssen die ganzen Werte von x, für welche mindestens eine Wurzel y ganz ist, am wenigsten so zerstreut liegen wie die Glieder einer endlichen Zahl geometrischer Reihen.*

Beweis: Die Richtigkeit folgt sofort nach dem vorhergehenden Satze, wenn man bemerkt, daß jede Wurzelfunktion y der Gleichung eine Entwicklung nach fallenden ganzen Potenzen von x besitzt, welche mit der ersten positiven Potenz von x anfängt.

Eine einfache Folgerung dieses Satzes ist, wie man sofort sieht, daß die Quotienten

$$\frac{x_t}{t^n}$$

mit wachsendem t über jede Grenze wachsen müssen für jeden positiven Wert von n. Satz 11 sagt dagegen nur aus, daß die Quotienten

$$\frac{x_t}{t}$$

über alle Grenzen wachsen müssen. Man sieht hieraus, wie weit schärfer der Satz 37 ist.

Auf algebraische Gleichungen angewandt bekommen wir den Satz:

Satz 38. *Ist H eine solche ganze rationale Funktion von x und y, daß die Gleichung*

$$h(1, z) = 0,$$

[1] Dies müßte natürlich vom ersten Grade sein.

wo $h(x, y)$ der höchste homogene Teil von H ist, nur einfache Wurzeln hat, und gibt es keine lineare Funktion von x mit rationalen Koeffizienten, welche statt y eingesetzt die Gleichung identisch befriedigt, so müssen die ganzen Zahlen x, für welche mindestens eine Wurzel y ganz ist, am wenigsten so zerstreut liegen wie die Glieder einer endlichen Zahl geometrischer Reihen.

Satz 39. *Hat man n unabhängige Gleichungen zwischen den $n+1$ Variabeln $x, y_1, \ldots, y_n$, ganz rational in $y_1 \ldots y_n$, so beschaffen, daß jede Wurzelkombination $y_1 \ldots y_n$ aus n Reihen nach fallenden ganzen Potenzen von x besteht, während z. B. die Reihe für y_1 immer mit x^{+1} anfängt und sich nie auf eine lineare Funktion mit rationalen Koeffizienten reduziert, so müssen die ganzen Zahlen x, für welche mindestens eine Wurzelkombination ganzzahlig ist, am wenigsten so zerstreut liegen, wie die Glieder einer endlichen Zahl geometrischer Reihen.*

Beweis: Da die Zahl der Wurzelkombinationen endlich ist, und sie für hinreichend große $|x|$ konsekvent unterschieden werden können, ist die Richtigkeit nach dem obigen sofort klar.

Satz 40. *Hat man eine irreduktible algebraische Gleichung mit rationalen Koeffizienten*

$$H(x, y) = y^n + A_1(x) y^{n-1} + \cdots + A_n(x) = 0,$$

wo $A_r(x)$ ein Polynom r^{ten} Grades ist, während $h(1, z) = 0$ nur einfache Wurzeln hat, und die Summe von nur einigen dieser Wurzeln nicht rational ist, indem $h(x, y)$ der höchste homogene Teil von $H(x, y)$ ist, so müssen die ganzen Zahlen x, für welche $H(x, y)$ im natürlichen Rationalitätsbereiche reduktibel wird, am wenigsten so zerstreut liegen, wie die Glieder einer endlichen Zahl geometrischer Reihen.

Beweis: Setzt man

$$y^n + A_1(x) y^{n-1} + \cdots + A_n(x) = (y^\nu + \alpha_1 y^{\nu-1} + \cdots + \alpha_\nu)$$
$$(y^{n-\nu} + \beta_1 y^{n-\nu-1} + \cdots + \beta_{n-\nu}),$$

so bekommt man n Gleichungen zwischen $x, \alpha_1 \ldots \alpha_\nu, \beta_1 \ldots \beta_{n-\nu}$, nämlich

$$\alpha_1 + \beta_1 = A_1(x), \cdots, \alpha_\nu \beta_{n-\nu} = A_n(x).$$

Diese Gleichungen sind sicher unabhängig; sie bestimmen nämlich $\alpha_1 \ldots \beta_{n-\nu}$ (allerdings endlich vieldeutig) als Funktionen von x, indem ja $\alpha_1 \ldots \alpha_\nu$ elementarsymmetrische Funktionen von gewissen ν der Wurzeln y der Gleichung $H(x, y) = 0$ sind, während $\beta_1 \ldots \beta_{n-\nu}$ elementarsymmetrische Funktionen der $n - \nu$ übrigen Wurzeln sind. Da alle Wurzeln der Gleichung $H(x, y)$ eine Entwicklung nach fallenden ganzen Potenzen haben, so besteht also auch jedes System zusammenhöriger Werte von $\alpha_1 \ldots \beta_{n-\nu}$ aus n solchen Entwicklungen. Außerdem kann in den Reihen für α_1 und β_1 kein höherer positiver Exponent als $+1$ auftreten, da in den Entwicklungen der Wurzeln y kein höherer Exponent auftritt, und weil α_1 und β_1 nur Summen einiger dieser Wurzeln sind. Da die Summe von ν der Wurzeln der Gleichung $h(1, z) = 0$ nie rational sein soll, so folgt, daß die Summe von ν der Wurzeln y nicht ein Polynom mit rationalen Koeffizienten sein kann. Es kann also keiner der möglichen Werte von α_1 (oder auch β_1) ein Polynom mit rationalen Koeffizienten sein. Nach dem vorigen Satze, und weil ν bloß $n - 1$ Werte haben kann, folgt dann die Richtigkeit der Behauptung.

Es ist wiederum klar, daß entsprechende Sätze für andere Rationalitätsbereiche als den natürlichen aufgestellt werden können. Ebenso kann man einen analogen Satz für Gleichungen zwischen x und y aufstellen, die ganz rational in bezug auf y sind; deren Koeffizienten $A_r(x)$ aber beliebige eindeutige analytische Funktionen von x sind, für welche $x = \infty$ ein Pol s^{ter} Ordnung, $s \leqq r$, ist — allerdings aber dann nur für Reduktibilitäten im natürlichen Rationalitätsbereich. (Siehe die beim Satze 17 gemachte Bemerkung).

Satz 41. *Es sei die Gleichung gegeben*

$$y^n = A_1(x)\, y^{n-1} + \cdots + A_n(x),$$

worin $A_1, \ldots, A_n$ *eindeutige analytische Funktionen von* x *sind, für welche* $x = \infty$ *entweder eine reguläre Stelle oder ein Pol ist, und die Reihen nach fallenden ganzen Potenzen von* x *rationale Koeffizienten haben, während außerdem mindestens eine der Funktionen* $A_1, \ldots, A_n$ *mindestens eine Singularität im Endlichen hat, so daß sie nicht alle bloße Polynome sind. Die Gleichung sei irreduktibel*[1]. *Unter diesen Voraussetzungen hat die Gleichung nur eine endliche Zahl von Lösungen in ganzen rationalen Zahlen* x *und* y.

Beweis: Da es höchstens n reelle unendliche Zweige der durch die gegebene Gleichung dargestellten Kurve gibt, genügt es zu zeigen, daß auf einem beliebigen dieser Zweige höchstens endlich viele Gitterpunkte existieren können. Auf einem solchen Zweige wird y sich wie eine Potenz von x mit rationalem Exponenten verhalten, d. h. es gibt eine solche rationale Zahl $\frac{p}{q}$, daß der Quotient $\frac{y}{x^{\frac{p}{q}}}$ für $x = \infty$ einen von Null verschiedenen endlichen Grenzwert hat. Nun haben wir

[1] Siehe die Erklärungen beim zweiten Beweis für Satz 11 oben.

$$y^n = \left(P_1(x) + \frac{a_{1,1}}{x} + \frac{a_{2,1}}{x^2} + \cdots\right) y^{n-1} + \cdots + P_n(x) + \frac{a_{1,n}}{x} + \frac{a_{2,n}}{x^2} + \cdots,$$

wo die Koeffizienten a alle rational sind, während $P_1(x), \ldots, P_n(x)$ Polynome mit rationalen Koeffizienten sind. Hieraus bekommt man durch Multiplikation beiderseits mit y und Elimination von y^n rechts eine Gleichung der Form

$$y^{n+1} = \left(Q_1(x) + \frac{b_{1,1}}{x} + \frac{b_{2,1}}{x^2} + \cdots\right) y^{n-1} + \cdots + Q_n(x) + \frac{b_{1,n}}{x} + \frac{b_{2,n}}{x^2} + \cdots,$$

wo $Q_1 \ldots Q_n$ Polynome mit rationalen Koeffizienten und die b rational sind. Durch Wiederholung dieser Operation bekommt man auch y^{n+2}, $y^{n+3}, \ldots$ durch $1, y, y^2, \ldots, y^{n-1}$ ausgedrückt. Man kann deshalb so viele solche Gleichungen bilden, daß die Quotienten

$$\frac{y^r}{x^s}\left(r = 1, 2, \cdots, n-1; s \leq \frac{q}{p} r\right)$$

eliminiert werden können. Das Eliminationsresultat ist von der Form

$$C'_n y^n + \cdots + C'_{n+m} y^{n+m} = H'(x, y) + R'(x, y),$$

wo die C' rationale Zahlen, die nicht alle verschwinden, und H' ein Polynom mit rationalen Koeffizienten ist, während $R'(x, y)$ von der Form ist

$$y^{n-1}\left(\frac{k'_0}{x^{s_{n-1}}} + \frac{k'_1}{x^{s_{n-1}+1}} + \cdots\right) + y^{n-2}\left(\frac{l'_0}{x^{s_{n-2}}} + \frac{l'_1}{x^{s_{n-2}+1}} + \cdots\right) + \cdots$$
$$+ \frac{t'_0}{x} + \frac{t'_1}{x^2} + \cdots,$$

wo $k'_0\, k'_1 \ldots,\ l'_0\, l'_1 \ldots, \ldots,\ t'_0\, t'_1 \ldots$ rationale Zahlen sind und s_{n-r} die kleinste ganze positive Zahl, die $> \frac{q}{p}(n-r)$ ist. Die Zahlen C' und die Koeffizienten von H' haben aber einen Hauptnenner N. Wird mit N multipliziert, bekommt man eine Gleichung

$$C_n y^n + \cdots + C_{n+m} y^{n+m} = H(x, y) + R(x, y),$$

wo jetzt H ein ganzzahliges Polynom ist, während die C ganz und $R(x, y)$ ein Ausdruck derselben Form wie $R'(x, y)$ ist. Augenscheinlich konvergiert $R(x, y)$ gegen Null längs dem Zweige, wenn x ins Unendliche wächst.

Gäbe es nun unendlich viele Gitterpunkte auf dem Zweige, so müßte für diese, wenn $x >$ ein gewisses M, $R(x, y) = 0$ sein, da ja $R(x, y)$ nach der letzten Gleichung immer eine ganze Zahl sein muß, so oft x und y

ganz sind. Da indessen y nach fallenden Potenzen von $\sqrt[q]{x}$ entwickelt werden kann, ist dies auch mit $R(x, y) = C_n y^n + \cdots + C_{n+m} y^{n+m} - H(x, y)$ der Fall. Sollte deshalb $R(x, y) = 0$ sein für unendlich viele ganze x, so müßte $R(x, y)$ identisch $= 0$ sein. Da aber H höchstens vom Grade $n-1$ in bezug auf y ist, würde die Gleichung

$$C_{n+m} y^{n+m} + \cdots + C_n y^n - H(x, y) = 0$$

bedeuten, daß y eine ganze algebraische Funktion[1] von x wäre, was gegen die Voraussetzung streitet, daß die Koeffizienten $A_1 \ldots A_n$ der gegebenen Gleichung nicht sämtlich Polynome sein sollten.

Anmerkung: Man wird leicht einsehen, daß die Voraussetzung, daß die Koeffizienten rational sein sollen, durch die schwächere, daß sie algebraische Zahlen sein sollen, die einem algebraischen Körper R angehören, ersetzt werden kann.

Es sei zuerst R ein Normalkörper, L der Funktionenkörper, der aus allen eindeutigen Funktionen von x besteht, die nach fallenden Potenzen von x mit rationalen Koeffizienten entwickelt werden können, und $L(R)$ der entsprechende Funktionenkörper, wenn die Koeffizienten zu R gehören. Wenn $f_1(x, y)$ irreduktibel ist in $L(R)$, so sind die konjugierten Funktionen $f_2(x, y), \ldots, f_\mu(x, y)$, die auch alle Koeffizienten in R haben, irreduktibel in $L(R)$. Das Produkt $f_1 f_2 \ldots f_\mu$ gehört jedenfalls zu L. Vielleicht ist das schon mit dem Produkte einer kleineren Anzahl unter ihnen der Fall. Es sei deshalb $f_1 f' f'' \ldots = F(x, y)$ ein Produkt aus einer so kleinen Zahl dieser Funktionen als möglich, so daß $F(x, y)$ zu L gehört. Ist dann $F_1(x, y)$ ein irreduktibler Faktor von $F(x, y)$ in L, so muß $F_1(x, y)$ das Produkt von einigen der Faktoren $f_1, f', f'' \ldots$ sein. Weil aber F_1 eine Funktion in L sein soll, und die Zahl der gewählten Faktoren $f_1, f', f'', \ldots$ so klein als möglich war, damit deren Produkt zu L gehören sollte, so muß F_1 mit F identisch sein, d. h. $F(x, y)$ ist irreduktibel in L. Außerdem kann keine ganze algebraische Funktion von x die Gleichungen $f_2(x, y) = 0, \ldots, f_\mu(x, y) = 0$ befriedigen, wenn keine solche $f_1(x, y) = 0$ befriedigt. Deshalb kann auch keine solche $F(x, y) = 0$ befriedigen. Nach Satz 41 hat also die Gleichung $F(x, y) = 0$ bloß endlich viele Lösungen in ganzen rationalen Zahlen. Dies muß folglich auch mit jeder Faktorgleichung $f_1(x, y) = 0$ usw. der Fall sein.

[1] Eine ‚ganze algebraische' Funktion soll eine Funktion y von x bedeuten, welche eine Gleichung der Form

$$y^n + f_1(x) y^{n-1} + \cdots + f_n(x) = 0$$

befriedigt, worin $f_1 \ldots f_n$ Polynome sind.

Ist aber R kein Normalkörper, so ist $R = (R_1, \ldots, R_\mu)$, wo $R_1\ R_2 \ldots R_\mu$ die sämtlichen mit R konjugierten Körper bedeuten, ein Normalkörper. Eine Funktion $f(x, y)$, die in $L(R)$ irreduktibel ist, zerfällt im Körper $L(R)$, der aus allen eindeutigen Funktionen besteht, welche nach fallenden ganzen Potenzen von x mit Koeffizienten in R entwickelt werden können, in eine gewisse Zahl (vielleicht nur eine) irreduktibler Funktionen $f_1 \ldots f_\nu$. Nun wird natürlich $f(x, y) = 0$ bloß endlich viele Lösungen in ganzen Zahlen haben, wenn dies für jede der Gleichungen $f_1(x, y) = 0, \ldots, f_\nu(x, y) = 0$ der Fall ist. Da nach Voraussetzung keine ganze algebraische Funktion die Gleichung $f(x, y) = 0$ befriedigen soll, so kann keine solche irgend eine der Gleichungen $f_1(x, y) = 0 \ldots f_\nu(x, y) = 0$ befriedigen. Da aber R ein Normalkörper ist, folgt aus dem obigen, daß die Gleichungen $f_1(x, y) = 0 \ldots f_\nu(x, y) = 0$ bloß endlich viele ganzzahlige Lösungen haben.

Falls die Koeffizienten wohl algebraisch sind, aber nicht demselben algebraischen Körper von endlichem Grade angehören, scheitert diese Zurückführung auf Satz 41. Auch scheint es im allgemeinen nicht mehr möglich mit Hilfe des im Beweise ebendiesen Satzes angewandten Eliminationsverfahrens zum Ziele zu gelangen. Ob der Satz noch materiell richtig bleibt, mag hier dahingestellt bleiben.

Der Beweis mit Hilfe des Eliminationsverfahrens wird auch im allgemeinen nicht mehr gelingen, falls die Koeffizienten nicht sämtlich algebraisch sind. Denn kommt eine transcendente Zahl τ vor in dem Ausdruck für y^n, so kommen in den Ausdrücken für $y^{n+1}, y^{n+2}, \ldots$ nach und nach auch höhere Potenzen von τ vor, und diese lassen sich nicht linear mit ganzen Koeffizienten durch eine endliche Anzahl unter ihnen ausdrücken. Die Zahl der Eliminanden wächst also mit der Zahl der Gleichungen. In speziellen Fällen gelingt natürlich noch der Beweis. Ein einfaches Beispiel darauf ist

$$y = ax + b + \frac{\tau_1}{x} + \frac{\tau_2}{x^2} + \cdots, \quad a \text{ und } b \text{ ganz rational},$$

wo die unendliche Reihe für alle x absolut $> R$ konvergiert. Es ist klar, daß hier bloß endlich viele ganze rationale x existieren können, die so beschaffen sind, daß zugleich y ganz rational wird, und dies ganz gleichgültig was für Zahlen $\tau_1, \tau_2, \ldots$ sind, wenn sie nur nicht alle Null sind. (Satz 8).

Satz 42. *Es sei die Gleichung gegeben*

$$y^n = A_1(x)\,y^{n-1} + \cdots + A_n(x),$$

wo $A_1, \ldots A_n$ nach fallenden ganzen Potenzen von x mit rationalen Koeffizienten entwickelt werden können, wobei diese Entwicklungen aber hier bloß als Elemente mehrdeutiger Funktionen vorausgesetzt werden.

Diese n Reihen haben dann einen gemeinsamen Konvergenzbereich $|x| > M$. *Werden nur die Werte von x innerhalb dieses Bereiches betrachtet, können wir die durch die n Reihen gegebenen Zweige der Funktionen festhalten. Werden diese Zweige festgehalten, so hat die Gleichung bloß endlich viele Lösungen in ganzen rationalen Zahlen x und y, falls keine ganze algebraische Funktion von x statt y eingesetzt die Gleichung befriedigt.*

In der Tat wird der Beweis für Satz 41 Wort für Wort auch hier gültig bleiben, wenn man bemerkt, daß höchstens n reelle Zweige der durch die Gleichung dargestellten Kurve existieren können, welche den betreffenden festgehaltenen n Zweigen der Koeffizientfunktionen A entsprechen.

Bedeutet $L(A)$ der Funktionenkörper, der aus allen analytischen Funktionen besteht, die rational durch eindeutige Funktionen, welche nach fallenden Potenzen von x mit rationalen Koeffizienten entwickelt werden können, und die betrachteten Zweige der Funktionen $A_1 \ldots A_n$ ausgedrückt werden können, so gilt auch innerhalb $L(A)$ der Satz von der eindeutigen Dekomposition reduktibler ganzer Funktionen von y in irreduktible. Damit keine ganze algebraische Funktion der Gleichung Genüge leisten soll, wenn diese als *irreduktibel* vorausgesetzt wird, ist nun notwendig und hinreichend, daß mindestens eine der Funktionen A entweder mindestens eine nicht-algebraische Verzweigungstelle hat oder eine Singularität im Endlichen, die kein Verzweigungspunkt ist. Jede ganze algebraische Funktion befriedigt ja auch in $L(A)$ eine irreduktible Gleichung, deren Koeffizienten ebensolche Funktionen sind, und die übrigen Wurzeln sind also auch ganzalgebraisch. Hat nun die gegebene Gleichung eine Wurzel y, die ganzalgebraisch ist, so müssen alle Wurzeln solche sein und folglich auch die Koeffizienten. Die erwähnte Bedingung ist also hinreichend; denn ist sie erfüllt, sind die Funktionen $A_1, \ldots, A_n$ nicht alle ganz-algebraisch. Andererseits ist die Bedingung notwendig; denn ist sie nicht erfüllt, sind $A_1, \ldots, A_n$ alle ganz algebraisch und folglich auch alle Wurzeln y.

Die Voraussetzung in den Sätzen 41 und 42, daß die Funktionen $A_r(x)$ Entwicklungen nach fallenden ganzen Potenzen von x besitzen, kann durch die schwächere, daß sie nach fallenden gebrochenen Potenzen entwickelt werden können, ersetzt werden, wenn nur die Koeffizienten rational[1] sind. Das rührt einfach davon her, daß eine Gleichung der Form

$$f\left(x^{\frac{1}{n}}, y\right) = 0$$

[1] Oder allgemeiner einem algebraischen Körper R angehören.

nicht erfüllt sein kann, ohne daß gleichzeitig

$$F(x,y) = f\left(x^{\frac{1}{n}}, y\right) f\left(\varepsilon\, x^{\frac{1}{n}}, y\right) \cdots f\left(\varepsilon^{n-1} x^{\frac{1}{n}}, y\right) = 0$$

erfüllt ist, wo ε eine primitive n^{te} Wurzel der Einheit ist. Falls nun

$$f\left(x^{\frac{1}{n}}, y\right) = y^m + a_1(x)\, y^{m-1} + \cdots + a_m(x),$$

wobei $a_r(x)$ $(r = 1, \ldots, m)$ nach fallenden Potenzen von $x^{\frac{1}{n}}$ mit Koeffizienten in R entwickelt werden kann, wird augenscheinlich $F(x,y)$ eine Funktion der Form

$$y^{mn} + A_1(x)\, y^{mn-1} + \cdots + A_{mn}(x),$$

worin $A_r(x)$ $(r = 1, \ldots, mn)$ eine Entwicklung nach fallenden ganzen Potenzen von x mit Koeffizienten in R hat. Außerdem kann keine ganze algebraische Funktion y von x der Gleichung $F(x,y) = 0$ Genüge leisten, ohne daß mindestens eine der Gleichungen

$$f\left(x^{\frac{1}{n}}, y\right) = 0,\; f\left(\varepsilon\, x^{\frac{1}{n}}, y\right) = 0, \cdots, f\left(\varepsilon^{n-1} x^{\frac{1}{n}}, y\right) = 0$$

dadurch befriedigt wird. Daß aber eine ganze algebraische Funktion y von x die Gleichung $f\left(\varepsilon^r x^{\frac{1}{n}}, y\right) = 0$ befriedigt, ist damit gleichbedeutend, daß eine ganze algebraische Funktion von x die Gleichung $f\left(x^{\frac{1}{n}}, y\right) = 0$ befriedigt[1]. Wenn also umgekehrt keine ganze algebraische Funktion die Gleichung $f\left(x^{\frac{1}{n}}, y\right) = 0$ befriedigt, so gilt dasselbe für die Gleichung $F(x,y) = 0$.

Da nun die letztere Gleichung nach den Sätzen 41 und 42 bloß endlich viele Lösungen in ganzen Zahlen x und y hat, muß dies auch für die erstere gelten.

Ich gebe zuletzt einige weitere Bemerkungen zu den früher bewiesenen Sätzen.

Es sei $f(x)$ eine Reihe der Form

$$a_0 x^n + \cdots + a_{n-1} x + a_n + \frac{a_{n+1}}{x} + \cdots,$$

---

1 Falls nämlich $f\left(\varepsilon^r x^{\frac{1}{n}}, H(x)\right) = 0$ identisch ist, wobei $H(x)$ ganz algebraisch ist, so ist, wenn $x^{\frac{1}{n}} = \xi$ gesetzt wird, auch $h(\xi) = H(\xi^n)$ eine ganze algebraische Funktion und folglich auch $h(\varepsilon^{-r}\xi)$. Es ist aber $f(\xi, h(\varepsilon^{-r}\xi)) = 0$ eine Identität, weil $f(\varepsilon^r \xi, h(\xi)) = 0$ es ist.

worin die Koeffizienten a_{n+1}, a_{n+2}... nicht alle gleich Null sein sollen. (Vergl. Satz 9).

Es ist dann leicht zu sehen, daß man eine so große positive Zahl X angeben kann, daß mindestens einer der Funktionswerte $f(x+r_i)$, wobei $r_0 = 0, 0 < r_1 < r_2 < \cdots < r_u$ wie früher, nicht eine ganze Zahl sein kann, wenn $|x| > X$ ist.

Ist nämlich die Konstante B (Seite 12 unten) eine ganze rationale Zahl und $\bar{A} = \text{Max}\,(A, A_1, \ldots, A_u)$, so braucht man nur X so groß zu wählen, daß $X > r_u$ und außerdem die Summe

$$\sum_i A_i\left(\frac{a_{n+1}}{x+r_i}+\frac{a_{n+2}}{(x+r_i)^2}+\cdots\right)=\sum_i A_i f(x+r_i)-B$$

nie mehr Null für endliches x, wenn $|x| > X$ ist (dies muß ja möglich sein, weil ein identisches Verschwinden dieser Summe nach Satz 6 bewirken würde, daß die Koeffizienten a_{n+1}, a_{n+2}, ... alle Null sein müßten), und

$$\frac{|a_{n+1}|}{X-r_u}+\frac{|a_{n+2}|}{(X-r_u)^2}+\cdots<\frac{1}{(u+1)\bar{A}}$$

wird, was offenbar stets möglich ist, da die Reihe

$$\frac{a_{n+1}}{x}+\frac{a_{n+2}}{x^2}+\cdots$$

für hinreichend große x konvergent sein soll. Hierdurch wird nämlich für alle x, für welche $|x| > X$ ist, und für jedes i

$$\left|\frac{a_{n+1}}{x+r_i}+\frac{a_{n+2}}{(x+r_i)^2}+\cdots\right|\leqq\left|\frac{a_{n+1}}{x+r_i}\right|+\left|\frac{a_{n+2}}{(x+r_i)^2}\right|+\cdots\leqq\frac{|a_{n+1}|}{|x|-r_i}+$$

$$+\frac{|a_{n+2}|}{(|x|-r_i)^2}+\cdots<\frac{|a_{n+1}|}{X-r_u}+\frac{|a_{n+2}|}{(X-r_u)^2}+\cdots<\frac{1}{(u+1)\bar{A}},$$

und folglich wird (Seite 12 unten)

$$0<\left|\sum_i A_i f(x+r_i)-B\right|<1,$$

so daß $\sum A_i f(x+r_i)$ nicht ganz ist. Da jede Zahl A_i ganz ist, folgt hieraus, daß mindestens eine der Zahlen $f(x+r_i)$ nicht ganz ist.

Ist dagegen B nicht ganz, so sei sie zuerst reel und $B = B_1 + b$, wo B_1 die nächste ganze rationale Zahl bedeutet, so daß $|b| \leqq \frac{1}{2}$ ist. Dann braucht man nur X so groß zu wählen, daß $X > r_u$ und

$$\frac{|a_{n+1}|}{X - r_\mu} + \frac{|a_{n+2}|}{(X - r_\mu)^2} + \cdots < \frac{b}{(\mu-1)A}$$

wird. Dann bekommt man nämlich, wenn $|x| > X$ ist

$$0 < |b| - \left|\sum A_i \left(\frac{a_{n+1}}{x+r_i} + \frac{a_{n+2}}{(x+r_i)^2} + \cdots\right)\right| \leq \sum_i A_i f(x+r_i) - B_1 \leq |b| +$$

$$+ \left|\sum A_i \left(\frac{a_{n+1}}{x+r_i} + \frac{a_{n+2}}{(x+r_i)^2} + \cdots\right)\right| < 2\,|b| < 1,$$

was wieder das gewünschte Ergebnis gibt.

Es sei zuletzt B komplex $= B_1 + B_2 \sqrt{-1}$. Dann braucht man nur X so groß zu wählen, daß

$$X > r_\mu, \text{ und } \frac{|a_{n+1}|}{X - r_\mu} + \frac{|a_{n+2}|}{(X - r_\mu)^2} + \cdots < \frac{|B_2|}{(\mu+1)A}$$

wird. Dadurch kann nämlich die Summe $B + \sum_i A_i \left(\frac{a_{n+1}}{x+r_i} + \cdots\right)$ offenbar nicht reel werden und also auch keine ganze rationale Zahl, was wieder dasselbe Ergebnis wie oben gibt.

Bedeutet $f(x)$ die im Satze 10 erwähnte Reihe, während doch hier die Koeffizienten $a_{p+1}, a_{p+2}, \ldots$ nicht alle Null sein sollen, kann man in ähnlicher Weise eine so große positive Zahl X angeben, daß mindestens einer der Werte $f(x + r_i)$ $(i = 0, 1, \ldots, \mu;\ r_0 = 0)$ nicht ganz sein kann, wenn $|x| > X$. Man hat ja nur X so groß zu wählen, daß die Reihen $\varphi_0(x), \ldots, \varphi_\mu(x), \psi_1(x), \ldots, \psi_\mu(x)$ (Seite 14 unten) alle hinreichend klein werden, wenn $|x| > X$ ist. Ich glaube nicht, daß es nötig sein kann dies näher auszuführen.

Ebenso kann man X so groß positiv annehmen, daß wenn $|x| > X$, für mindestens einen der Werte $x, x + r_1, \ldots, x + r_\mu$ von x keine Wurzel y einer Gleichung der im Satze 11 betrachteten Form ganz rational sein kann, falls nicht eine ganze rationale Funktion von x die Gleichung identisch befriedigt. Ich will dies etwas näher zeigen.

Die betrachtete Gleichung sei $f(x, y) = 0$. Die Zweige von y als Funktionen von x seien $f_1(x) \ldots f_n(x)$; sie können wie früher gezeigt für hinreichend große x konsekvent unterschieden werden. Weiter sei μ eine ganze positive Zahl, $r_0 = 0$, $0 < r_1 < r_2 < \cdots < r_\mu$, und alle r ganz rational. Gibt man $i_0, i_1, \ldots, i_\mu$ beliebige (gleiche oder verschiedene) Werte unter den Zahlen $1, 2, \ldots, n$, bekommt man $n^{\mu+1}$ verschiedene Wertsysteme. Für jedes dieser $n^{\mu+1}$ Wertsysteme besitzen die Funktionen $f_{i_t}(x + r_t)$ $(t = 0, 1, \ldots, \mu)$ Reihenentwicklungen nach fallenden (gebrochenen)

Potenzen von x. Mann kann μ so groß wählen, daß in jedem der $n^{\mu+1}$ Gleichungssysteme (nämlich Reihenentwicklungen) die Potenzen von x mit positiven Exponenten eliminiert werden können (Vergl. Seite 15). Man erhält durch diese Eliminationen $n^{\mu+1}$ Gleichungen der Form (Vergl. Seite 15)

$$\sum_{t=0}^{\mu} A_t^{(\varrho)} f_{i_t}(x+r_t) = B^{(\varrho)} + \varphi_0^{(\varrho)}(x) + \sum_{t=1}^{\mu} A_t^{(\varrho)} \left(\varphi_t^{(\varrho)}(x) + \psi_t^{(\varrho)}(x)\right),$$

$$(\varrho = 1, 2, \ldots, n^{\mu+1}),$$

worin $\varphi_0^{(\varrho)}(x), \ldots, \varphi_\mu^{(\varrho)}(x), \psi_1^{(\varrho)}(x), \ldots \psi_\mu^{(\varrho)}(x)$ ähnliche Reihen sind wie die Reihen φ und ψ Seite 14 unten. In jeder dieser Gleichungen kann man ein so großes positives X_ϱ wählen, daß $\Sigma A_t^{(\varrho)} f_{i_t}(x+r_t)$ nie mehr ganz sein kann, wenn $|x| > X_\varrho$ ist. Setzt man $X = \text{Max}\,(X_1, \ldots, X_{n^{\mu+1}})$, wird also in allen $n^{\mu+1}$ Gleichungen $\Sigma A_t^{(\varrho)} f_{i_t}(x+r_t)$ nicht ganz, wenn $|x| > X$ ist. Hieraus folgt aber, daß für mindestens ein t ($t = 0, 1, \ldots, \mu$) alle Funktionen $f_1(x+r_t), \ldots, f_n(x+r_t)$ nicht ganze Zahlen sind.

Ähnliche Bemerkungen können zu den folgenden Sätzen gemacht werden. Betrachtet man z. B. das Gleichungssystem des Satzes 16′, so hat man: Falls nicht n Polynome $P_1(x) \ldots P_n(x)$ existieren, welche statt $y_1 \ldots y_n$ eingesetzt den Gleichungen identisch genügen, so gibt es, wenn $|x| >$ ein gewisses X ist, unter den Zahlen $x, x+r_1, \ldots, x+r_\mu$, wenn μ hinreichend groß ist und $r_1, \ldots, r_\mu$ eine beliebige Reihe wachsender ganzer rationaler Zahlen, mindestens eine, für welche die Gleichungen in bezug auf die y nicht ganzzahlig auflösbar sind.

Man kan auch so sagen: Teilt man die Zahlenreihe in Intervalle einer hinreichend großen Länge l, so kann man in jedem Intervall Zahlen x, auch ganze rationale, wirklich angeben, für welche die gegebenen Gleichungen kein ganzzahliges Wurzelsystem $y_1 \ldots y_n$ besitzen.

Betrachtet man den Satz 21, so kann man in analoger Weise Zahlen x angeben, auch ganze rationale, für welche $F(x, y)$ eine irreduktible Funktion von y in R wird, wenn $F(x, y)$ in L irreduktibel ist. Es ist auch leicht zu sehen, *daß die Zahlen x in R, für welche $F(x, y)$ irreduktibel in R ist, überall dicht im Körper R liegen.* Es sei nämlich der Körper R vom Grade g in einem g-dimensionalen Raume abgebildet; d. h. die Punkte dieses Raumes mit rationalen Koordinaten stellen dann die sämtlichen Zahlen des Körpers R dar. Es seien nun a und b zwei beliebige Zahlen des Körpers R. Macht man jetzt die Transformation

$$x = a + \frac{b-a}{x_1},$$

so sieht man, daß so oft x_1 eine absolut rationale Zahl zwischen 1 und $+\infty$ ist, ist x eine Zahl in R auf der Verbindungsstrecke zwischen den Punkten a und b, und umgekehrt. Durch diese Transformation geht $F(x, y)$ in eine Funktion $F_1(x_1, y)$ über. Allerdings ist $F_1(x_1, y)$ in bezug auf x_1 gebrochen, aber man kann mit einer solchen ganzen Funktion von x_1 allein multiplizieren, daß das Produkt eine primitive durchaus ganze Funktion $G(x_1, y)$ wird, welche natürlich auch in L irreduktibel sein muß. Dann kann man aber in ebenso ausgedehntem Maße wie früher ganze Werte von x_1 angeben, für welche $G(x_1, y)$ und also auch $F_1(x_1, y)$ in R irreduktibel wird. Dies bedeutet, daß man auf der Verbindungsstrecke zwischen den Punkten a und b unendlich viele Zahlen x in R finden kann, für welche $F(x, y)$ irreduktibel in R ist.

Weiter muß folgender Satz gültig sein:

Satz 21'. *Es sei die Funktion* $F(x, y)$

$$F(x, y) = A_0 y^n + A_1 y^{n-1} + \cdots + A_n,$$

worin $A_0, \ldots, A_n$ *Polynome sind, deren Koeffizienten einem Körper* R *(Satz 21) angehören, das Produkt einer gewissen Zahl irreduktibler Faktoren*

$$F(x, y) = F_1(x, y)^{m_1} \cdots F_\nu(x, y)^{m_\nu}$$

im Körper L *(Satz 21). Höchstens ausgenommen eine Klasse ganzer rationaler Zahlen mit nur verschwindender Dichte muß für jede ganze rationale Zahl* x *die Funktion* $F(x, y)$ *im Körper* R *genau in derselben Weise aus irreduktiblen Faktoren zusammengesetzt sein, d. h. die Funktionen* $F_1(x, y), \ldots, F_\nu(x, y)$ *bleiben auch in* R *irreduktibel, und außerdem bleiben sie von einander verschieden.*

Beweis: Nach Satz 21 kann die Klasse K_r $(r = 1, 2, \ldots, \nu)$ ganzer rationaler Zahlen x, für welche $F_r(x, y)$ reduktibel in R wird, nur die Dichte Null haben. Nach Satz 1 hat also die Klasse K aller ganzer rationaler x, für welche mindestens eine der Funktionen $F_1(x, y), \ldots, F_\nu(x, y)$ reduktibel in R ist, die Dichte Null. — Soll für ein x eine Gleichung der Form

$$F_r(x, y) = F_s(x, y) \left(r \gtrless s; \begin{array}{l} r = 1, 2, \ldots, \nu \\ s = 1, 2, \ldots, \nu \end{array} \right)$$

identisch in y stattfinden, so bekommt man hieraus, da dies jedenfalls keine Identität sowohl in x als y ist, gewisse Gleichungen in x allein, welche keine Identitäten sind. Also erhält man bloß endlich viele Werte von x, für welche irgend eine Gleichung der Form $F_r(x, y) = F_s(x, y)$ identisch in y gültig sein kann.

Mit Hilfe einer Transformation der Form $x = a + \frac{b-a}{x_1}$ wird man natürlich wieder beweisen können, daß die Zahlen in R, für welche eben die erwähnte Art der Reduktibilität stattfindet, überall dicht in R liegen.

Auf dieser Grundlage kann man entsprechende gruppentheoretische Sätze aufstellen,[1] so z. B. den folgenden Satz:

Es habe die Gleichung

$$f(x, y) = 0,$$

wo $f(x, y)$ ein Polynom mit Koeffizienten in einem algebraischen Zahlkörper R ist, in dem Körper L aller rationaler Funktionen von x mit Koeffizienten in R eine Gruppe G. Dann hat für jede ganze rationale Zahl x, höchstens ausgenommen eine Klasse mit Dichte Null, die Gleichung dieselbe Gruppe G in Körper R.

Beweis: Man bilde eine Galoische Resolvente $R(x, z)$ der Gleichung für den Körper L. Man kann z. B. $z_1 = u_1 y_1 + u_2 y_2 + \cdots + u_n y_n$ setzen und $u_1 \ldots u_n$ als ganze rationale Zahlen so wählen, daß die $n!$ Ausdrücke, welche durch alle möglichen Umstellungen der n Variablen y erhalten werden, alle innerhalb L verschieden sind, d. h. keine zwei identisch gleich in bezug auf x. Bezeichnen $z_1 \ldots z_{n!}$ diese $n!$ Ausdrücke, so sind sie die Wurzeln einer Gleichung $H(x, z) = 0$, und $R(x, z) = 0$ ist eine Galoische Resolvente, wenn $R(x, z)$ ein irreduktibler Faktor von $H(x, z)$ ist.

Die Funktion $H(x, z)$ zerfällt also in das Produkt einer gewissen Zahl irreduktibler Faktoren in L, und einem beliebigen dieser Faktoren entspricht in bekannter Weise die Gruppe G. Nach dem Satze 21′ bleibt aber die Art der Zusammensetzung von $H(x, z)$ aus irreduktiblen Faktoren genau dieselbe in R für jede ganze rationale Zahl x, wenn eventuell eine gewisse Menge solcher Zahlen der Dichte Null ausgenommen wird. Dies bedeutet aber, daß mit der erwähnten Ausnahme die Gruppe der Gleichung dieselbe bleibt.

Natürlich wird man auch hier beweisen können, daß die Zahlen in R, für welche die Gruppe der Gleichung eben G ist, überall dicht in R liegen[2].

Mehrere interessante Bemerkungen ließen sich für den Fall einer größeren Zahl von Variabeln aufstellen; ich will aber hier nicht näher darauf eingehen.

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[1] Vergl. Hilbert l. c.

[2] Vergl. auch H. Weber, Lehrbuch der Algebra, Kl. Ausg., Braunschweig 1912, § 83.

Gedruckt 27. April 1922.

BERICHT ÜBER DIE NACHGELASSENEN SCHRIFTEN L. SYLOWS

VON

TH. SKOLEM

(Videnskapsselskapets Skrifter. I. Mat.-Naturv. Klasse. 1921. No. 18)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
IN KOMMISSION BEI JACOB DYBWAD
1922

Fremlagt i fællesmøtet den 3dje mai 1921.

A. W. BRØGGERS BOKTRYKKERI A/S

Seit einigen Monaten habe ich die nachgelassenen Schriften L. Sylows zum Durchsehen gehabt. Erstens habe ich untersucht, ob etwas *auffallend* neues darunter vorkomme; in dem Falle wäre eine sofortige Publikation wünschenswert gewesen. Es zeigte sich aber bald, daß das nicht der Fall war. Zweitens dachte ich ursprünglich alles zu kassieren, das nicht von mathematisch-wissenschaftlichem Werte war; da es aber oft schwer war diesen Wert zu beurteilen, und die Papiere vielleicht auch sonst (z. B. historisch, biographisch, pädagogisch) Interesse haben könnten, habe ich nur ganz wenige Papiere entfernt, nämlich solche, welche völlig wertlos oder überflüssig waren. Drittens habe ich — und das ist meine wesentliche Arbeit gewesen — die (übrigen) Papiere katalogisiert und dem aufgestellten Verzeichnis entsprechend in Pakete verteilt. Nach dem Verzeichnis zerfallen die Papiere in 6 Abteilungen I—VI, wovon die erste wieder in I_A und I_B geteilt wird. Diese Abteilungen enthalten bezw.:

I. Originalarbeiten.
   A) Manuskripte früher publizierter Abhandlungen oder Studien, die dazu Anlaß gegeben haben. 9 Pakete.
   B) Andere Originalarbeiten oder Studien, welche nicht mit bestimmten Abhandlungen anderer Mathematiker verknüpft zu sein scheinen. 20 Pakete.

II. Studien (zum Teil Kritik), welche Abhandlungen anderer Mathematiker betreffen. 22 Pakete.

III. Vorlesungsmanuskripte. 19 Pakete.

IV. Biographien, Urteile beim Besetzen von Professoraten und ähnliches. 4 Pakete.

V. Papiere, welche die Herausgabe der Werke Abels und zum Teil auch die Sekulärfeier Abels betreffen. 6 Pakete.

VI. Briefe. 4 Pakete.

Die Pakete sind dem Verzeichnis entsprechend numeriert worden. Sie enthalten zum Teil mehrere Manuskripte, welche dann mit Buchstaben a, b, c, . . . versehen sind.

Von dem Verzeichnis habe ich einen Auszug gemacht, der die wichtigsten Papiere aufzählt, nämlich diejenigen, welche vielleicht neue mathematische Resultate enthalten. Dieser Auszug ist hier unten gedruckt worden. Die in eckigen Klammern hinzugefügten Zahlen beziehen sich auf die Paketennummer des vollen Verzeichnisses. Die in diesem Auszug aufgezählten Manuskripte sind alle auf norwegisch geschrieben.

Die Papiere werden in der hiesigen Universitätsbibliothek aufbewahrt; ihre Nummern in dem Kataloge der Bibliothek sind unten mit Ms. Fol. bezeichnet, und diese Bezeichnung ist bei jeder Requisition zu benutzen.

Auszug des Verzeichnisses der nachgelassenen Schriften.

1. Über Gruppen vom Grade n^3.[1] Ms. Fol. 736. [I_A, 7_e].

Mehrere Manuskripte mit einem von SYLOW selbst verfaßten Inhaltsverzeichnis.

Dies Verzeichnis ist folgendes:

Ältere Arbeiten:

a. Behandlung von Gruppen 8ten Grades u. a.

b. Gruppen, deren Ordnung[2] eine Potenz einer Primzahl ist, hauptsächlich p^3.

c. Über Gruppen vom Grade n^3.

Vom Jahre 1884:

d. Etwas darüber, daß D_b und Δ hinreichend sind, so daß $D_0 \,.\,.\, D_{h-1}$ vernachlässigt werden können. Mit roter Farbe von 12—21 numeriert.

e. Die Gruppe H.

f. Anfang einer Behandlung der Frage, was für eine Form die Ordnung der Gruppe G hat. Fälle, in welchen $\Omega G = n^2 v\ (n^3 p + 1)$ ist.

g. Die Gruppe H_0; mit blauer Farbe von 1—57 numeriert.

h. Welche (transitive) I-Gruppen können in mehreren verschiedenen Cauchyschen Gruppen (Γ-Gruppen) enthalten sein; mit roter Farbe von 1—11 und mit schwarzer von 1—20 numeriert.

i. Über Gruppen vom Grade n^3. Auf Grundlage des Verhältnisses der Gruppen zur Causchyschen gegründet. Seitenzahlen von 1—120 mit roter Farbe, blau unterstrichen. Einige Rechnungen beigelegt, die gemacht waren, da die Arbeit im Anfang 1885 zur Seite gelegt wurde.

Außerdem fügt SYLOW folgende Bemerkung hinzu:

»Die Pakete h und i sind die wichtigsten; i greift etwas zurück. Es kommen einige Resultate vor; vieles steht doch noch aus, und es scheint nicht leicht zu sein eine solche Arbeit zu liefern wie die über den Grad n^2. Sollte aber das gelingen, wäre vielleicht weitere Verallgemeinerung möglich«.

2. Einige Papiere in einem Briefumschlag, auf welchem geschrieben ist: »Minimale unauflösbare Gruppen von Primzahlgrad (1—6); die Untergruppen der Cauchygruppe (1—9); Sätze, welche gebraucht werden können (nämlich beim Aufsuchen aller primitiven Gruppen gegebenen Grades) (A—C); nützlicher Satz beim Aufsuchen aller primitiven Gruppen gegebenen Grades (1—3)«. Ms. Fol. 742. [I_B, 4].

[1] SYLOW denkt sich immer die Gruppen als Substitutionsgruppen. Er unterscheidet deshalb ‚Ordnung' und ‚Grad'; der Grad ist die Zahl der Dinge, welche untereinander vertauscht werden, während die Ordnung die Zahl der Substitutionen der Gruppe ist.

[2] Es steht Ordnung, soll wohl aber Grad sein.

3. Die primitiven Gruppen niedrigsten Grades. Eine große Arbeit, 125 Seiten; enthält eine Untersuchung darüber, welche primitiven Gruppen von den niedrigsten Graden, nämlich von 1 bis 15, vorhanden sind. Ms. Fol. 743. [I_B, 5f].

4. Umschlag mit dem Titel: »Spezielle Resultate über die Konstitution der Gruppen«. (Herbst 1901). Enthält erstens 12 Seiten, welche davon handeln, wie viele Untergruppen der Ordnung p^β die Gruppe I der Ordnung p^α enthält, wenn I Untergruppe einer Gruppe G der Ordnung $p^\alpha\pi(np+1)$ ist. Zweitens 17 Seiten, wesentlich über die Folgerungen aus der Voraussetzung, daß I zyklisch ist. Ms. Fol. 749. [I_B, 11].

5. Umschlag mit dem Titel: »p und $\frac{p-1}{2}$ Primzahlen«. Eine Untersuchung über die Gruppen vom Primzahlgrad p, wenn $\frac{p-1}{2}$ auch Primzahl ist. Die letzten 7 Seiten scheinen die Resultate zu enthalten. Wahrscheinlich von 1910. Ms. Fol. 750. [I_B, 12].

6. Eine Verallgemeinerung eines Satzes von Mathieu. 8 Seiten. Der Hauptsatz, der hier bewiesen wird, ist: Wenn eine Gruppe G eine (kleinere) Untergruppe H enthält, welche nicht mit anderen Substitutionen in G als ihren eigenen permutabel ist, so gibt es unter den zu H konjugierten Gruppen mindstens eine, welche mit H andere Substitutionen gemein hat als die identische. Ms. Fol. 753. [I_B, 15].

7. Ms. Fol. 754.

a) 13 Seiten (die Paginanummer in roten Kreisen mit blauem Bleistift geschrieben). Handeln von der Cauchygruppe vom Grade p^n. Es wird angefangen mit Betrachtungen über Einteilungen der p^n Elemente in p^{n-r} Systeme mit je p^r Elementen und entsprechende Einteilungen der Substitutionen in Klassen nach der Art, wie sie diese Systeme untereinander vertauschen. Nachher folgen »Untersuchungen über Gruppen vom Grade n^3 auf dem Verhältnis zur Cauchyschen Gruppe gegründet«. Diese letztere Untersuchung schließt sich an die oben unter 1. erwähnte Arbeit. [I_B, 16_a].

b) Seiten a—k (mit rotem Bleistift paginiert) nebst zwei beigelegten Blättern mit Rechnungen. Scheinen ähnliche Untersuchungen wie a) zu enthalten. Die letzten Seiten (h—k) enthalten etwas über Kongruenzen mit mehreren Variabeln nach Primzahlmoduln. [I_B, 16_c].

8. Einige Studien über Gruppen, deren Grad eine Primzahl oder das doppelte einer Primzahl ist. Ms. Fol. 755.

a) Seiten 1—8 (mit Tinte paginiert). Scheinen wesentlich Untersuchungen zu enthalten über Gruppen G der Ordnung $p^a\pi\,(np+1)$, innerhalb welcher eine Untergruppe I der Ordnung p^a zyklisch ist. (Vergl. 4 oben). [I_B, 17_b].

b) 4 Seiten (mit Tinte paginiert). Eine Studie über Gruppen G vom Primzahlgrad p und der Ordnung $p\pi(Np+1)$. Scheint besonders den Fall zu betreffen, da G einfach ist. [I_B, 17_c].

c) Seiten a—l (mit rotem Bleistift paginiert). Es wird eine Gruppe G von der Ordnung $(Np+1)p\pi$ und dem Grade p (p Primzahl) betrachtet, wobei sie eine Untergruppe H der Ordnung $(np+1)p\pi$ enthält; H wird maximal angenommen, und H_0 $H_1 \dots H_{m-1}$ sind die sämtlichen zu H konjugierten Gruppen. Der Durchschnitt von H_0 und H_1 wird I genannt. Für diese Gruppe I werden 3 Möglichkeiten angegeben, welche Gegenstand weiterer Diskussion sind. [I_B, 17_e].

d) 5 Seiten (mit Tinte paginiert); außerdem 5 Blätter mit Rechnungen. Es werden Gruppen vom Primzahlgrade p und der Ordnung $(np+1)p\pi$ betrachtet, n wird > 0 angenommen. Die Untersuchung betrifft die Konstitution solcher Gruppen auf die Existenz einer Substitution von der Ordnung p und einer anderen 2ter Ordnung basiert. [I_B, 17_f].

e) 11 Seiten (mit rotem Bleistift paginiert; vom Sommer 1909). Handeln von Gruppen der Ordnung $p(np+1)\pi$. Der Fall $n=1$ ist besonders studiert. [I_B, 17_g].

f) 11 Seiten (mit Tinte paginiert; Dez. 1912). Es werden transitive Gruppen vom Grade $2p$, p Primzahl, und der Ordnung $p\pi(np+1)$ studiert. Von der Seite 2 an wird vorausgesetzt, daß auch $\pi = \frac{p-1}{2}$ eine Primzahl ist. [I_B, 17_h].

g) 44 Seiten (mit Bleistift paginiert; Jan.—April 1913). Gruppen der Ordnung $(np+1)p\pi$ werden untersucht. Die Untersuchung betrifft, welche Substitutionen die $np+1$ H-Gruppen der Ordnung $p\pi$ enthalten und die größte gemeinsame Untergruppe dieser Gruppen usw. [I_B, 17_i].

9. Ms. Fol. 756.

a) 5 Seiten (mit Tinte paginiert; Weihnachtsferien 1913—14) in einem Umschlag mit Titel: »Maximale, nicht-invariante Untergruppe; es wird angenommen, daß sie keine andere Substitution als die identische mit ihren konjugierten gemeinsam hat«. [I_B, 18_a].

b) Seiten 1—3 (mit rotem Bleistift paginiert), a—g (mit rotem Bleistift), und 26 beigelegte Blätter. In einem Umschlag gelegt, worauf geschrieben ist: »Betrifft maximale, nicht-invariante Untergruppe«. [I_B, 18_b].

c) Seiten 1—8 (mit blauem Bleistift, rot unterstrichen, paginiert). [I_B, 18_c].

Alle hier unter 9 aufgezählten Papiere enthalten ähnliche Untersuchungen wie die oben unter 6 erwähnte.

10. Papiere in einem Umschlag, worauf geschrieben ist: »Über maximale, nicht-invariante Untergruppe«. 47 Seiten. Enthält besonders Untersuchungen über die Substitutionen der ganzen Gruppe, welche in keiner der mit der maximalen Untergruppe konjugierten Untergruppen vorkommen. Ms. Fol. 757. [I_B, 19].

11. Vorlesungen über »Composition und Auflösung« (1893). Ca. 120 Seiten mit Tinte und 19 Seiten mit rotem Bleistift paginiert. Außerdem sind 4 Seiten Umarbeitung der Seiten 41—44 und 19 Seiten Umarbeitung der Seiten 58—88 beigelegt. Weiter sind auch beigelegt 89 Seiten mit Rechnungen, die hierher zu gehören scheinen. Handeln von der Anwendung der Substitutionstheorie auf algebraische Gleichungen. Ms. Fol. 783. [*III*, 3].

Gedruckt 23. Februar 1922.

DIE STRUKTUR DES NORDLICHTS UND DIE ART DER KOSMISCHEN STRAHLEN

VON

L. VEGARD

MIT 2 FIG. IM TEXT

(VIDENSKAPSSELSKAPETS SKRIFTER. I. MAT.-NATURV. KLASSE. 1921. No. 19)

KRISTIANIA

IN KOMMISSION BEI JACOB DYBWAD

1921

Fremlagt i den mat.-naturv. klasses møte den 23de september 1921.

A. W. BRØGGERS BOKTRYKKERI A/S

Die Lichtverteilung und ihre Deutung.

Wir können es jetzt als festgestellt ansehen, daß das Nordlicht dadurch gebildet wird, daß elektrische Strahlen von der Sonne in die Atmosphäre der Erde hineindringen.

BIRKELAND und STÖRMER haben zeigen können, daß diese Hypothese eine Reihe typischer Züge beim Nordlichte, wie die Nordlichtzone, das Auftreten des Nordlichts bei Nacht, sein Auftreten in langgestreckten Bogen und Banden, die den magnetischen Parallelen entlang annähernd gerichtet sind, und endlich die schnellen Änderungen des Nordlichts, erklären kann.

Es gibt aber viele Eigentümlichkeiten, die eine nähere Aufklärung brauchen. Unter diesen Verhältnissen werde ich mich heute der Frage der Struktur des Nordlichts besonders widmen, einer Sache, mit welcher ich mich seit vielen Jahren beschäftige, und welche, in Verbindung mit der Frage von der Art der kosmischen Strahlen, die das Nordlicht hervorrufen, besonders großes Interesse hat. Bei diesen Untersuchungen ist es mir auch gelungen, über diese Verhältnisse neues Licht zu werfen.

Wir können uns die verschiedensten Nordlichtformen aus Strahlenbündeln gebildet denken, welche sich aneinander zusammenfügen. Diese Strahlenbündel sind, wie wir wissen, annähernd den magnetischen Kraftlinien entlang gerichtet. Wir sollen jetzt ein solches einfaches Strahlenbündel (ein Nordlichtelement) betrachten, und besonders die Lichtverteilung einem solchen entlang ins Auge fassen.

Diese Lichtverteilung muß teils für die Zusammensetzung der Atmosphäre Ausdruck geben, teils ist sie von der Natur der kosmischen Strahlen und teils von der Weise, in welcher diese absorbiert werden, bedingt.

Das Studium dieser Lichtverteilung hat daher großes Interesse, besonders wenn sie mit der Bestimmung der Höhe des Nordlichts über der Oberfläche der Erde zusammengehalten wird.

Mit Hülfe eines großen Materials Nordlichtphotographien, von Direktor KROGNESS an dem Haldde Observatorium aufgenommen, bin ich im Stande gewesen, die Frage der Lichtverteilung einer recht eingehenden Untersuchung zu unterwerfen, und ist es von einem Teil der dabei gewonnenen Ergebnisse, daß ich hier eine kurze Mitteilung geben möchte.

Anm. Vortrag bei der Sitzung der Wissenschaftgesellschaft (mat.-nat. Kl.) am 23. September 1921 gehalten.

Eine kurze Übersicht dieser Ergebnisse wurde auf dem Geophysikertage in Göteborg im Jahre 1918[1] gegeben, und eine ausführliche Darstellung findet man in einem Werke, das als Einleitung der Geophysikalischen Publikationen[2] erschien, sowie in einer Abhandlung in Phil. Mag., die am 8. Oktober 1920 eingesandt wurde.[3]

Eine genaue Bestimmung der Lichtverteilung würde eine genaue Photometrierung der Schwärzung mit Schwärzungskurven auf jeder Platte verlangen. Das Material gestattete nicht eine solche Behandlungsweise, und ich mußte mir damit helfen, die Lichtverteilung durch Ausmessung der

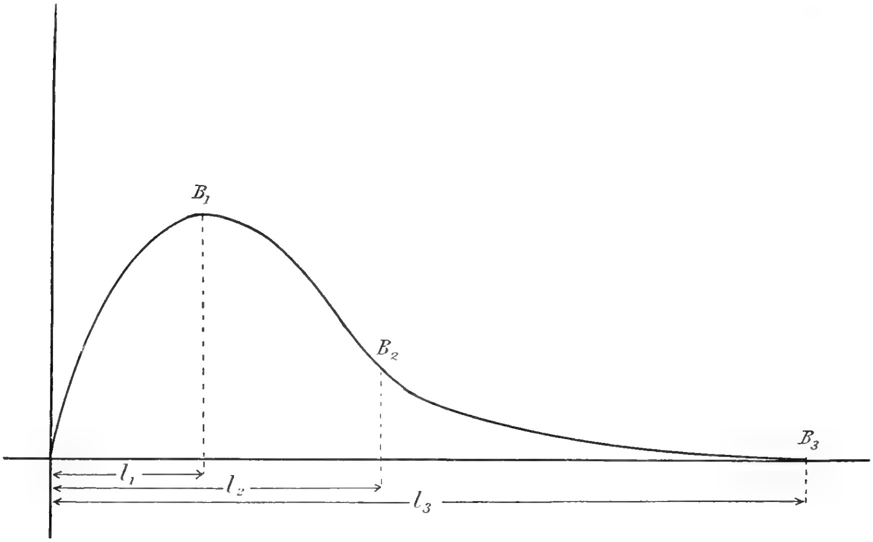

Fig. 1.

Entfernung von dem untersten Ende (Rand) bis zu gewissen charakteristischen Punkten B_1, B_2 und B_3 (Fig. 1) in der Lichtverteilungskurve zu charakterisieren, nämlich:

Die Länge l_1, oder die Entfernung vom unteren Rand bis zum Maximum des Leuchtens.

Die Länge l_2, oder die Entfernung vom unteren Rand bis zu dem Punkte, wo das helle Leuchten aufhört.

Die Länge l_3, oder die Entfernung vom unteren Rand bis zur oberen beobachtbaren Grenze.

Es zeigte sich, daß die Größen l_1, l_2 und l_3 ganz bedeutenden Änderungen unterworfen sind. Die Variation geht aus den Kurven Fig. 2 hervor. Die Ordinaten repräsentieren die Längen (l_1, l_2 und l_3). Diese

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[1] L. VEGARD, Verhandlungen auf dem skandinavischen Physikertage in Göteborg den 28. August 1918, pag. 12.

[2] L. VEGARD, & O. KROGNESS, The Position in Space of the Aura Borealis. Geophys. Publ. Vol. 1, nr. 1, 1920.

[3] L. VEGARD, Phil. Mag. XLII, 1921, pag. 47.

sind in gleiche Intervalle geteilt, und als Abszisse dient die Anzahl Fälle, wo die betrachteten Größen zwischen zwei Ordinatintervallen fallen. Die Kurven repräsentieren mit anderen Worten die Häufigkeit als Funktion der Länge für die drei Größen l_1, l_2 und l_3.

Wir können sagen, daß sich das Licht für Bogen und draperieförmige Bogen wesentlich in der Nähe des unteren Endes der Strahlen sammelt.

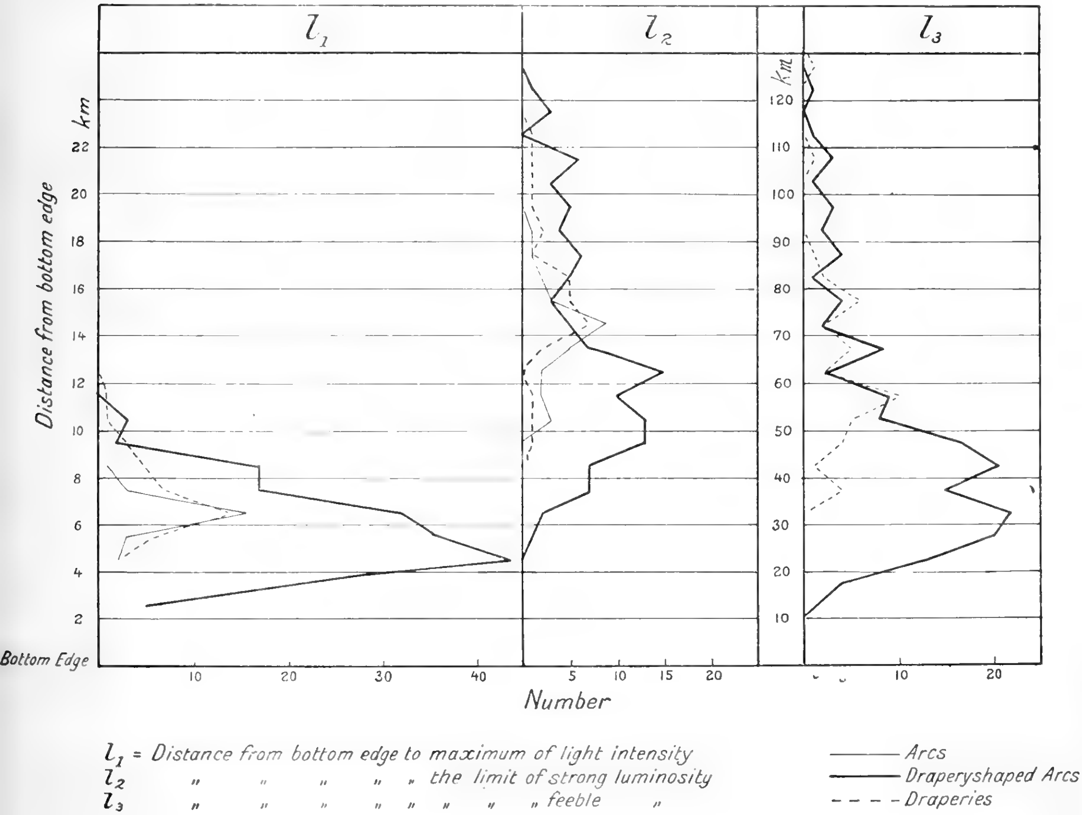

Fig. 2.

Für Draperien zieht sich das Licht weiter hinauf, und für Strahlen noch weiter. Besonders deutlich tritt dies hervor, wenn man l_3 (die ganze Ausdehnung des Leuchtens) betrachtet. Für diese wurden die Durchschnittswerte der beigefügten Tabelle gefunden:

	l_3	h
Bogen	14 Km.	109,1 Km.
Draperieförmige Bogen	47 "	106,6 "
Draperien	63 "	109,8 "
Strahlen	137 "	113,2 "

In der Tabelle sind auch die Durchschnittshöhen (h) für die untere Grenze aufgeführt worden. Die diffusen Bogen zeigen wahrscheinlich, wegen systematischer Fehler bei der Bestimmung, eine zu große Höhe. Nimmt man dies in Betracht, zeigt die untere Grenze eine Verschiebung aufwärts, welche mit der Änderung der Strahlenlänge parallel geht.

Gleichzeitig damit, daß sich die obere Grenze des Leuchtens aufwärts zieht, wird die Höhe der unteren Grenze des Nordlichts etwas vergrößert. Die Höhenänderung ist aber verhältnismäßig unbedeutend im Verhältnis zu der großen Änderung der Lichtverteilung. Und es verhält sich nicht so, daß die Lichtverteilung eine Funktion der Nordlichthöhe ist, denn man findet häufig, daß Nordlichter, welche zu derselben Höhe hinunterreichen, eine ganz verschiedene Lichtverteilung zeigen.

Variationen in der Lichtverteilung können also nicht davon herrühren, daß die Nordlichter in verschiedener Höhe, also in verschiedenen Schichten der Atmosphäre, auftreten.

Müssen wir auch mit der Möglichkeit rechnen, daß die kosmischen Strahlen nicht immer identisch sind, so werden die hier beobachteten Variationen der Lichtverteilung doch nicht von einem Wechseln der Eigenschaften der Strahlen herrühren können. Dies folgt daraus, daß Nordlichter in derselben Höhe verschiedene Lichtverteilung geben, und sogar dasselbe Nordlicht wird allmählich, oder sogar plötzlich, die Lichtverteilung ändern können. Eine Form wird nach und nach in eine andre Form mit verschiedener Lichtverteilung übergehen können, ohne ihre Lage zu ändern, und man muß voraussetzen, daß ein gewisses Band durch homogene Strahlen gebildet wird.

Wir werden also mit Notwendigkeit zu der Annahme geführt, daß Strahlen derselben Art je nach den Umständen eine verschiedene Lichtverteilung geben können.

Nun wissen wir indessen, daß ein Strahlenbündel, das in einen gasgefüllten kraftfreien Raum hineindringt, einem bestimmten Gesetze gemäß absorbiert wird und dementsprechend eine bestimmte Lichtverteilung geben muß. Die erwähnten Variationen müssen deshalb durch die Wirkung von Kraftfeldern verursacht werden.

Unter der Voraussetzung, daß wir von der Wirkung von Kraftfeldern wegsehen können, habe ich früher die Lichtverteilung für α-Strahlen und Elektronenstrahlen, die in der Atmosphäre absorbiert werden, bestimmt.[1]

Es zeigte sich, daß die berechnete Lichtverteilung von α-Strahlen gewisse Formen, wo das Leuchten zu dem untersten Rand begrenzt ist, erklären konnte. Ich machte jedoch ausdrücklich darauf aufmerksam, daß man in der Wirklichkeit mit einer Absorbtion in einem magnetischen Felde zu tun hat, und daß man dies in Betracht nehmen müsse.

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[1] L. VEGARD, Nordlichtuntersuchungen, Ann. d. Phys. 50, 853, 1916. L. VEGARD, Bericht über eine Expedition nach Finnmarken, Vid.-Selsk. Skr. Nr. 13, 1916.

Die erwähnten Ergebnisse der unternommenen Untersuchungen über die Lichtverteilung haben also in der Tat gezeigt, daß Kraftfelder einen Einfluß auf das Absorbtionsgesetz ausüben.

Das Kraftfeld, welches hier in erster Linie in Betracht kommt, ist das magnetische Feld der Erde, und die Frage wird dann, ob dieses Feld auf die Absorbtion einen solchen Einfluß ausüben kann, daß dadurch die gefundenen Variationen der Lichtverteilung zustande kommen können. Wie ich schon auf dem Geophysikertage in Göteborg im Jahre 1918 klargelegt habe, ist das magnetische Feld der Erde im Stande, einen Einfluß dieser Art zu bewirken.

Wie es von den Untersuchungen von Poincaré, J. J. Thomson und einer Reihe anderer Forscher, sowie durch die Arbeiten des Professors Störmer über die Theorie des Nordlichts wohlbekannt ist, werden elektrische Strahlen, deren Richtung mit derjenigen der Kraftlinien nicht zusammenfällt, sich in Spiralen rings um diese bewegen.

Die Anzahl Umdrehungen des Strahls für jede Längeneinheit in der Richtung der Kraftlinien wird mit dem Winkel, den der Strahl mit den magnetischen Kraftlinien bildet, wachsen.

Da das Licht durch den Stoß des Strahls gegen die Gasmolekylen der Atmosphäre hervorgebracht wird, muß die Lichtintensität mit der Zahl von Umdrehungen per Längeneinheit proportional wachsen. Unter übrigens denselben Umständen wird die Lichtintensität ein Minimum sein, wenn sich die Strahlen den Kraftlinien entlang bewegen, und ein Maximum, wenn sie sich nähern senkrecht darauf zu werden.

Eine Vergrößerung der Zahl von Umdrehungen per Längeneinheit würde also eine ähnliche Wirkung haben, als ob der Druck vergrößert wäre, indem die Zahl von Stößen per Längeneinheit (in der Richtung der Kraftlinien) zwischen dem Strahl und den Gasmolekylen in beiden Fällen vergrößert wird.

Wie ich schon auf dem Geophysikertage in Göteborg klargelegt habe, kann man die Variationen der Lichtverteilung in folgender Weise erklären:

Falls sich alle Strahlen durch die Atmosphäre mit den magnetischen Kraftlinien annähernd parallel bewegen, werden die Strahlen die oberste Schicht der Atmosphäre mit wenig möglichster Zahl von Stößen per Längeneinheit in der Richtung des Nordlichtstrahls durchdringen, und erst in der Nähe des unteren Rands wird die Stoßzahl per Längeneinheit wegen des vergrößerten Druckes so groß sein, daß die Lichtintensität eine merkbare Größe erreicht.

Wir bekommen dann die Formen, wo das Licht hauptsächlich an den untersten Rand begrenzt ist, und wo der untere Rand so nahe der Erdoberfläche ist, wie es dieser bestimmten Art von Strahlen möglich ist.

Denken wir uns dieselben Strahlen, daß aber diese in einer gegebenen Höhe alle denselben Winkel mit den magnetischen Kraftlinien bilden, so wird dies zur Folge haben, daß der Strahl, um zu einer gegebenen Höhe hinabzureichen, einen viel größeren Weg zurückgelegt haben muß, und die Strahlen werden jetzt in einer größeren Höhe über der Erdoberfläche absorbiert werden.

Eine Vergrößerung der Winkel zwischen dem Strahl und den magnetischen Kraftlinien wird also zur Folge haben, daß die untere Grenze des Nordlichts weiter hinauf rückt. Falls aber alle Strahlen denselben Winkel mit den Kraftlinien bilden, wird sich auch in diesem Falle das Licht wesentlich auf eine kurze Strecke in der Nähe des unteren Rands begrenzen. Kennt man das Gesetz für die Absorbtion der Strahlen und für die Verteilung der Gase in der Atmosphäre, kann man, wie ich in früheren Abhandlungen[1] gezeigt habe, die Höhe und Lichtverteilung ohne Schwierigkeit auch für den Fall berechnen, daß sich die Strahlen so bewegen, daß sie mit den Kraftlinien einen Winkel bilden.

Falls man nun ein Strahlenbündel hat, wo die einzelnen Strahlen in einer gegebenen Höhe die verschiedensten Winkel mit den magnetischen Kraftlinien bilden, wird sich für jeden Winkel eine bestimmte untere Grenze mit relativ starker Lichtintensität bilden, und diese untere Grenze wird desto höher liegen, je mehr sich der Winkel, den die Strahlen mit den Kraftlinien bilden, 90° nähert.[2]

Der resultierende Nordlichtstrahl wird also durch die Superposition von Nordlichtstrahlen mit seinen lichtstarken unteren Grenzen in verschiedener Höhe gebildet.

Das starke Leuchten wird sich also in die Höhe erstrecken. Es ist dieses Verhältnis, das wir bei den Draperien und in besonders ausgeprägtem Grade bei den isolierten Nordlichtstrahlen wiederfinden.

Die Bogen und die draperieförmigen Bogen dagegen werden gewöhnlich durch elektrische Strahlen, welche in einem bestimmten Augenblick und einer gegebenen Höhe alle annäherend denselben Winkel mit den magnetischen Kraftlinien bilden, hervorgebracht. Die Lichtverteilung der Drapieren bildet eine Übergangsform zu derjenigen der typischen Strahlenform. Für die pulsierenden und diffusen Formen läßt sich die Lichtverteilung aufwärts gewöhnlich nicht beobachten.

Je nach der Weise, in welcher sich die Richtungen der elektrischen Strahlen relativ zu denjenigen der Kraftlinien beim Eintritt der Strahlen in die Atmosphäre verteilen, werden die Lichtverteilung und die Höhe des unteren Rands variieren können. Je nachdem man immer mehr Strahlen hat, die mit den magnetischen Kraftlinien große oder annähernd rechte

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[1] L. Vegard, Nordlichtuntersuchungen, Ann. d. Phys. 50, p. 853, 1916.
— Berichte einer Exp. nach Finnmarken.
— Chr. Vid.-Selsk. Skr. No. 13, 1916.
— Recent Results of Northlight Investigations etc.
— Phil. Mag. 42. P. 47.

[2] Numerische Berechnungen einer Reihe Fälle sind auch von Professor Störmer in seinem soeben erschienenen Nordlichtwerke unternommen worden, Geoph. Publ. Vol. 1, Nr. 5.

Winkel bilden, wird die Lichtintensität nach oben zunehmen, die Länge des Nordlichtstrahls wächst. Falls es gleichzeitig relativ wenige Strahlen gibt, die in der Richtung der Kraftlinien in die Atmosphäre hineindringen, wird dies zur Folge haben, daß die untere Grenze des Nordlichts hinauf rückt, und wir sehen, daß unsere Erklärung der Struktur des Nordlichts *das Verhältnis auch erklärt, daß die strahlenförmigen Nordlichter gewöhnlich einen größeren Wert für die Höhe des unteren Rands zeigen,* mit anderen Worten: eine Verrückung der Lichtintensität nach oben ist von einer Hebung der unteren Grenze begleitet. Dies stimmt, wie wir gesehen haben, mit der Erfahrung.

Wir haben früher stillschweigend vorausgesetzt, daß die magnetischen Kraftlinien miteinander parallel verlaufen, und daß die Bewegung der Strahlen von der Atmosphäre nicht beeinflußt wird.

In der Tat konvergieren die Kraftlinien schwach gegen die Erde, und die Atmosphäre bewirkt Geschwindigkeitsverminderungen und Zerstreuung der Strahlen, und wir werden untersuchen, welchen Einfluß diese Verhältnisse auf die Lichtverteilung haben können.

Um die Wirkung der Konvergenz der Kraftlinien zu untersuchen können wir annehmen, daß die Kraftlinien innerhalb des Gebietes des betrachteten Nordlichtelements gerade Linien sind, die alle gegen denselben Punkt konvergieren. Das Feld wird also dasselbe sein wie das Feld eines einzelnen Magnetpols, der sich im Konvergenzpunkte befände.

Nach Poincaré wird die Bahn eines elektrischen Strahls in einem solchen Felde eine geodätische Linie auf einem Umdrehungskegel mit Scheitelpunkt im Konvergenzpunkte sein. Oder im Falle wir uns die Bahn auf einer Ebene ausgewickelt denken, wird diese eine gerade Linie bilden, die den Konvergenzpunkt in einem gewissen Abstande d passiert. Die wirkliche Bahn im Raume wird eine Spirale, die in immer dichteren Windungen rings um die Kraftlinien läuft, bis sie in einer Entfernung d vom Konvergenzpunkte sich senkrecht auf diese bewegt, wonach der Strahl in einer ähnlichen Bahn gegen die Unendlichkeit zurückkehrt.

Wie wir leicht bei Betrachtung der Bahn, wenn die Kegelfläche in der Ebene ausgefaltet ist, ersehen können, wird die Entfernung d, wo der Strahl zurückkehrt, nur von dem Winkel, den der Strahl mit den magnetischen Kraftlinien in einer bestimmten Entfernung des Konvergenzpunktes bildet, abhängig sein. Da uns nur die Strahlen, die in die Atmosphäre hineinkommen, interessieren, könnten wir z. B. die Winkel, welche die Strahlen in einer Höhe von 500 Km. bilden, betrachten. Je größer der Winkel, den der Strahl in dieser Höhe mit den Kraftlinien bildet, desto ferner hinauf liegt der Umkehrpunkt.

Strahlen sollten also allein durch die Wirkung des magnetischen Feldes aus der Atmosphäre hinausgeworfen werden können.

Dieses Verhältnis, daß der Strahl ohne absorbiert zu werden ausgetrieben werden kann, ändert nicht die schon gegebene Erklärung von der Änderung der Lichtverteilung und der unteren Grenze des Nordlichts. Denn wir bekommen in jedem Falle, daß die Höhe des niedrigsten Punktes, zu welchem der Strahl gelangt, mit dem Winkel wächst, den der Strahl mit den magnetischen Kraftlinien in dem Augenblicke, wo er in die Atmosphäre hineintritt, z. B. in einer Höhe von 500 Km., bildet. Die Konvergenz der Kraftlinien wird sogar bewirken, daß der Strahl nicht so weit hinabdringt, als er unter denselben Eintretungsbedingungen gekommen wäre, falls die Kraftlinien parallel gewesen wären. Mit anderen Worten: *die Konvergenz des Kraftfeldes wird ein Verschieben der Lichtintensität nach oben dem Nordlichtstrahl entlang begünstigen.*

Wenn es sich auch so verhält, daß die Konvergenz der Kraftlinien ein Verschieben des Nordlichts aufwärts begünstigt, so ist doch dieses Verhältnis für die Erklärung der Variationen der Lichtverteilung nicht von entscheidender Bedeutung.

Dagegen ist die Tatsache, daß die Strahlen nach dem Raume zurückgetrieben werden können ohne gänzlich absorbiert zu werden, von Bedeutung für die Frage nach der Ursache der Farbenänderung des Nordlichts. Wie ich schon auf dem Geophysikertage zu Göteborg bemerkt habe, und wie ich in späteren Arbeiten ausführlicher behandelt habe, kann man die Farbenänderungen erklären, wenn man annehmen darf, daß ein großer Teil der kosmischen Strahlen gewöhnlicherweise zum Raume zurückkehrt, so daß nur ein Bruchteil absorbiert wird.

Man weiß nämlich, daß im Stickstoff das Spektrum, welches durch Bombardement des Gases mit elektrischen Strahlen gebildet wird, durch die Strahlengeschwindigkeit im hohen Grade geändert wird.

Falls ein großer Bruchteil der Strahlen mit einer bedeutenden Geschwindigkeit zurückkehrt, sollten wir die gewöhnlichen grünlich-gelben Nordlichter bekommen. Der rote Farbenton sollte hervortreten, wenn eine große Anzahl Strahlen gänzlich oder annähernd absorbiert würde.

Die Bestimmung des Herrn POINCARÉ von den Bahnen eines konvergierenden Feldes setzt voraus, daß sich der Strahl im luftleeren Raume bewegt.

Wegen der Bedeutung, die das Zurückkehren der Strahlen nach dem Raume für die Erklärung der Farbenänderungen hat, wird es von Bedeutung sein, die Strahlenbahnen, unter der Voraussetzung, daß die Bewegung in einem absorbierenden Medium geschieht, zu untersuchen. Das Medium bewirkt eine Herabsetzung der Geschwindigkeit und eine Zerstreuung.

Was die Zerstreuung betrifft, wird diese damit gleichbedeutend sein, daß die Bahn auf eine ganz zufällige und unregelmäßige Weise ihre Richtung ändert, und genaue Vorausberechnungen der wirklichen Strahlenbahn sind deswegen für Strahlen, die eine starke Zerstreuung zeigen, ganz ausgeschlossen.

Wenn wir auch die Bahnen der zerstreuten Strahlen nicht berechnen können, *so können wir jedoch den Schluß ziehen, daß die Zerstreuung das Zurückkehren der Strahlen in den Raum durchschnittlich begünstigen wird,* indem ein Strahlenbündel, das unter einem kleinen Winkel mit den Kraftlinien hineinkommt, durch die Zerstreuung durchschnittlich größere Winkel mit den Kraftlinien bilden wird. Einige Strahlen werden sogar durch Zerstreuung ihre Richtung so stark ändern, daß der Winkel zwischen dem Strahl und dem nach unten gerichteten Ende der Kraftlinien größer als 90° wird. Die Strahlen werden also in den Raum zurückgetrieben als eine Wirkung der Zerstreuung.

Falls es einen Sinn haben soll eine Gleichung für die Strahlenbahn eines absorbierenden Mediums zu suchen, müssen wir von der Zerstreuung wegsehen. Unter dieser Voraussetzung, welche für die α-Strahlen fast erfüllt ist, habe ich in einer vor kurzem herausgegebenen Abhandlung in der Phil. Mag. die allgemeine Differentialgleichung für die Bahnen der Strahlen in einem absorbierenden Medium aufgestellt, und ich habe gezeigt, wie die in die Differentialgleichung eingehenden Konstanten und Funktionen bestimmt werden können.

Die allgemeine Differentialgleichung ist sehr schwer zu lösen, ich habe aber einige wichtige Eigenschaften der Bahnen für den Fall herleiten können, daß die magnetischen Kraftlinien gerade Linien sind, welche gegen denselben Punkt konvergieren.

Die Bahnen werden jetzt nicht mehr geodätische Linien einer Umdrehungskegelfläche, werden aber entstehen, wenn eine gerade Linie durch den Konvergenzpunkt sich so bewegt, daß sie immer eine gewisse Spirale berührt, oder der Öffnungswinkel nimmt ab, je nachdem die Geschwindigkeit des Strahls durch die Einwirkung des Mediums immer kleiner wird.

Man wird jetzt zeigen können, daß die kleinste Entfernung d vom Konvergenzpunkte, die der Strahl erreicht, von dem Medium unabhängig ist.

Der Strahl kehrt also in derselben Entfernung von der Erde nach dem Raume zurück entweder das Medium anwesend ist oder nicht, selbstverständlich vorausgesetzt, daß der Strahl, ehe er den Wendepunkt erreicht hat, nicht zu Ruhe gebracht ist.

Falls wir noch von der Zerstreuung wegsehen, sehen wir unmittelbar ein, daß Strahlen, die unter einem sehr kleinen Winkel mit den Kraftlinien in die Atmosphäre hineindringen, absorbiert werden, und sie kehren nicht nach dem Raume zurück. Wenn dagegen die Strahlen unter einem Winkel, der eine gewisse Größe überschreitet, hineintreten, werden dieselben nur eine gewisse Strecke in die Atmosphäre hineindringen, wonach sie nach dem Raume zurückkehren.

Gleichzeitig ist zu bemerken, daß die Wahrscheinlichkeit dafür, daß die Strahlen in einer Höhe von etwa 500 Km. mit den Kraftlinien große Winkel bilden sollen, bei perturbierenden magnetischen Feldern vergrößert wird, indem diese Perturbation Änderungen in den Richtungen der Kraftlinien verursachen, welche in diesen Höhen, wo die elektrischen Ströme, die die Perturbation hervorrufen, wesentlich ihren Sitz haben, sehr groß sein können.

Dies stimmt mit dem Verhältnis, daß Strahlen und Draperien gewöhnlich zu der Zeit, wo der magnetische Sturm am stärksten ist, auftreten.

Wir können auch auf diese Weise erklären, daß die Nordlichtstrahlen, wie es von STÖRMER nachgewiesen ist, auf niedrigeren Breiten in die Atmosphäre durchschnittlich höher emporsteigen, denn, wie ich früher bemerkt habe, wird das Nordlicht von Stromsystemen, die während starken magnetischen Stürmen auftreten, nach dem Süden geführt.

Wenn das Nordlicht auf niedrigen Breiten auftritt, sind folglich starke perturbierende Kräfte tätig, und diese werden also bewirken können, daß das Leuchten nach oben rückt, so daß die Strahlen länger werden.

Die hier gegebene Erklärung der Variationen der Lichtverteilung und die Auffassung der Struktur des Nordlichts, worauf sie baut, müssen unzweifelhaft im wesentlichen richtig sein, wenn es jedoch nicht ausgeschlossen ist, daß auch elektrische Kräfte, die während der magnetischen Perturbationen entstehen, in gewissen Fällen auf die Lichtverteilung einen Einfluß ausüben können.

Es darf in dieser Verbindung von Interesse sein zu bemerken, daß Professor STÖRMER in seinem soeben erschienenen Werke[1] sich meiner Auffassung gänzlich anschließt. Er gibt hier auch einige numerische Berechnungen, die ihr wesentliches Interesse in Verbindung mit der hier gegebenen Erklärung der Lichtverteilung im Nordlicht bekommen.

Die Natur der kosmischen Strahlen.

Ein Nordlicht in der Form eines Strahls wird also von elektrischen Strahlen gebildet, welche an jedem Orte des Strahls alle möglichen Winkel mit den magnetischen Kraftlinien zwischen 0° und 90° bilden.

Da man also annehmen darf, daß sich die elektrischen Strahlen senkrecht auf die Kraftlinien bewegen, können wir davon eine untere Grenze für die Ablenkbarkeit der Strahlen berechnen.[2]

Da man die magnetische Feldstärke $= 1/2$ Gauß setzen kann, bekommt man: $\frac{mv}{e} < \frac{d}{4}$, wo d der Querschnitt des Nordlichts, m, e und v Masse, Ladung und Geschwindigkeit des kosmischen Strahls bedeuten.

Von dem untersuchten Material aus dem Haldde Observatorium geht hervor, daß die Strahlendicke zuweilen kleiner als 1 Km. ist, also:

$$\frac{mv}{2} < \frac{5}{2} \cdot 10^4$$

[1] C. STÖRMER, Geophys. Publ. Vol. 1, No. 5.

[2] Schon unter seinen theoretischen Berechnungen der möglichen Strahlenbahnen hat STÖRMER darauf aufmerksam gemacht, daß man, falls sich die elektrischen Strahlen auf die Kraftlinien senkrecht bewegten, von dem Querschnitte eines Nordlichtstrahls eine untere Grenze für die Ablenkbarkeit der elektrischen Strahlen berechnen kann.

STÖRMER erwähnt aber gleichzeitig die Möglichkeit, daß die kosmischen Strahlen sich annähernd in der Richtung der Kraftlinien bewegen, und dann kann man aus der Dicke eines Strahls keine Schlüsse betreffs der Ablenkbarkeit der Strahlen ziehen.

Erst durch meine Untersuchungen über die Lichtverteilung ist es nachgewiesen worden, daß die kosmischen Strahlen sich in der Tat senkrecht auf die Kraftlinien bewegen, und erst dadurch ist es möglich gewesen, durch Messung des Querschnittes eines Nordlichtstrahls die untere Grenze der Ablenkbarkeit der kosmischen Strahlen zu bestimmen.

Dieses Resultat ist von außerordentlich großer Bedeutung für die Entscheidung der Frage von der Art der elektrischen Strahlen.

Die Strahlen, die in Betracht kommen können, sind entweder negative Elektronenstrahlen (β- oder Kathodenstrahlen) oder Strahlen, die eine Masse von atomistischer oder molekylärer Größenordnung besitzen. Die letzteren werden gewöhnlich eine positive Ladung führen.

Die Annahme von Strahlen, deren Träger als Staubkörnchen zu betrachten sind, kann nicht in Betracht kommen, denn das Auftreten des Nordlichts in scharf begrenzten Bogen und Banden läßt sich damit nicht vereinigen, da solche Staubstrahlen notwendigerweise sehr heterogen sein müßten.

Für gewöhnliche α-Strahlen von radioaktiven Substanzen haben wir:

$$3.0.10^5 < \frac{mv}{e} < 4,6.10^5$$

Der Wert von $\frac{mv}{e}$ für diese Strahlen ist, wie wir ersehen, zu groß, um die strahlenförmigen Nordlichter erklären zu können.

Da viel darauf deutet, daß sämtliche Nordlichttypen von wesentlich derselben Art von Strahlen hervorgebracht werden, können wohl überhaupt keine α-Strahlen dieser Geschwindigkeit als Ursache des Nordlichts in Betracht kommen.

Dagegen würden α-Partikeln geringerer Geschwindigkeit wohl genügend weiche Strahlen geben können. (Kleine Werte von $\frac{mv}{e}$).

Die Frage wird aber jetzt, *ob α-Partikeln oder andere Atomen- oder Molekülenstrahlen mit der verlangten Ablenkbarkeit gleichzeitig eine genügende Durchdringlichkeit haben, um die Höhe des Nordlichts zu erklären.*

Für die Elektronenstrahlen variiert $\frac{mv}{e}$ von 0 bis $4,5.10^3$, den durchdringlichsten β-Strahlen entsprechend.

Die Elektronenstrahlen vereinigen also eine genügende Durchdringlichkeit mit der genügenden Ablenkbarkeit, um die Höhe und Struktur des Nordlichts zu erklären, denn die schnellsten β-Strahlen würden bis zu einer Höhe von etwa 40 Km. hinabdringen.

Um zu sehen, ob auch andere Strahlen als die negativen Elektronenstrahlen möglich sind, müßten wir die Zusammensetzung der höchsten Schicht der Atmosphäre sowie das Gesetz der Absorption der Atomen- und Molekülenstrahlen kennen.

Ist die Masse der Strahlenpartikel $\frac{M}{N}$, wo N Avogadros Zahl ist, und ist ihre Ladung ne, wo e die Ladung des Elementarquantums ist, bekommt man:

$$\frac{mv}{E} - \frac{Mv}{Nne}$$

und diese Größe soll kleiner als eine Größe a sein, also:

$$v < Ne\,\frac{na}{M}$$

oder da $Ne = 10^4$, so ist

$$v < 10^4\,\frac{na}{M}$$

Nun ist die Durchdringungsfähigkeit von v, n und M, sowie von der Dichte und dem Atomgewicht des absorbierenden Mediums abhängig. Für ein gegebenes Medium wird die Reichweite eine Funktion von v, n und M sein. Aus einer Theorie von BOHR[1] für die Absorbtion von Atomstrahlen können wir für die Reichweite x im Stickstoff bei 0^0 und 760 mm. Druck den folgenden Ausdruck herleiten:

$$x = 10^{-27} \frac{M}{n^2} v^3 \text{ cm.}$$

Ist nun gleichzeitig $$v < 10^4 \frac{na}{M}$$

so wird $$x < 10^{-15} \frac{n}{M^2} a^3 \text{ cm.}$$

Setzen wir: $a = 2, 5. 10^4$, so bekommen wir:

$$x < 1, 56. 10^{-2} \frac{n}{M^2} \text{ cm.}$$

$$a = 10^4 \text{ gibt } x < 10^{-3} \frac{n}{M^2} \text{ cm.}$$

Entsprechende Ausdrücke gelten für die Absorbtion in anderen Gasen, nur mit einem etwas verschiedenen Zahlenfaktor.

M bedeutet das Atomgewicht (oder Mol.gewicht)

der Partikel. Da die Zahl n die Atomnummer oder die Summe der Atomnummer des Trägers nie überschreiten kann, so wissen wir, daß für alle Substanzen (der Wasserstoff ausgenommen)

$n < M$ sein wird,

und *die Reichweite wird mit wachsender Masse des Trägers* sehr schnell abnehmen.

Unter allen Atomen- (oder Molekülen-)strahlen, die gleichzeitig die Ablenkbarkeitsbedingung befriedigen, geben die Wasserstoffstrahlen die größte Durchdringlichkeit.

Nächst kommt die α-Partikel. (He-Atom mit 2 Elementarladungen). *Sollte es sich dennoch zeigen, daß ein Wasserstoffstrahl, der die Bedingung für magnetische Ablenkbarkeit befriedigt, eine zu geringe Durchdringungsfähigkeit besäße, um bis zu einer Höhe von 100 Km. herabzudringen, so würden auch keine anderen Materienstrahlen als Ursache derjenigen Nordlichter, welche Strahlenstruktur besitzen, in Betracht kommen können.*

Die Zusammensetzung der Atmosphäre, die von WEGENER angegeben ist, würde dazu führen, daß Atomen- oder Molekülenstrahlen jeder Art eine gar zu geringe Durchdringlichkeit besitzen würden, um die Höhe des Nordlichts erklären zu können. Die WEGENER'sche Massenverteilung gibt für eine Höhe von 400 Km. eine Luftreichweite von 1,3 cm. Der Strahl müßte also, um zu dieser großen Höhe hinabzukommen, eine Reichweite $x = 1{,}3$ cm. besitzen.

[1] N. BOHR, Phil. Mag. 25, p. 10, 1913.

Ein Wasserstrahl, der die Ablenkbarkeitsbedingung befriedigen, soll wird laut der obigen Formel nur eine Reichweite von 0,16 Mm. haben, also nur $^1/_{100}$ Teil der Reichweite, die erforderlich ist, um eine Höhe von 400 Km. zu erreichen.

Nun zeigen indessen die Spektraluntersuchungen, daß eine solche dominierende Wasserstoffatmosphäre, wie von WEGENER angenommen ist, nicht existieren kann.

Sehen wir von der grünen Linie weg, dominieren im Nordlichtspektrum im allgemeinen die negativen Stickstoffbanden. Weder Wasserstoff noch Helium sollten in dem Höhenintervall (100—125), wovon die Hauptmasse des Nordlichtes ausgeht, in dominierenden Mengen existieren können.

Wir haben also mit der Möglichkeit zu rechnen, daß der Stickstoff in der obersten Schicht der Atmosphäre über 100 Km. dominierend ist.

Wird die Dichte des Stickstoffs in Übereinstimmung mit WEGENER berechnet, so würde ein Wasserstoffstrahl mit einer Ablenkbarkeit, die $a = 2,5 . 10^4$ entspricht, nur bis zu einer Höhe von 118 Km. gelangen. Wird $a = 10^4$ gesetzt, würde er nur zu einer Höhe von 135 Km. gelangen. Alle anderen Materienstrahlen mit denselben Ablenkbarkeitsbedingungen würden noch größere Höhe geben.

Nun müssen wir indessen damit rechnen, daß die Verteilung des Stickstoffdrucks, die durch die WEGENER'sche Formel gegeben ist, möglicherweise mit bedeutenden Fehlern behaftet sein könne, welche u. a. einer mangelhaften Kenntnis der Temperatur der höchsten Luftschichten zuzuschreiben sind.

Der Druck müßte aber in der Tat beträchtlich kleiner sein, falls Materienstrahlen mit genügend großer Ablenkbarkeit zu einer Höhe von 90—100 Km. gelangen sollten.

Sollten die Wasserstoffstrahlen eine Höhe von 95 Km. erreichen, müßte der Stickstoffdruck in dieser Höhe nur etwa $^1/_{25}$ Teil des von WEGENER berechneten Druckes besitzen.

So große Fehler sind kaum wahrscheinlich, man muß aber eine genauere Bestimmung der Stoffverteilung der Atmosphäre abwarten, ehe man mit voller Sicherheit die Frage erledigen kann.

Im Falle die WEGENER'sche *Verteilung des Stickstoffs bis zu einer Höhe von 100 Km. einigermaßen richtig ist, können wir den Schluß ziehen, daß jedenfalls die strahlenförmigen Nordlichter durch Elektronenstrahlen hervorgebracht werden müssen.*[1]

[1] Diese Schlußfolgerung stützt sich darauf, daß, von Elektronen weggesehen, nur Atome, die in das periodische System hineingehen, als Strahlenträger möglich sind.

Für die letzteren gilt das Rutherford-Borsche Konstitutions-Schema, nach welchem der Wasserstoff das leichteste aller Atome ist.

Man wird jedoch nicht ohne weiteres die Möglichkeit ausschließen können, daß Atomionen existieren, für welche die spezifische Ladung zwischen derjenigen des Wasserstoffkerns und derjenigen des Elektrons fällt.

Die Nebelspektren, die Koronalinie, sowohl die grüne Linie im Nordlicht dürften auf die Existenz derartiger Atome deuten. Diese Frage hat hier ein besonderes

Für die Bestimmung der Zusammensetzung der höheren Atmosphärenschichten werden weitere Untersuchungen über das Spektrum des Nordlichts uns eine wichtige Auskunft geben können. Die älteren Beobachtungen sind aber meistens zu ungenau. Ich habe aber schon seit vielen Jahren mit Präzisionsmessungen über das Nordlichtspektrum angefangen, und einige wichtigen Verhältnisse habe ich, wie erwähnt, schon durch meine Beobachtungen in Finnmarken festsetzen können. Es steht aber noch viel übrig, und ich habe die Arbeit hier in Kristiania fortgesetzt.

Ich habe hier zuerst einen Gitterapparat mit sehr großer Dispersion geprüft. Dieser zeigte sich aber zu lichtschwach.

Jetzt habe ich einen lichtstärkeren Apparat anschaffen lassen, und hoffe ich, daß dieser gute Ergebnisse geben wird.[1]

Die durch das Studium der Lichtverteilung erhaltenen Ergebnisse gestatten uns, auch andere wichtigen Schlüsse zu ziehen, und soll ich hier kurz die folgenden erwähnen:

1) Die Nordlichtstrahlen (die entweder isoliert sind oder als ein Teil einer Draperie auftreten) fallen immer mit den magnetischen Kraftlinien genau zusammen, und wir können die Richtung der magnetischen Kraftlinien in großen Höhen dadurch untersuchen, daß wir die Richtung der Nordlichtstrahlen bestimmen. Die Richtung wird durch die Kronenbildung am besten bestimmt.

2) Das magnetische Feld der Erde in Entfernungen von der Größenordnung des Erddurchmessers muß sich ganz wesentlich von demjenigen eines Elementarmagnets unterscheiden. Es kann auch nicht angenommen werden, daß das erdmagnetische Feld gänzlich von magnetischen Massen, welche innerhalb der Erdoberfläche liegen, seinen Ursprung hat.

   Um die Lage der Polarlichtzone mit der gefundenen großen Ablenkbarkeit der Strahlen zu erklären müssen wir annehmen daß wenigstens während des Nordlichts elektrische Ströme oberhalb der Erdoberfläche, wahrscheinlich in der Nähe des magnetischen Äquatorplanes, existieren.

3) Da die Strahlen von der Sonne ausgehen, können wir den Schluß ziehen, daß die Strahlenquelle (die Sonne) eine elektrische Potential größer als etwa 30 000 Volt nicht besitzen kann.

Interesse, denn es ist zu erwarten, daß solche Atomenstrahlen mit Träger, welche leichter als Wasserstoff sind, für die Erklärung der Nordlichtstruktur eine genügende Durchdringlichkeit sowie Ablenkbarkeit besitzen würden.

[1] Anmerkung bei der Korrektur. Mit diesem Apparat ist es mir gelungen, genaue Messungen der Wellenlänge der grünen Nordlichtlinie durchzuführen. Die Ergebnisse sind zur Veröffentlichung in den Geophys. Publikationen anfangs November 1921 eingesandt worden und werden hoffentlich bald in Druck erscheinen.

Gedruckt 9. Februar 1922.

TROMS FYLKES ANTROPOLOGI

AV

HALFDAN BRYN

MED 20 FIGURER OG KARTER I TEKSTEN
(MED TYSK RESUMÉ)

(VIDENSKAPSSELSKAPETS SKRIFTER. I. MAT.-NATURV. KLASSE. 1921. No. 20)

UTGIT FOR FRIDTJOF NANSENS FOND

KRISTIANIA
I KOMMISSION HOS JACOB DYBWAD
1922

Fremlagt i fællesmøtet den 11. novbr. 1921 ved professor Axel Johannessen.

A. W. BRØGGERS BOKTRYKKERI A/S

Indhold.

I. Indledning.

Med stipendium av Nansenfondet foretok jeg sommeren 1919 en reise til vort lands nordligste egne for at foreta antropologiske undersøkelser paa ekserserpladsene. Jeg opholdt mig da først paa Sætermoen, hvor jeg fik undersøkt 662 mænd fra Troms fylke. Det er det paa denne ekserserplads indsamlede materiale jeg i denne avhandling skal gi en fremstilling av.

Undersøkelsene omfatter altsaa kun militært tjenestedygtige mænd i alderen 20—21 aar, samtlige fra Troms fylke. Det brogede menneskemateriale i dette fylke gir den antropologiske undersøkelse en særlig interesse.

Ved siden av at gi en beskrivelse av Troms fylkes antropologi vil jeg i denne avhandling søke at gi en fremstilling av de forskjellige bastarders utbredelse.

1. Beliggenhet og størrelse.

Troms fylke er Norges næst nordligste fylke. Det ligger i sin helhet nordenfor polarcirkelen. Det grænser mot nord til Nordishavet, mot syd til Haalogaland fylke, Sverige og Finland, mot øst til Finmark fylke.

Det hadde ved sidste folketælling i 1910 81902 indbyggere. Da dets flateindhold er 26221 □ km., blir det kun 3,19 indbyggere paa hver □ km. Til sammenligning vil jeg anføre at i Opland fylke er der 4,94 indbyggere pr. □ km. Gjennemsnitlig er der i Norges landdistrikter 5,50 indbyggere paa hver □ km. Troms fylke staar altsaa ikke saa svært meget tilbake for hvad der er gjennemsnitlig i Norge.

Befolkningens væsentligste næringsvei er fædrift, fiskeri og akerbruk. Der er kun lite bergverksdrift og skogbruk.

Fylket er delt i 2 sorenskriverier, Senjen og Tromsø, og har i alt 25 herreder.

Man har kun lite kjendskap til naar Troms fylke først blev bebygget. Med fuld sikkerhet kan man dog gaa ut fra at bebyggelsen hadde naadd selv til den nordligste del av Troms fylke i den yngre jernalder (800 til 1000 e. Kr.). Det synes ogsaa temmelig sikkert at øene ute ved havet først blev bebygget. Om disse første bebyggere var nordmænd, er vel endnu et aapent spørsmaal.

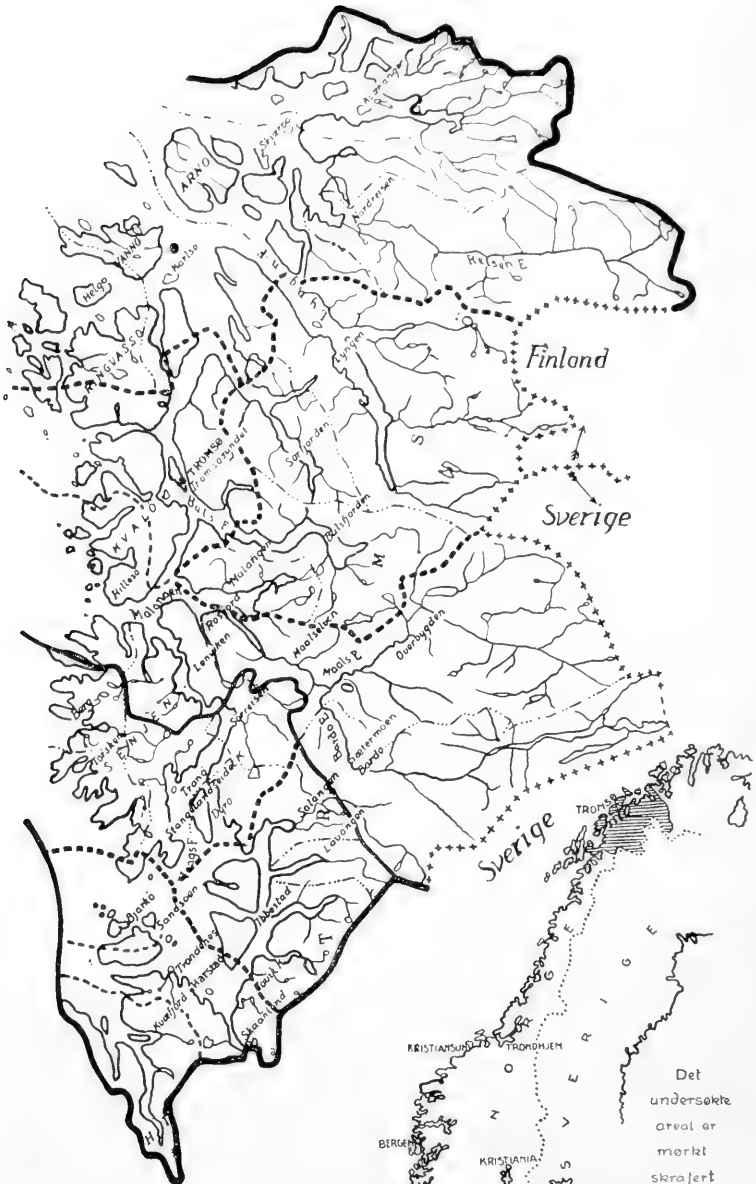

Fig. 1. Kart over det undersøkte omraade.

2. Befolkningen.

Befolkningen i Troms fylke er og har i lange tider været overmaade uensartet. Stort set kan man jo si, at befolkningen i den del av Norge som ligger söndenfor Troms fylke, er en nogenlunde homogen masse. Rigtignok kan man ad antropologisk vei paavise at der indgaar ogsaa i denne befolkning vidt forskjellige raceelementer. Men disse forskjellige raceelementer har nu gjennem umindelige tider været saa intimt blandet at de ikke længer selv har opfatningen av raceforskjellighetene. Krydsningen er saa grundig gjennemført at hver enkelt urraces eiendommelighet er fuldstændig splintret. Ganske anderledes er forholdet i denne henseende i Troms fylke.

Tabel 1.

	% 1891	Blandt de av mig undersøkte var forholdet følgende
1. Rent norsk	74,7	83,3
2. Blandet norsk	6,5	7,4
3. Rene lapper	11,3	4,5
4. Blandede lapper	3,6	1,2
5. Rene finlændere	2,5	2,4
6. Blandede finlændere	1,4	1,3

Her utgjør ganske vist ogsaa den norske befolkning grundstammen i den nuværende befolkning, og hovedmassen av befolkningen taler norsk. Men denne norske befolkning er i sterkere grad end i noget av landets sydligere fylker opblandet med 2 etnisk vidt forskjellige folkestammer, lapper og kvæner. Jeg gjør her med én gang opmerksom paa at dette er den norske befolknings navne paa disse fremmede elementer. Selv kalder de sig henholdsvis samer og finner. Hvis man for oversigtens skyld til at begynde med vil regne med runde tal, kan man vel si at omtrent 90 % regner sig selv for norske, 8 % regner sig for lapper og 2 % regner sig for finlændere. Nu er imidlertid disse 90 % norske aldeles ikke rent norske. En hel del av disse har enten finsk blod eller lappeblod i sine aarer. Ja, det er visselig vanskelig at si med bestemthet hvor stor del av befolkningen som er rent norsk. Om en bedstemor eller oldemor har været en lappepike, saa vil man helst la det bli glemt. Inden de lavere lag av befolkningen er indgifte mellem lapper, finner og norske saa almindelig at man bør være meget varsom med at tale om renracede folk heroppe. Man faar nøie sig med at regne for rent norske dem som selv regner sig for saadanne, og som selv ikke vet om nogen fremmed indblanding. Likesaa faar man gjøre med lappene og finnene. Jeg har paa tabel 1 anført, hvordan befolkningen fordelte sig i 1891 naar de her nævnte principper lægges til grund.

Av folketællingen synes at fremgaa at det norske element er i tilvekst i de senere aar. Dette er imidlertid ikke saa sikkert. Det kan bero paa at de fremmede elementer skjuler sig for folketællingen. Saafremt faren er norsk og moren finsk eller lappisk, saa vil vel folketællingen faa rede paa forholdet, og avkom av saadanne forældre vil bli opført som „blandet“. Men saafremt barn av saadan blandet herkomst blir boende i en norsk bygd og gifter sig med norske, vil utvilsomt i de fleste tilfælder avkommet bli regnet som rent norsk. Selv „rene“ finner prøver nemlig at hemmeligholde sin herkomst. I anden generation vil man kun vanskelig komme efter det virkelige forhold, og i tredje generation maa man ty til kirkeboken eller en antropologisk undersøkelse for at kunne paavise den fremmede avstamning. Men paa folketællingslisten vil saadant avkom bli opført som rent norsk. Dette *kan* ialfald være forklaringen til at folketællingen i de sidste 80 aar viser følgende tal:

Tabel 2.

	Nordmænd	Lapper	Finner	Ubestemmelig blanding
1845	78,1	18,7	3,2	-
1855	76,8	17,8	5,4	-
1865	76,0	17,0	7,0	
1875	76,8	15,5	7,7	-
1891	81,2	14,9	3,9	-
1910	88,8	8,9	2,3	-
I dette materiale	83,3	4,5	2,4	9,9

Som man vil se, er det siden 1865 at det norske element har vokset litt. Men jeg vil paany fremholde at dette efter al sandsynlighet kun er et selvbedrag. I virkeligheten er forholdet det, at flere og flere tidligere opblandede slegter gaar over til at regne sig for norske. Disse „urene“ elementer gifter sig atter ind i tidligere „rene“ norske familier. *Og da raceeiendommelighetene ikke derved forsvinder, vil dette i virkeligheten si at den norske race i Troms fylke for hvert aar som gaar blir mere og mere forurenset med fremmede elementer.*

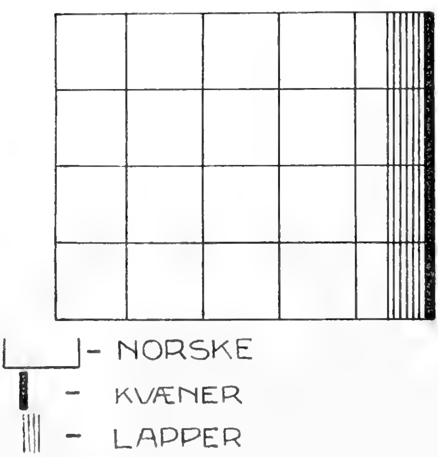

Fig. 2. Folkeblandingen i Troms fylke ifølge folketællingen 1910.

Hensigten med denne undersøkelse er da at paavise dette antropologisk, at paavise at selv den saakaldte rene norske befolkning frembyder tegn paa at være uren, opblandet. De forskjellige herreder i Troms fylke viser en meget forskjelligartet folkeblanding. Jeg anfører paa tabel 3, sidste 3 kolonner, hvorledes forholdet i denne henseende var i 1910.

Kvænene indgaar hyppigst blandede egteskaper, snart med lapper, snart med norske. For nordmændenes vedkommende er det især mændene som indgaar blandede egteskaper, hyppigst med kvæner. Naar der i det foregaaende tales om „rene" finner og rene lapper, saa er i grunden dette ganske misvisende. Gjennem aarhundreder har utvilsomt lappene blandet sig med andre folkeslag: russere, finner, svenske og norske. Og heller ikke finnene er nogen „ren" race. Det skal jeg straks gjøre nærmere rede for.

Hvor skriver de sig fra, disse fremmede elementer? Naar er de kommet til vort land, og hvad vei er de kommet? Jeg skal her kun ganske kortelig komme ind paa disse spørsmaal. Den almindelige benævnelse paa den finske befolkning i vort land er som bekjendt „kvæner". Men spør man dem selv, faar man ofte det svar, at de ikke er kvæner. De er finlændere, sier de. Sammenhængen er utvilsomt den, àt den norske befolkning kun har lite kjendskap til de forskjellige finske folketyper. Usandsynlig er det vel ikke at de først indvandrede har været kvæner, siden har alle finske indflyttere her til landet blit kaldt „kvæner", og deres hjemsted kaldes i folkemunde „Kvænland". Men utvilsomt er det at der ialfald i den senere tid er indflyttet til Norge andre finlændere end de egentlige kvæner. Men vi kan vel gaa ut fra at kvænene utgjør hovedmassen av den i Norge bosatte finske befolkning. Angaaende de finske kvæners herkomst hersker der imidlertid endnu megen uklarhet. „Kvænland" kaldtes i gamle dage de egne som laa omkring den nordligste del av den Bottniske Bugt. Kvænene omtales ofte i de ældste historiske beretninger og sidste gang i 1271, da de sammen med karelene foretok et plyndringstog til Norge. WESTERLUND mener ogsaa at den nuværende befolkning i nordre Österbotten er ætlinger av disse gamle kvæner. Han mener at det nuværende Uleåborgs län (den nordligste del av Österbotten) er deres egentlige hjemsted i Finland. Disse kvæner har altid været urolige av sig. Fra denne sin faste boplads ved den Bottniske Bugt har de flakket viden om mot nordost til det Hvite Hav, som efter dem har været kaldt Kvænhavet, og mot nordvest til Norge. De er ikke i den grad nomadiserende som lappene, men i sin levevis fjerner de sig ikke meget fra nomadene, sier A. H. KEANE[1].

Den samme forfatter angir antallet av dem i vore dager til henimot 300,000.

F. W. WESTERLUND beskriver dem saaledes:

Legemshøiden er 164,5 cm. med 3 frekvensmaxima ved 163, 165 og 167 cm. Deres cephalindex er 82,1, 75 % av dem er brachycephaler, og ikke mindre end 23,5 % har en index paa 85 eller høiere. 66 % av dem

[1] A. H. KEANE: Man, Past and Present (London 1920).

Tabel 3.

	Rent norske fra				Ren lap	Ren kvæn	Lap norsk	Lap kvæn	Lap svensk	Kvæn norsk
	Tromsø bisped.	Gud-brands-dalen	Øster-dalen	Andre steder i Norge						
Kvæfjord II	13	1	-	1	-	-	-	-	-	-
Trond. — Harstad III .	50	2	-	2	3	-	-	-	-	-
Bjarkøy	7	-	-	1	-	-	-	-	-	-
Ibestad VIII	35	-	-	-	4	-	1	-	-	1
Salangen VIII	20	-	-	1[1]	3	-	-	-	-	2
Bardu II	5	7	1	-	-	-	-	-	-	-
Lavangen IV	12	-	-	1	1	-	-	-	-	1
Tranøy IV	36	1	1	1	-	-	-	1	-	-
Sørreisa	2	-	-	-	-	-	-	-	-	-
Dyrøy II	20	-	-	2	-	-	-	-	-	-
Berg II.	7	-	-	1	-	-	-	-	-	-
Torsken	8	-	-	1	-	-	-	-	-	-
Lenvik III.	31	1	-	-	-	-	1	-	-	-
Hillesøy	4	-	-	-	-	-	-	1	-	-
Maalselv I.	15	2	4	-	-	-	-	-	-	-
Balsfjord IV	32	-	-	1	-	-	1	-	-	-
Malangen IV	25	1	-	2	-	-	-	-	-	-
Tromsøysund VI	45	-	-	-	-	1	-	-	-	-
Tromsø I	27	-	-	3	-	-	-	-	-	-
Sørfjord VIII	12	-	-	-	-	-	2	-	-	-
Lyngen XIII.	32	1	-	-	12	7	5	3	1	10
Karlsøy IV	25	-	-	-	2	2	1	-	-	-
Helgøy II	12	-	-	-	-	-	-	-	-	-
Skjervøy II.	30	-	-	-	4	1	7	3	-	10
Nordreisa	1	-	-	-	1	-	-	-	-	-
Kvænangen	5	-	-	-	-	6	4	-	-	2
Antal	511	16	6	17	30	17	22	8	1	26
Procent	83,35				4,5	2,4	3,3	1,2	0,15	3,9

[1] Faren var fra Tyskland, moren fra Nordland.

De ovenfor streken anførte herreder tilhører Senjen sorenskriveri, under streken Tromsø sorenskriveri.

har lyst haar og blaa eller graa øine. Mørke øine og mørkt haar findes kun hos 9 %.

46 % er leptoprosope med index facial. totalis 55—64
43 % er mesoprosope —„— —„— 65—69
11 % er chamæprosope —„— —„— 70—80
66 % av dem er leptorhine.

45 % har opstoppernæse, og 40 % har ret næse. Sittehøiden er 88,7 cm. og favnevidden 176,1 cm., resp. 54 og 107 % av legemshøiden. Vi skal senere se hvorledes disse tal svarer til de tilsvarende hos de norske kvæner.

Tabel 3.

Kvæn × svensk	Norsk × svensk	Sum	Fordeling av folketyper var i 1891 iflg. HELLAND			Ifølge folketælling av 1910				
			Norske	Finner	Lapper	Folkemængde	pr. kv. km.	% Norske	% Finner	% Lapper
-	-	15	95,7	0,3	4,0	3043	3,55	97,92	0,13	1,95
-	1	58	92,0	0,4	7,6	8255	16,41	93,26	0,02	6,72
-	-	8	99,9	0,1	0,0	1909	14,67	-	-	-
-	-	41	86,3	1,2	12,5	5709	6,65	89,82	0,41	9,77
-	-	26	76,2	3,3	20,5	3027	6,03	85,76	1,10	13,14
-	-	13	95,5	3,3	1,2	1689	0,69	98,21	1,17	0,62
-	2	17	-	-	-	1536	5,78	91,37	0,20	8,43
-	1	41	96,3	0,5	3,2	1823	3,92	97,09	0,06	2,85
-	-	2	89,9	1,5	8,6	2099	5,60	93,08	0,64	6,28
-	1	23	94,1	1,0	4,9	1723	8,21	96,36	0,97	2,67
-	-	8	96,2	2,4	1,4	1169	4,42	96,09	1,00	2,91
-	-	9	100	0,0	0,0	1597	5,07	99,75	0,25	-
-	-	33	88,3	0,8	10,9	5469	8,04	93,39	0,50	6,11
-	-	5	97,4	0,4	2,2	1990	4,17	99,51	0,10	0,39
-	2	23	94,4	2,7	2,9	3894	1,19	98,26	0,84	0,90
-	-	34	82,4	0,7	16,9	3420	2,89	91,93	0,36	7,71
-	-	28	97,2	0,1	2,7	1686	5,15	96,35	0,35	3,30
-	-	46	90,1	1,3	8,6	5691	3,69	98,41	0,23	1,36
-	-	30	-	-	-	7633	12115,87	99,84	0,13	0,03
-	-	14	-	-	-	1229	2,20	42,22	1,20	56,58
-	1	72	31,0	16,6	52,4	5260	1,71	57,07	11,82	31,11
-	-	30	81,4	0,7	17,9	2143	2,88	87,19	0,47	12,34
-	-	12	85,2	0,6	14,2	1444	2,24	92,46	0,27	7,27
-	-	55	63,9	8,5	27,6	2987	2,57	88,14	4,78	7,68
-	-	2	56,7	28,4	14,9	1552	0,57	72,41	25,33	2,26
-	-	17	26,05	15,8	57,7	1870	0,90	45,70	12,44	45,70
	8	662				81902	3,13	88,77	2,29	8,94
	1,2									

Det synes temmelig sikkert at kvænene er kommet til Finland sammen med karelene, og de skiller sig i antropologisk henseende kun lite fra karelene. De er da kommet ind i Finland østenfra over det karelske nes, har saa fulgt floden opover og er i de nordlige deler av Finland støtt sammen med lappene. De har utvilsomt paa et tidligt tidspunkt krydset sig med disse, og det som nu væsentlig skiller dem fra deres stamfrænder karelene, er netop dette lappiske element, som er mere fremtrædende hos dem end hos nogen anden finsk folkegruppe. Det er fra lappene de har faat sit „mongolske“ præg. Alle nyere undersøkelser synes tyde paa at kvænene likesom alle de øvrige finske folkegrupper oprindelig har været blonde og dolichocephale. Saavidt man nu kan forstaa, har finske folkeslag intet med Asia at bestille. Deres urhjem ligger i det centrale Rusland, antagelig i guvernementet Moskva.

Imidlertid kan man ikke paa forhaand utelukke den mulighet, at de norske kvæner delvis ogsaa kan nedstamme fra andre finske folketyper end de egentlige kvæner. Jeg skal derfor ganske kortelig gjøre rede for hvilke andre finske folketyper der i denne forbindelse kan bli tale om.

Vestfinnene eller de egentlige finner bor i det sydvestlige hjørne av Finland. Blandt alle finlændere har disse den største legemshøide (168,6 cm.) og den laveste cephalindex (79,9); de er ogsaa de mest lyshaarede og blaaøiede av alle finner.

Tavastenes middelhøide er 167,8 cm. og deres cephalindex 80,9; de er litt høiere end vestfinnene, men lysere end karelene. Og disse sidste staar igjen i enhver henseende midt mellem kvæner og tavaster. Vi finder altsaa her igjen den samme paralellisme som vi saa godt kjender fra Norge. Til stor legemshøide svarer relativt langt hode, lyst haar og lyse øine, til liten legemshøide kortskallethet, mørkere haar og mørkere øine. Den nuværende rent finske befolkning i Finland er altsaa opstaat ved at en lys blok paa ca. 80,6 % er blandet med en mørk blok paa 19,4 %, sier WESTERLUND. Det lyse element tilhører efter WESTERLUNDS mening den nordiske race; det mørke element skyldes for en væsentlig del tilblanding av lapper, mener han. Men netop herfor har ogsaa sammenligningen mellem den finske og den vestnorske befolkning saa stor interesse. Ogsaa den vestnorske befolkning er jo tydeligvis opstaat ved at den nordiske race er blit blandet med et mørkt element, og blokkenes gjensidige størrelse er i Norge omtrent som i Finland. For kvænenes vedkommende er der ingen grund til at tvile paa at det mørke element hovedsagelig skriver sig fra lappene.

Her i Norge er det betydelig vanskeligere at si noget bestemt herom. De hittidige undersøkelser har nærmest pekt i den retning, at det mørke element skriver sig fra den mellemeuropæiske alpine race, og derfor er det av stor interesse at foreta en sammenligning mellem den vestlandske brachycephale befolkning og den nordiske, hvor det brachycephale og mørke elements etniske oprindelse ialfald for en del kjendes.

Naar begyndte saa kvænene at komme til Norge? AMUND HELLAND mener at de første kvæner kom til Norge for noget over 200 aar siden. ANDREAS M. HANSEN mener de begyndte sin indvandring til Norge omkring aar 1600, altsaa for vel 300 aar siden. I hvert fald kan man vel anse det for utvilsomt at nogen nævneværdig indvandring av kvæner først er foregaat i de sidste 2 à 300 aar.

Ganske anderledes vanskelig er det at bli klar over naar lappene kom til Norge. ANDREAS M. HANSEN mener at lappene første gang er kommet til Finmarken mellem 1100 og 1300 e. Kr. Og de skulde da neppe være kommet til Troms fylke før ca. 100 aar senere. MANTEGAZZA og SOMMIER angir lappenes legemshøide for voksne mænd til 152,4 cm. og for kvinder til 145,0 cm., VON DÜBEN og HUMBOLDT angir 150,0 cm. Om deres antropologi foreligger der desværre kun meget mangelfulde oplysninger. Tildels ogsaa meget motstridende. Enkelte angir cephalindex til 83,5 (VON DÜBEN), andre til 85,2 (VIRCHOW), atter andre til 86 à 88 (RIPLEY, DENIKER).

Mantegazza og Sommier, hvis materiale er størst, angir deres cephalindex til 87 à 88. Karakteristisk er det meget brede ansigt, som smalner sterkt av nedad. Haken er meget liten. Av de fleste skildres lappene som relativt blonde (Virchow). Hos Amund Helland heter det, at „øinenes farve er hos lappene den som er egen for den blonde race, blaa og graa". Haarfarven er brun, ofte lysebrun, meget sjelden sort.

At lappene oprindelig har været nomader, og at de har sit hjem i det centrale Asia, derom hersker der vel for tiden enighet. Derimot er der vel endnu meget delte meninger om naar de kom til Europa, og især angaaende deres utbredningsomraade i tidligere tider. Der er vel endnu dem som mener at de gamle skridfinner er lapper. Hvis denne opfatning er rigtig, maa lappene tidligere ha hat en meget stor utbredelse i Norge.

I Norge er nu lappene kun for en del nomader. I løpet av de sidste par hundrede aar er stadig flere og flere blit fastboende, fornemlig i Finmark og Troms fylker. Og vi har da nu paa øene og langs fjordene i Troms fylke en befolkning som almindelig benævnes „sjøfinner". Selv kalder de sig lapper. Disse *sjøfinner* utgjør en ganske stor procent av den i denne avhandling beskrevne befolkning. Den almindelige opfatning er som bekjendt den, at disse sjøfinner er forarmede fjeldlapper som har søkt ned til kysten for at finde levebrød. Og at dette virkelig er tilfældet med endel av dem, derom kan der neppe være tvil. Her har de saa i tidens løp krydset sig dels med norske, dels med kvæner. Deres sprog er nu i almindelighet lappisk eller norsk, og de fleste av dem er vistnok selv av den opfatning, at de nedstammer fra lapper. Helt sikkert er imidlertid ikke dette.

Andr. M. Hansen mener at disse sjøfinner er ætlinger av de gamle skridfinner; han mener at man her har for sig de sidste rester av den anariske befolkning, som bebodde Norge før den „ariske" befolkning kom hit. Hans rike bevisrække herfor kan jeg ikke her referere; jeg maa nøie mig med enkelte punkter. Han henter sine beviser baade fra det sproglige, arkæologiske og historiske omraade. Og han mener at det hittil foreliggende ganske sparsomme antropologiske materiale ogsaa støtter hans opfatning. Likeledes seder og skikker og aandelige eiendommeligheter hos den nulevende befolkning.

At den urgamle befolkning ikke har kunnet sætte særlig mange merker efter sig i sproglig henseende, finder han ganske forklarlig. Men han mener dog at kunne paavise endel. En undersøkelse av norske stedsnavne viser at finner i urgammel tid har holdt til helt til Norges og Sveriges sydligste spidser, og netop i de strøk ute mot kysten og oppe i markebygdene hvor de sidste rester av urbefolkningen lettest kunde holde sig. Og at disse stedsnavne ikke skriver sig fra lappene, er klart allerede av den grund, sier han, at vi i en meget sen tid kan følge baade sproghistorisk og gjennem stedsnavne lappenes langsomme utbredelse utover Skandinavien.

Et sproglig bevis for lappenes sene ankomst til Finmark og Troms, efterat nordmændene hadde bosat sig der, har man i den kjendsgjerning, at alle ord i lappisk for sjøbedrift og alle fremtrædende stedsnavne ved den norske kyst er norske laaneord. Har nu skridfinnenes sprog efterlatt sig nogen merker? Kan man i det norske sprog paavise forskandinaviske laaneord? Man kan dog ikke vente at finde mange saadanne, mener han. Ti der kan ikke være tvil om at „arierne“ fra første stund av stod paa et høiere kulturtrin end „skridfinnene“; derfor maatte det ariske sprog gi, ikke faa. ANDR. M. HANSEN mener dog, at al sandsynlighet taler for at en række stedsnavne langs kysten er saadanne laaneord fra skridfinnenes sprog. Som eksempler paa saadanne nævner han: Óstr, Fistr, Sotr, Bókn, Sókn, Hítr, Títr, Matr, Fugl, Drafn, Vefsn. Ogsaa endel bygdenavne er efter ham slike laaneord: Þótn, Dofr, Fósn o. fl.

Alle disse navne er énstavelsesord med enkel eller vokalisk fremlyd og en sammensat utlyd, hvor stadig en stængt medlyd smelder av i en aapen, og de skiller sig derved sterkt ifra de blote oldnordiske, germansk-ariske navne[1].

Men hvorledes kan man saa forklare sig at skridfinnenes sandsynlige mest direkte arvtakere, sjøfinnene, nu taler lappisk. At de en gang i tiden har hat sit eiendommelige sprog, synes tydelig nok at fremgaa av PEDER CLAUSSØNS skildring av dem: „Siofinnerne haffue dog deris eget Maal, som de bruge indbyrdis oc med Lappen; huilcket Norske Mend icke kand forstaae, oc det siges at de haffue flere Sprog end et; af deris Maal hafue de dog et andet at bruge indbyrdes, som ingen kand forstaae.“ Her har vi altsaa en samtidig paalidelig hjemmelsmand for at sjøfinnene midt i 1500-aarene hadde sit eget sprog, samtidig med at de kunde tale norsk og lappisk. At det lappiske har kunnet holde sig, er helt naturlig av den grund, at der stadig er kommet nye indflyttere, bumænd, av lapper.

Hvis det virkelig forholder sig saa, at sjøfinnene er ætlinger av de gamle skridfinner, saa maa man vel kunne paavise dette antropologisk. Ti de antropologiske eiendommeligheter er ganske anderledes seiglivet end sproglige og kulturelle.

De antropologiske eiendommeligheter løsner ganske vist fra sine oprindelige forbindelser ved krydsning med fremmede racer; men de forsvinder ikke. Og hvis man saasandt kjendte skridfinnenes oprindelige antropologiske eiendommeligheter, og hvis man kjendte de antropologiske eiendommeligheter hos de folketyper som de i Troms fylke har krydset sig med, saa skulde det vel ikke være saa vanskelig at paavise hos den nulevende befolkning antropologiske eiendommeligheter som skrev sig fra skridfinnene.

Men ulykken er at man ikke kjender skridfinnenes oprindelige antropologiske eiendommeligheter og kun har et meget sparsomt kjendskap til lappenes. Det er heller ingen let sak at paavise hos den nulevende befolkning antropologiske træk som kunde tænkes at skrive sig fra skridfinnene. Men det blir dog en av opgavene for denne undersøkelse.

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[1] ANDREAS M. HANSEN: Oldtidens Nordmænd, p. 97.

3. Tidligere antropologiske undersøkelser.

Der er ikke tidligere foretat nogen samlet antropologisk undersøkelse av Troms fylkes befolkning. Overlæge C. F. Larsen har i sin avhandling „Nordlandsbefolkningen" git enkelte spredte meddelelser.

Han finder at den norske befolkning i alt væsentlig har de samme træk som den trønderske befolkning. Han mener fremdeles at kunne paavise, at der med hensyn til pandebredden er en karakteristisk forskjel paa de brachycephale lappekranier og paa de brachycephale kranier som skriver sig fra „norske" brachycephaler. Lappekraniene smalner hurtigt og sterkt til forover, saa at differensen mellem pandens bredde og hodets bredde blir betydelig større paa lappekranier end paa norske brachycephale kranier. Den samme forskjel mellem lapper og „norske brachycephaler" mener han ogsaa at kunne paavise inden den levende befolkning. Forøvrig er hans materiale fra Troms fylke altfor sparsomt (85 mand) til at man av dette kan opgjøre sig nogen mening om fylkets antropologiske forhold.

Brigadelæge Grønn har ogsaa git endel mindre meddelelser om de antropologiske forhold. Han meddeler saaledes at lappenes middelhøide var 159,5 cm., kvænenes 162,4, medens den norske befolknings middelhøide i Troms fylke var 169,9 cm. Han finder at der er meget stor forskjel paa „sjøfinner" og fjeldlapper. De førstnævnte er meget spinkle, har gjennemgaaende en daarlig legemsbygning. Fjeldlappene er ganske anderledes kraftig bygget.

Han finder blandt lappene forholdsvis mange av en særegen mørk type med brune øine og sort haar.

Anders Daae og Hans Daae meddeler i deres avhandling „Indlands- og kystbefolkningens legemshøide, favnevidde, siddehøide og brystomfang" følgende: „Den yderste kyst mot Nordsjøen, Atlanterhavet og Nordishavet har en befolkning med for største delen mindre legemshøide og saavel absolut som i forhold til legemshøiden kortere ben og større brystomfang end det øvrige lands befolkning."

II. Legemshøiden.

Saavel i dette som i de følgende avsnit har jeg ved beregning av middelværdi (M), standardavvikelse (σ), variationskoefficient (υ), sandsynlige feil av middelværdi E (M), av standardavvikelse E (σ) og variationskoefficient E (υ) benyttet den vanlige beregningsmetode (se Martins haandbok p. 67—92).

Jeg har for legemshøidens vedkommende fundet følgende:

Middelhøide (M) = 169,287 cm.
Sandsynlig feil av middelhøiden E (M) = ± 0,167.
Standardavvikelse (σ) = 6,78.

Sandsynlige feil av standardavvikelse E (σ) ± 0,177.
Variationskoefficienten (υ) = 4,004.
Sandsynlige feil av denne E (υ) ± 0,7004.

Den gjennemsnitlige legemshoide for hele fylket, 169,287 cm., ligger ikke saa lite under gjennemsnittet for hele Norge, som nu er omkring 172 cm. Legemshoiden er imidlertid meget uensartet i fylkets forskjellige herreder. Mindst er legemshoiden i fylkets nordostligste herreder, i Nordreisa saaledes kun 166,5 cm., i Lyngen og Karlsøy 167,6 og 167,7 cm. Andre herreder med særlig liten legemshoide er Sorfjord (168,3), Helgøy (168,7), Skjervoy (169,0) og Kvænangen (169,1). Av de 190 mand som blev undersokt fra disse distrikter, kunde imidlertid ikke mindre end 83 (= 43,7 %) opgi enten at de var rene lapper eller kvæner, eller at deres slegt var sterkt opblandet med lap eller kvæn. Det kan vel heller ikke være nogen grund til at tvile om at krydsning med lapper er den vigtigste aarsak til den ringe legemshoide i disse herreder.

Storst legemshoide har jeg fundet i følgende herreder: Tranøy (173,2), Bardu (172,8), Balsfjord (172,8), Salangen (172,7), Kvæfjord (171,2), Trondenes (171,2), Dyroy (171,6) og Maalselv 171,7. I disse distrikter var der kun 2,6 % som hadde lappeblod eller kvænblod i sine aarer, medens der derimot var 11,7 % som kunde meddele at de nedstammede fra indflyttede Østerdoler og Gudbrandsdoler. At dette er forklaringen til den store legemshoide i disse distrikter, er vel hoist sandsynlig. Ti hvis jeg særskilt undersoker legemshøiden for de forskjellige racer og raceblandinger som findes her i fylket, da finder jeg folgende:

1.	Lapper	164,1 cm.
2.	Kvæner	166,2 —
3.	Lapper × kvæner	165,4 —
4.	Lapper × norske	166,8 —
5.	Kvæner × norske	168,7 —
6.	Norske fra Troms fylke	170,9 —
7.	Norske av gudbrandsdalsk herkomst	170,9 —
8.	Norske av østerdalsk herkomst	172,8 —

Jeg vil med én gang gjøre opmerksom paa, at de som her er opført som lapper, selvfølgelig ikke er rene lapper. Om man andre steder i Norge kan være i nogen tvil om hvilken betydning herkomsten spiller for distriktets gjennemsnitlige legemshøide, saa kan man dog neppe være i tvil her i Troms fylke.

Nu er naturligvis ingen av de ovenfor anførte grupper „rene" i antropologisk forstand. Lappene *angav* ganske vist at være rene lapper; men en nærmere undersøkelse viser dog at de er sterkt opblandet. Og det samme er utvilsomt tilfældet ogsaa med de ovrige grupper. Hvis jeg ordner de fundne legemshoider i serier for hver cm., saa faar kurven et helt andet utseende end man er vant til at finde i den sydlige del av Norge. Kurven blir meget mere avlang end vanlig.

Medens hoidekurven i Trondelagen som regel fremviser 3 tydelige spidser ved 172, 168 og 176 cm., finder man her, som det vil sees, ikke mindre end 6 vel markerte spidser. Den høieste av disse spidser tæller kun ca. 7 % individer, medens den hoieste spids i Trondelagen tæller omkring det dobbelte antal individer (ca. 14 %). Av de ovrige 5 spidser vil man se at de tre tæller fra $5^1/_2$ til $6^1/_2$ % individer. De er altsaa kun litt mindre end den hoieste, og den 5te spids tæller over 4 % individer. Hele kurven faar derved et betydelig mere avlangt forlop end man ellers vanlig finder i Norge. Det beror selvfølgelig paa at befolkningen her i Troms fylke er meget mere heterogen end sydpaa.

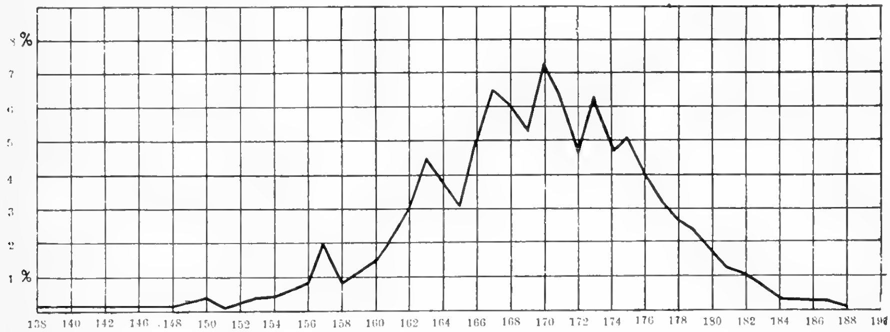


Fig. 3. Kurve for legemshoiden i Troms fylke.

Jeg antar, at de tre spidser som findes ved 168, 173 og 175 cm., svarer til de tre spidser som er de vanlige ellers. At de med hensyn til beliggenheten er blit noget forrykket, er kun en naturlig følge av opblandingen med andre typer med andre legemshøider[1]. Spidsen ved 170 cm. er kun en summeringsspids. De to spidser som findes paa kurvens opadstigende ben, er fremkaldt av de to nye typer som er tilkommet i Troms fylke, og som ikke findes i de sydligere deler av Norge. Av spidsenes beliggenhet kan man imidlertid i en saadan kurve som denne neppe dra nogen sikre slutninger angaaende disse typers virkelige middelhøide. Blandt de av mig undersøkte 662 mænd var den høieste 187 cm., den laveste 148 cm. Da imidlertid undersokelsen er foretat paa ekserserpladsene, er allerede befolkningens laveste individer eliminert. Dette har selvfølgelig ikke saa ganske lite at si i disse distrikter. Jeg vil derfor anse det for hoist sandsynlig, at befolkningens virkelige middelhoide særlig i herreder med liten legemshøide er ikke saa lite mindre end av mig anført paa tabel 4. I et distrikt som Skjervoy til eks. har jeg fundet en middelhoide paa 169 cm.; kun halvparten av befolkningen her er av norsk herkomst. Her kan man

[1] Se nærmere herom i „Møre fylkes antropologi" og „To grundracer i Norge".

Tabel 4. Legemshoiden i Troms

	Gj.snits-hoide	139	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162
Kvæfjord	171,2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Harstad og Trondenes	171,2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	2
Bjarkoy	168,3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Ibestad	170,2	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	1	-	-
Salangen	172,7	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	-	-	1
Bardu	172,8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lavangen	170,6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Franoy	173,2	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	1
Sorreisa	167,3	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Dyroy	171,6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
Berg.	169,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Torsken	166,8	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Lenvik	170,5	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	1
Hillesoy	167,8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Maalselv	171,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Balsfjord	172,8	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	2	-
Malangen	170,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Tromsoysund . .	169,5	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	1
Tromso	169,3	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1
Sørfjord	168,1	-	-	-	-	-	1	-	-	-	-	-	-	-	2	1	-	1	-	1
Lyngen	167,2	-	-	-	1	-	-	-	-	2	1	-	-	-	1	-	1	1	5	5
Karlsoy	167,2	-	-	-	-	1	-	1	-	-	-	-	1	-	1	-	-	-	1	-
Helgoy	167,8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2
Skjervoy	168,4	1	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	2
Nordreisa	168,2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kvænangen . . .	169,3	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Serier for de av mig undersokte soldater	Absolute tal. . . .	-	-	-	-	1	-	-	-	-	-	-	-	2	8	4	6	10	13	21
	Procent .	-	-	-	-	0,15	-	-	-	-	-	-	-	0,3	1,2	0,6	0,9	1,5	2,0	3,2
	Procent .	-	-	-	-	-	-	-	-	-	-	-	-	0,3	1,8		1,4		5,2	
Tidl. kasserte mandskaper		1	1	1	1	1	2	3	1	2	3	3	4	4	7	4	2	2	3	2
Serie for hele aarsklassen		1	1	1	1	1	2	3	1	2	3	3	4	6	15	6	8	12	16	23
		0,13	0,13	0,13	0,13	0,13	0,26	0,39	0,13	0,26	0,39	0,39	0,53	0,80	2,0	0,8	1,1	1,5	2,2	3,1
		0,13	0,26		0,26		0,65		0,39		0,78		1,33		2,8		2,6		5,3	

da være sikker paa at der ved utskrivningsmotene er blit eliminert flere mænd paa grund av for liten legemshoide.

For at bringe dette paa det rene har jeg gjennemgaat utskrivningslistene for det foregaaende aar, og jeg vil da faa med ialfald de allerfleste undermaalere. Jeg har samlet resultatet av denne undersokelse paa tabel 4.

Alle de individer som paa denne tabel er opfort foran den tykke strek mellem 155 og 156 cm. (paa én mand nær), var ved utskrivningen blit kjendt udygtige. Jeg har opfort disse distriktsvis. Selvfølgelig blev ved utskrivningen ogsaa en god del hoiere individer kassert. Disse er samlet paa 4de linje fra neden. Tar jeg alle disse med ved beregningen av legemshøiden i de forskjellige distrikter, blir resultatet det som er fremstillet paa det medfølgende kart fig. 4. Man vil av dette kart se at der helt ute ved fylke for hver cm. Tabel 4.

163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188
1	-	-	2	1	2	-	1	-	-	1	-	3	-	1	-	-	1	-	1	-	-	-	-	-	15
1	2	2	-	3	5	4	5	4	2	5	2	2	-	3	5	4	-	2	1	-	-	-	-	-	58
-	-	-	-	-	2	-	2	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	8
1	2	3	3	3	2	4	1	2	4	3	5	-	-	1	2	1	1	-	1	-	-	-	1	-	41
-	-	2	2	3	-	2	1	-	-	2	1	3	2	1	-	-	1	1	-	-	-	-	-	1	26
-	1	-	-	-	-	-	2	1	-	4	1	2	-	1	1	-	-	-	-	-	-	-	-	-	13
-	-	-	1	3	1	4	-	1	3	2	-	1	-	-	1	-	-	-	-	-	-	-	-	-	17
1	1	-	3	3	3	2	1	2	1	1	4	2	1	3	2	1	2	3	3	1	-	-	-	-	41
1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
1	-	-	1	-	-	1	3	2	1	1	1	4	2	1	2	1	-	-	-	-	-	-	-	-	23
1	1	-	-	-	1	-	-	-	-	-	-	1	-	1	-	2	-	-	-	-	-	-	-	-	8
-	1	1	3	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	9
1	1	1	3	3	2	1	1	4	2	2	3	1	1	2	1	-	-	-	1	-	-	-	-	1	33
-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	5
1	-	-	2	1	2	2	-	5	1	1	1	1	2	-	-	1	1	-	-	-	-	1	-	-	23
-	1	-	3	2	-	1	2	3	1	2	2	6	3	-	1	2	1	-	-	-	1	-	1	-	34
-	1	-	3	3	-	3	2	1	2	2	3	2	2	-	-	-	1	-	-	-	-	1	-	-	28
2	2	2	2	3	4	2	5	2	3	5	-	2	2	-	3	-	1	1	-	-	1	-	-	-	40
3	1	2	2	2	1	2	2	3	2	-	-	2	3	2	-	1	-	-	-	-	-	-	-	-	30
-	-	-	1	-	-	-	1	-	2	2	1	-	-	-	-	-	-	2	-	-	-	-	-	-	14
9	4	2	3	6	8	3	7	2	3	3	-	3	1	1	-	1	2	-	1	-	-	-	-	-	72
1	4	2	1	3	2	1	4	3	2	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	30
-	1	1	-	-	-	1	1	1	-	-	2	-	1	-	-	1	-	-	-	-	-	-	-	-	12
3	3	3	3	5	2	6	6	1	4	3	1	2	5	1	-	1	-	-	-	1	-	-	-	-	55
1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
1	2	-	-	-	3	-	-	4	-	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	17
29	28	21	38	44	42	39	48	41	34	42	30	38	29	21	18	17	11	9	8	2	2	2	2	2	662
4,4	4,25	3,2	5,7	6,6	6,4	5,9	7,3	6,2	5,1	6,4	4,5	5,7	4,4	3,2	2,7	2,6	1,7	1,3	1,2	0,3	0,3	0,3	0,3	0,3	
8,6		9,1		12,9		13,2		11,3		10,8		10,1		5,9		4,3		2,5		0,6		0,6		0,3	
4	-	2	-	3	1	-	6	3	-	4	5	-	1	3	1	-	2	-	-	2	-	-	-		
33	28	23	38	47	43	39	54	44	34	46	35	38	30	24	19	17	13	9	8	4	2	2	2	2	78
4,5	3,8	3,1	5,1	6,5	6,1	5,3	7,3	6,2	4,6	6,3	4,7	5,1	4,1	3,2	2,6	2,3	1,7	1,2	1,1	0,53	0,26	0,26	0,26	0,26	740
8,3		8,1		12,6		12,6		10,8		11,0		9,1		5,8		4,0		2,3		0,8		0,5		0,2	

kysten findes en række distrikter med en paafaldende liten legemshoide. Jeg nævner saaledes Berg, Torsken, Bjarkoy, Hillesøy, Helgøy, Karlsøy o. fl. Undertiden finder man en ganske paafaldende forskjel paa legemshøiden i 2 nabodistrikter, til eks. Tranøy 173,2 og Torsken 166,8. Det minder ikke saa lite om forholdene i Møre fylke. Blandt de av mig undersøkte fra Berg og Torsken sa alle sig fri for at være lapper eller nedstamme fra lapper. Det vilde jo ogsaa være noksaa paafaldende om fjeldlapper skulde ha slaat sig ned i nogen storre mængde i slike distrikter. Men en hel mængde av disse distrikters mænd hadde dog et helt fremmed utseende. Der kan ikke være nogen tvil om at det norske element her var sterkt opblandet med et fremmed element, som vel ogsaa har forvoldt den ringe legemshøide.

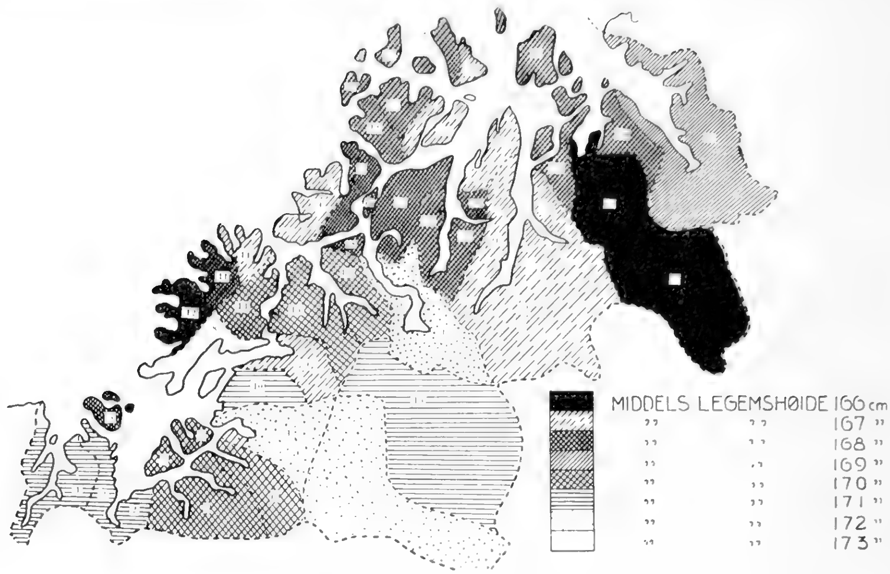


Fig. 4. Kart over legemshøiden.

1. Kvæfjord.
2. Trondenes og Harstad.
3. Bjarkøy.
4. Salangen.
5. Bardu.
6. Lavangen.
7. Ibestad.
8. Tranøy.
9. Sørreisa.
10. Dyrøy.
11. Berg.
12. Torsken.
13. Lenvik.
14. Hillesøy.
15. Maalselv.
16. Balsfjord.
17. Malangen.
18. Tromsøysund.
19. Tromsø.
20. Sørfjord.
21. Lyngen.
22. Karlsøy.
23. Helgøy.
24. Skjervøy.
25. Nordreisa.
26. Kvænangen.

Tabel 5.

		Troms fylke	Asiatiske folkeslag [1]		
			Lebediner	Tubatarer	Teleugeter
Meget smaa	129,0—147,9 cm..	0,52 } 6,7	4,9	-	-
Smaa	148,0—157,9 cm..	5,18 }	21,3	18,0	10,3
Undermiddels	158,0—161,9 cm..	5,50	14,8	20,0	31,0
Middelshøi	162,0—164,9 cm..	11,40	23,0	24,0	27,6
Overmiddels	165,0—167,9 cm..	14,30	9,8	6,0	17,2
Høie	168,0—177,9 cm..	52,70	24,0	32,0	13,8
Meget høie	178,0—190,0 cm..	10,40	1,6	-	-
		100,00			

Sammenligner vi denne befolkning med virkelig smaavoksne folkeslag (se tabel 5), saa vil man se at Troms fylkes befolkning nærmest blir som kjæmper.

[1] Efter Kaarlo Hildén: Die Eingeborenen des russischen Altai.

En sammenligning med finske folkegrupper gir følgende resultat:

Tabel 6.

	Middels legems-høide	Meget smaa, under 157 cm.	Smaa 157,0—161,9 cm.	Middels 162,0—169,9 cm.	Høie 170,0—180,0 cm.	Meget høie, over 180,0 cm.
Troms fylke	170,1	5,70	6,15	36,75	47,55	3,85
Vestfinner	168,6	2,29	8,83	44,53	42,21	2,14
Tavaster	167,8	3,12	11,19	45,96	37,85	1,88
Kareler	165,4	7,30	18,56	48,76	24,65	0,73
Kvæner	164,4	9,25	21,65	49,20	19,50	0,40

Som man vil se av denne tabel, har vi betydelig flere høie folk i Troms fylke end blandt nogen av de finske folkegrupper. Vi staar i denne henseende nærmest vestfinnene. Da det vel er hævet over tvil, at det er det nordiske element som gir begge disse folkegrupper deres store legemshøide, saa skulde Troms fylkes befolkning enten være mere rent nordisk end den mest nordisk rene av de finske folkegrupper. Eller ogsaa maa de finske folkegrupper være opblandet med en endnu mere lavvoksen type end tilfældet er i Norge. WESTERLUND kommer gjennem sine beregninger til det resultat, at der i den finske befolkning indgaar en nordisk blok paa 80 % og en fremmed paa 20 %. Utføres den samme beregning nøiagtig likedan her i Troms fylke, blir resultatet at den nordiske bloks størrelse kun er paa 66 %. Da allikevel legemshøiden her er betydelig større, maa dette bero paa, at den fremmede blok her i Norge har hat en større legemshøide end den fremmede blok i Finland har hat.

Men merkelig nok er *ogsaa den lavvoksne befolkning hos os større end blandt vestfinnene.* Det er kun blandt kareler og kvæner man finder flere smaavoksne folk end i Troms fylke. Den ringe legemshøide hos disse finske folketyper skyldes, mener WESTERLUND, krydsning med lapper. Den fremmede blok hos os kan da neppe ha været lapper. Da maatte selvsagt befolkningen i Troms fylke været betydelig lavere end i Finland.

Den eneste kjendte folketype med meget liten legemshøide i Nordeuropa er som bekjendt lappene. MANTEGAZZA fandt hos voksne lapper en gjennemsnitlig legemshøide paa 152,4 cm. Hos voksne lapper (mænd) varierer høiden ifølge hans undersøkelse fra 138 til 161 cm. En mand paa 134 og to paa 168 og 170 cm. er ialfald saa tvilsomme at jeg tror det er rigtigst ikke at regne dem med.

Inden en serie av fjeldlapper finder man derfor 50 % av samtlige undersøkte under 152,5 cm. Inden en for lapper helt fri norsk indlandsbefolkning finder man praktisk talt ingen under denne legemshøide. Tar man derimot for sig den lavvoksne vestlandske brachycephale befolkning, saa finder man ganske vist en og anden under denne legemshøide. Men det blir dog ikke mere end ca. 4 promille under denne høide.

I den her foreliggende serie fra Troms fylke kan man derfor med stor sikkerhet si, at de mænd hvis høide ligger under 153 cm., i denne henseende bærer paa arv fra lapper. Dette er i alt 15 mænd. Da man maa regne med likesaa mange +-avvikere, skulde altsaa i alt 30 mænd i denne serie med hensyn til legemshøide være av lappisk avstamning. Dette utgjør omtrent 4 %. Efter den offentlige statistik skulde imidlertid i 1910 8,8 % av befolkningen være av lappisk herkomst. Forholdet maa da enten være det, at der i statistikken er medregnet som lapper mange som ikke er det, eller som kun for en ringe del er av lappisk herkomst. Eller ogsaa maa det lappiske islæt ikke gi sig tilkjende ved den antropologiske undersøkelse av legemshøiden.

III. Pigmentering.

1. Øienfarven.

Øientypene er betegnet saaledes: 1 = blaa og graa (= MARTIN 13—16), 2 = lyst melerte (M. 9—12), 3 = mørkt melerte (M. 6—8), 4 = lysebrune (M. 5), 5 = mørkebrune (M. 4).

Tabel 7.

Herredets navn	Antal undersøkte	Øientyper					Index	Procent av		
		1	2	3	4	5		blaaøiede 1	melerte 2. 3	brune 4. 5
Kvæfjord	15	10	2	-	2	1	1,80	66,4	13,6	20,0
Harstad og Trondenes	58	38	8	6	5	1	1,67	65,1	24,2	10,7
Bjarkøy	8	6	-	2	-	-	1,50	75,0	25,0	-
Ibestad	41	26	7	2	1	5	1,82	62,3	34,1	4,6
Salangen	26	18	1	3	2	2	1,80	69,2	15,4	15,4
Bardu	13	9	3	1	-	-	1,38	69,2	30,8	-
Lavangen	17	11	3	1	-	2	1,76	64,8	23,5	11,7
Tranøy	41	29	9	-	2	1	1,46	70,8	21,9	7,3
Sørreisa	2	1	-	-	-	1	3,00	50,0	-	50,0
Dyrøy	23	15	5	1	1	1	1,60	58,0	33,3	8,7
Berg	8	4	1	-	2	1	2,37	50,0	12,6	37,4
Torsken	9	4	2	1	2	-	2,11	44,5	33,75	22,25
Lenvik	33	20	6	3	2	2	1,78	60,8	27,1	12,1
Hillesøy	5	2	1	2	-	-	2,00	40,0	60,0	-
Maalselv	23	14	7	1	1	-	1,52	61,8	34,9	4,35
Balsfjord	34	20	10	2	2	-	1,58	58,0	36,2	5,8
Malangen	28	22	4	1	1	-	1,32	78,0	17,9	3,9
Tromsøysund	46	22	16	6	2	-	1,73	47,8	47,8	4,35
Tromsø	30	14	10	1	3	2	1,96	53,6	36,9	16,7
Sørfjord	14	6	4	3	1	-	1,92	43,0	59,0	7,0
Lyngen	72	33	12	5	15	7	2,31	43,7	23,3	33,0
Karlsøy	30	13	8	6	1	2	2,03	43,5	46,5	10,0
Helgøy	12	4	4	2	2	-	2,16	33,3	50,0	16,7
Skjervøy	55	37	6	6	3	3	1,70	67,3	21,8	10,9
Nordreisa	2	2	-	-	-	-	1,00	52,6	31,6	15,8
Kvænangen	17	8	4	2	2	1	2,05			
Antal	662	388	133	57	52	32				
Procent	-	58,5	19,9	8,9	7,8	4,9				

Som det fremgaar av tabel 7, har jeg blandt samtlige undersøkte fundet 388 (58,5 %) blaaøiede, 133 (19,9 %) med lyst melerte øine, 57 (8,9 %) med mørkt melerte øine, 52 (7,8 %) med lysebrune øine og 32 (4,9 %) med mørkebrune øine. Sammenholdt med hvad man finder andre steder i Skandinavien, maa altsaa denne befolkning kaldes mørkøiet.

Tabel 8.

	Troms fylke %	Nidaros %	Møre fylke %	Nordmør %	Søndre Søndmør %
Blaa og graa øine	58,5	69,5	67,2	69,4	55,7
Lyst melerte øine	19,9	11,4	13,7	14,4	12,1
Mørkt melerte øine	8,9	6,6	7,3	5,4	7,0
Brune øine	12,7	12,5	11,8	10,8	25,2

Endnu rikere materiale til sammenligning faar man hvis man nøier sig med 2 grupper: 1. blaa- og graaøiede, 2. melerte og brune øine. Grænsene mellem lyst melerte, mørkt melerte og brune øine er ogsaa saa ubestemte at man ved denne inddeling faar et sikrere grundlag at bygge paa.

Tabel 9.

	Troms fylke	Søndre Søndmør	Nidaros	Sverige	Lappland	Vesterbotten
Blaa og graa øine	58,5	55,7	69,5	66,7	55,9	60,1
Melerte og brune øine	41,5	44,3	30,5	33,3	44,1	39,9

Men som man vil se av begge de ovenstaaende tabeller, har vi baade i Norge og i Sverige distrikter med en mere mørkøiet befolkning end denne. Specielt er det av interesse at lægge merke til at Søndre Søndmør, hvor der slet ikke findes og heller ikke i historisk tid har eksistert lapper, har en mere mørkøiet befolkning end den med lapper sterkt opblandede befolkning i Troms fylke.

Der er derimot med hensyn til øienfarven meget stor forskjel paa de forskjellige distrikter. De to lyseste herreder er Bardu og Maalselv og Malangen. I disse distrikter fandt jeg i alt 70,2 % blaaøiede, 21,8 % med lyst melerte øine, 4,8 % med mørkt melerte øine og kun 3,2 % med lysebrune øine. Disse tal svarer omtrent til hvad man finder i de lyseste distrikter i Norge og Sverige. Befolkningen i disse herreder er for en væsentlig del indvandret fra Østerdalen. Det har derfor en stor interesse at sammenligne disse tal med hvad man finder i Nordre Østerdalen.

Tabel 10.

	Bardu, Maalselv, Malangen	Nordre Østerdalen	Södermanland	Blandt svensktalende i Finland
Blaa og graa øine	70,2	68,1	70,0	82,57
Lyst melerte øine	21,8	19,2	27,5	10,53
Mørkt melerte øine	4,8	8,2		
Brune øine	3,2	4,5	2,5	6,05

Det er et nyt bevis paa den seighet hvormed denne egenskap nedarves. Man kan vel endvidere av disse tal dra den slutning, at den befolkning som fandtes i disse distrikter før, har været like saa lysøiet som indvandrerne. Hvis jeg saa derefter undersøker øienfarven i et av de mest mørkøiede distrikter, da finder jeg følgende tal:

Tabel 11.

	Lyngen	Russere 10—18 aar gl.	Englændere	Lapper og Norske i Troms fylke	Kvæner og Norske i Troms fylke	Blandt finsktalende i Finland	I Finland
Blaa og graa øine	45,7	22,0	53,0	32,6	53,5	77,04	71,80
Lyst melerte øine	16,7	44,0	27,0	29,0	13,9	15,01	10,09
Mørkt melerte øine	7,0			7,6	11,7		
Brune øine	30,6	33,0	20,0	30,8	20,9	7,35	9,11
	100,0	100,0	100,0	100,0	100,0		

En saa mørkøiet befolkning finder man ganske utvilsomt ikke i noget herred søndenfor Tromsø. Man maa gaa til østligere eller sydligere lande for at finde tilsvarende mørk befolkning. Vi har i Lyngen 2 fremmede elementer, nemlig lapper og kvæner. Det vil av denne tabel sees, at det er „lappene" som tilfører befolkningen her dens store procenttal av mørkøiede. Blandt samtlige lapper og lappebastarder i Troms fylke har jeg fundet kun 32,6 % blaaøiede, altsaa endnu betydelig færre end i Lyngen. Blandt kvænene derimot har jeg fundet 53,5 % blaaøiede. Disses tilstedeværen i Lyngen herred bidrar altsaa kun til at forøke antallet av blaaøiede.

Det fremgaar videre av samme tabel, at befolkningen i Lyngen herred har saa meget lappeblod i sig at der hvad øienfarven angaar, kun er en rent ubetydelig forskjel paa den del av befolkningen som kalder sig lapper, og paa den del som kalder sig norsk. Man kan vel herav dra den slutning, at de som kalder sig norske, har i tidligere slegtled været krydset med lapper. Det er kun de færreste som kjender sin avstamning mere end 2 generationer bakover.

Tabel 12.

Herredets navn	Antal under-sokte	Haartyper					Index	Procent av	
		1	2	3	4	5		lyshaarede 1. 2. 3	morkhaarede 4. 5
Kvæfjord	15	3	-	4	8	-	3,13	40,5	53,5
Harstad og Trondenes	58	13	1	22	19	3	2,96	62,0	38,0
Bjarkoy	8	3	-	1	4	-	2,75	50,0	50,0
Ibestad	41	12	1	9	15	4	2,95	53,5	46,5
Salangen	26	4	-	9	11	2	3,15	-	-
Bardu	13	3	2	5	3	.	2,61	77,0	23,0
Lavangen	17	5	-	5	7	-	2,82	59,0	41,0
Tranøy	41	12	-	20	9	-	2,63	78,0	22,0
Sorreisa	2	-	-	-	2	-	4,00	52,0	48,0
Dyroy	23	7	-	6	9	1	2,86		
Berg	8	-	-	3	4	1	3,75	37,5	62,5
Torsken	9	-	-	5	4	-	3,44	55,5	44,5
Lenvik	33	6	1	9	13	4	3,24	48,5	51,5
Hillesoy	5	1	-	2	1	1	3,20	60,0	40,0
Maalselv	23	5	1	11	4	2	2,86	74,0	26,0
Balsfjord	34	7	2	13	11	1	2,91	64,5	35,5
Malangen	28	8	-	11	8	1	2,78	68,0	32,0
Tromsoysund	46	9	1	19	14	3	3,02	63,0	37,0
Tromso	30	8	-	10	8	4	3,00	60,0	40,0
Sørfjord	14	2	-	4	8	-	3,28	43,0	57,0
Lyngen	72	15	-	22	27	8	3,18	51,5	48,5
Karlsøy	30	7	1	8	10	4	3,10	53,5	46,5
Helgøy	12	5	-	5	2	-	2,33	83,4	16,6
Skjervøy	55	15	-	15	20	5	3,00	54,5	45,5
Nordreisa	2	-	-	-	2	-	4,00	47,5	52,5
Kvænangen	17	5	-	4	5	3	3,05		
Antal		155	10	222	228	47	662		
Procent		23,4	1,5	33,4	34,5	7,2			

En nærmere undersokelse viser at i følgende distrikter er der særlig faa blaaoiede: Helgoy, Berg, Torsken, Hillesoy og Tromsøysund, Sørfjord, Lyngen og Karlsoy. Det er med andre ord en række ø- og kystdistrikter. Gjennemsnitlig er der i de her nævnte distrikter kun 45,6 % med blaa eller graa oine uten spor av brunt pigment. For at dette forhold skal kunne komme istand, maa den blaaoiede norske befolkning her være blit opblandet i meget stor utstrækning med en sterkt brunoiet befolkning. Vore norske fjeldlapper er efter de sidste foreliggende oplysninger om dem neppe i nogen utpræget grad brunoiede. Nogen paalidelig statistik foreligger desværre ikke.

Den bedste jeg kjender skriver sig fra MANTEGAZZA og SOMMIER. De opgir følgende:

Brunoiede . . . . 30 %.
Melerte oine . . . . 40 %.
Graa og blaa oine . . . . 30 %.

Her er altsaa ikke flere brunoiede end der nu findes blandt den blandede befolkning i Lyngen. Det synes da lite sandsynlig at befolkningen i Lyngen, hvorav ialfald hovedmassen tilhorer den nordiske race, kan ha faat sine sterkt pigmenterte oine fra lappene. Det synes ogsaa lite sandsynlig at det kan skyldes nogen indvandring fra Finland. Ti som det fremgaar av tabel 11, har selv det mest brunoiede landskap i Finland kun litt over 9 0/0 brunoiede. Og her har lappene i lange tider krydset sig med den finske befolkning, saa Westerlund mener, at det for en væsentlig del er gjennem denne krydsning at denne befolkning er blit saa brunoiet som den er. Men den er dog lite brunoiet i forhold til befolkningen i Lyngen.

Hvorfra befolkningen i Lyngen og de ovrige morkoiede herreder i Troms fylke har faat sine morke oine, faar da indtil videre bli et aapent sporsmaal.

2. Haarfarven.

Jeg regner i det folgende med kun 5 typer av haar:

Type 1 er blondt haar og svarer til Fischers .... 12—24
— 2 er rodt og svarer til Fischers 1 3
— 3 er lysebrunt og cendré og svarer til Fischers 7 samt 25 og 26
— 4 er morkebrunt og svarer til Fischers............... 5 og 6
— 5 er sort og svarer til Fischers.................... 4 og 27

Blandt samtlige undersokte fandtes 23,4 0/0 lyseblonde, 1,5 0/0 rodhaarede, 34,0 0/0 lysebrune, 33,9 0/0 med morkebrunt haar og 7,2 0/0 sorthaarede. Til sorthaarede er her medregnet baade de brunsorte og de blaasorte nuancer. Disse sidste forekommer dog her som ellers i Norge saa sparsomt at de omtrent kan sættes ut av betragtning. De allerfleste av de sorthaarede horer altsaa til Fischers type 4.

Tabel 13.

	I de 5 lyseste herreder	I det morkeste herred Lavangen	Gjennemsnit for hele fylket	Nidaros bispedomme	Sondre Sondmor	Nordre Østerdalen	Pohjanmaa i Finland
Blondt haar	27,5	20,8	23,4	22,3	13,3	27,1	13,32
Rodt haar	2,6	-	1,5	3,7	3,7	1,9	-
Lysebrunt haar	42,5	30,5	34,0	38,4	37,1	35,5	76,60
Morkebrunt haar	24,8	37,5	33,9	31,2	37,7	29,5	
(Brunt) Sort haar	2,6	11,2	7,2	4,3	8,1	6,0	9,21
Beddoes index	÷ 0,1	+ 39,1	+ 24,0	÷ 13,8	÷ 36,9	÷ 12,5	-
Lyshaarede	72,6	51,3	58,3	64,5	54,2	-	-
Morkhaarede	27,4	48,7	41,7	35,5	45,8	35,5	-

Der er dog med hensyn til haarfarven likesom med øienfarven stor forskjel paa de forskjellige herreder. Flest sorthaarede og mørkhaarede findes i følgende herreder: Berg, Torsken, Skjervøy, Lyngen, Sørfjord, Hillesøy, Lenvik, Salangen og Kvæfjord. De 5 med hensyn til haar lyseste herreder er Bjarkøy, Bardu, Tranøy, Maalselv og Malangen. Forskjellen mellem de lyseste og mørkeste herreder er, som det vil sees av tabel 13, meget stor.

Forholdet i de 5 lyseste herreder minder meget om forholdet i Nordre Østerdalen. Der er dog avgjort flere mørkhaarede i Nordre Østerdalen. Lyngen har overordentlig mange sorthaarede. Rødhaarede mangler helt i Lyngen og findes i det hele tat meget sparsomt i de mørkeste herreder. I Maalselv og Bardu er 3/4 av befolkningen lyshaaret og kun 1/4 mørkhaaret (FISCHERS 4, 5 og 6). Dette svarer temmelig præcis til hvad man finder i de lyseste herreder sydpaa, hvorfra befolkningen i disse herreder jo ogsaa er kommet for ca. 100 aar siden.

De distrikter hvis befolkning har mørkest haar, er i alt væsentlig de samme som fremviste de største antal brunøiede. Og at det skriver sig fra de i disse distrikter boende „lapper", er sikkert nok. Det eiendommelige er blot at der blandt disse „lapper" er saa mange sorthaarede. Ti derom synes alle som har undersøkt fjeldlappene, at være enige, at hovedmassen av disse er brunhaarede; for en meget væsentlig del har de endog lysebrunt haar (og rent sorthaarede fjeldlapper er utvilsomt sjeldne).

Hos voksne mænd over 15 aar opgir MANTEGAZZA og SOMMIER følgende:

Sort haar	3,4 %	18,7 %
Mørkebrunt haar ...	15,3 —	
Mellembrunt haar...	24,2 —	34,4 —
Lysebrunt haar	10,2 —	
Mørkeblondt haar...	15,3 —	47,8 —
Mellemblondt haar ..	20,4 —	
Lyseblondt haar....	12,1 —	

Sammenholder man disse tal med hvad jeg har fundet i de mørkeste herreder i Troms fylke, vil man straks forstaa at disse umulig kan ha faat sit mørke haar fra flytlappene. Og sammenholder man de samme tal med hvad WESTERLUND har fundet i de mørkeste landskap i Finland, blir det ogsaa klart at det heller ikke kan skyldes nogen invasion fra Finland.

Ogsaa for haarfarvens vedkommende faar det da indtil videre bli et aapent spørsmaal hvor den mørke befolkning i Troms fylke har faat sit mørke haar fra.

3. Pigmentindex.

For at faa et sikrere holdepunkt for bedømmelsen av pigmenteringsgraden i de forskjellige herreder har jeg gaat frem saaledes: Jeg har i hvert enkelt herred multiplicert antallet av sorthaarede med 5, mørkebrunthaarede med 4, lysebrunthaarede med 3, rødhaarede med 2 og blondhaarede med 1. De derved fremkomne tal er summert sammen og dividert med de samlede antal undersøkte i herredet. Det derved fremkomne tal har jeg kaldt haarfarveindex.

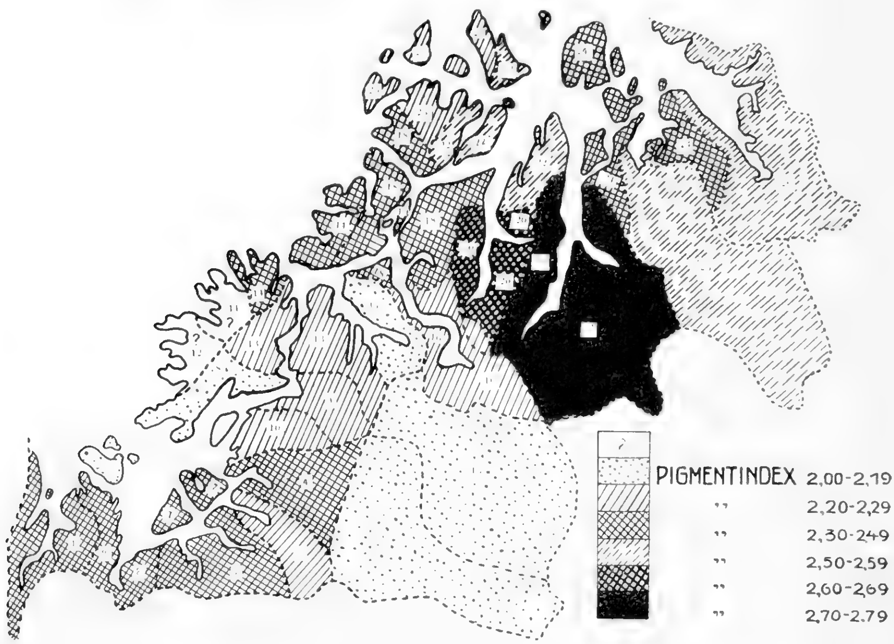


Fig. 5. Kart over pigmentindex.

1. Kvæfjord 2,46.
2. Trondenes og Harstad 2,32.
3. Bjarkøy 2,12.
4. Salangen 2,47.
5. Bardu 2,00.
6. Lavangen 2,29.
7. Ibestad 2,37.
8. Tranøy 2,04.
9. Sørreisa } 2,23.
10. Dyrøy }
11. Berg } 2,91.
12. Torsken }
13. Lenvik 2,26.
14. Hillesøy 2,41.
15. Maalselv 2,19.
16. Balsfjord 2,25.
17. Malangen 2,05.
18. Tromsøysund 2,38.
19. Tromsø 2,46.
20. Sørfjord 2,60.
21. Lyngen 2,75.
22. Karlsøy 2,56.
23. Helgøy 2,25.
24. Skjervøy 2,35.
25. Nordreisa } 2,54.
26. Kvænangen }

Paa samme maate har jeg gaat frem for at finde øienfarveindex. Mørkebrunøiet faar 5 point, lysebrunøiet 4 point, mørkt melerte øine faar 3 point, lyst melerte øine 2 point og blaa eller graa øine 1 point. Middeltallet av den for herredet fundne haarfarveindex og øienfarveindex har jeg benævnt pigmentindex. I de lyseste herreder blir pigmentindex omkring 2,00, i de mørkeste herreder omkring 2,80.

Det omstaaende kart gir en fremstilling av hvorledes pigmentindex forholder sig i hele fylket. Der er et lyst utstraalingscentrum i Bardu og Maalselv og et mørkt utstraalingscentrum i Lyngen. Pigmenteringsgraden synes hovedsagelig at være avhængig av om der i bygdens befolkning indgaar lapper. Jo flere lapper des sterkere pigmentering.

Blandt de av mig undersøkte fra Helgøy var der angivelig ingen fremmed indblanding, hverken av lapper eller kvæner. Og som man vil se, er distriktet meget lyst til trods for at der paa de samme øer er andre meget mørke herreder beroende paa en relativ sterk lappeindblanding (Karlsøy).

IV. Hodet.

1. Hodets største længde.

Hodets længde varierer mellem 17,0 og 21,3 cm. Middellængden er 19,28 cm. Kurvens nedadgaaende ben er, som det vil sees, relativt jevnt,

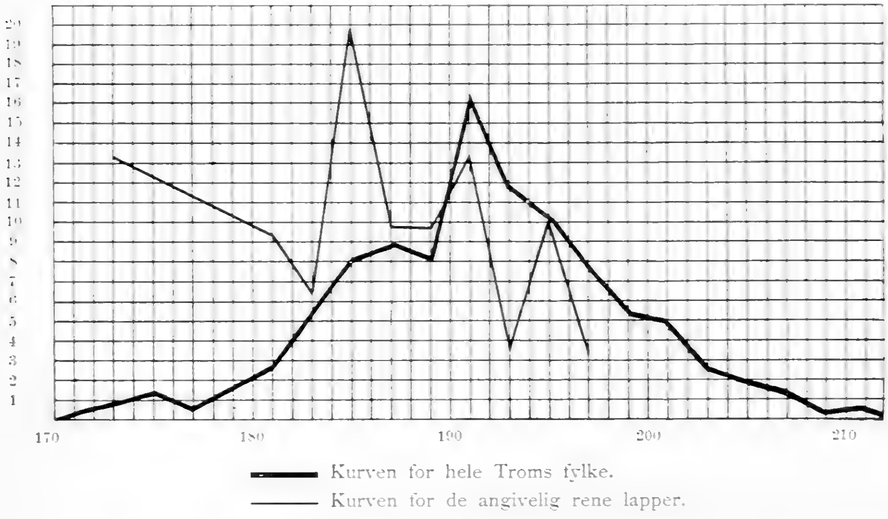


Fig. 6. Grafisk fremstilling av hodets største længde.

medens det opadstigende ben er meget ujevnt. Kurven har *en* tydelig spids ved 19,1 cm. I de enkelte herreder veksler middellængden fra 18,5 til 19,4 cm.

Undersøker jeg saa middellængden hos de forskjellige etniske grupper inden fylket, finder jeg følgende:

Kvæner	19,5 cm.
Norske	19,4 —
Lapper	18,5 —

Tabel 14. Hodets største længde for

	168 169	170 171	172 173	174 175	176 177	178 179	180 181	182 183	184 185	186 187	188 189	190 191
Kvæfjord	-	-	-	-	-	-	-	1	1	2	-	3
Harstad og Trondenes	-	-	-	3	1	-	-	2	-	3	3	16
Bjarkøy	-	-	-	-	-	-	1	1	-	-	-	-
Salangen	-	-	-	-	1	-	-	2	4	7	-	2
Bardu	-	-	-	-	-	-	-	-	-	1	-	3
Ibestad	-	-	-	-	-	1	-	1	1	5	2	6
Lavangen	-	1	-	-	-	1	2	2	-	3	3	-
Tranøy	-	-	-	-	-	3	2	1	3	1	4	3
Sørreisa	-	-	-	-	-	-	-	1	-	-	-	-
Dyrøy	-	-	-	1	-	-	-	5	3	1	2	3
Berg	-	-	-	-	-	-	-	1	1	1	1	-
Torsken	-	-	-	-	-	1	-	-	1	2	1	1
Lenvik	-	-	-	-	-	-	1	1	-	4	1	7
Hillesøy	-	-	-	-	-	-	-	-	-	-	1	-
Maalselv	-	-	-	-	-	-	-	-	1	4	1	3
Balsfjord	-	-	-	-	-	-	-	2	1	3	3	4
Malangen	-	-	-	1	-	1	-	3	4	1	1	6
Tromsøysund	-	-	1	-	-	1	-	2	8	6	1	5
Tromsø	-	-	-	-	-	1	1	-	3	3	1	4
Sørfjord	-	-	-	1	-	-	1	-	1	-	1	2
Lyngen	-	-	-	-	1	-	1	-	3	-	5	9
Karlsøy	-	-	-	-	-	-	1	-	4	3	5	3
Helgøy	-	-	-	-	-	-	2	1	-	-	5	1
Skjervøy	-	-	-	1	1	-	1	1	1	2	2	9
Nordreisa	-	-	-	-	-	-	-	-	-	-	1	-
Kvænangen	-	-	-	-	-	-	-	1	-	-	-	-
		1	-	7	4	9	13	28	40	52	44	80
Lapper	-	-	4	-	-	-	3	2	6	3	3	4
Kvæner	-	-	1	-	-	1	-	1	2	1	2	3
Lap × kvæn	-	-	-	-	-	-	-	2	2	-	1	1
Lap × norsk	-	-	-	1	-	-	1	1	3	-	4	6
Kvæn × norsk	-	-	-	-	-	1	1	3	1	3	-	4
		1	5	8	4	11	18	37	54	50	54	108

Det er ikke mulig at faa istand nogen sikker kurve for lappenes vedkommende. Dertil er de for faa i antal. Men saa meget kan man dog se av fig. 6, at lappenes kurve maa ligge ganske betydelig tilvenstre for nordmændenes; tydelig fremgaar dette av tab. 15, kol. 7 og 8.

Det fremgaar av denne tabel, at medens der blandt de rent norske er 48,3 % som har et hode længere end 191 mm., saa er dette kun tilfældet med 16,5 % av de undersøkte lapper. Hos de norske utgjør hodets længde 11,43 % av legemshøiden, hos lappene 11,13. For den norske befolknings vedkommende stemmer dette tal noiagtig med hvad jeg har fundet i Trøndelagen (se Anthropologia nidarosiensis, pag. 84). Jeg har som sagt paavist at hos den norske befolkning er hodets længde i høi grad avhængig av legemshøiden.

samtlige distrikter, ordnet i serier.

192 193	194 195	196 197	198 199	200 201	202 203	204 205	206 207	208 209	210 211	212 213	214 215	216 217	218
-	3	2	2	-	-	-	1	-	-	-	-	-	-
4	3	6	3	5	1	2	2	1	-	-	-	-	-
2	2	1	-	1	-	-	-	-	-	-	-	-	-
1	2	-	1	1	1	-	-	-	-	-	-	-	-
3	3	2	-	1	-	1	-	-	-	-	-	-	-
6	5	2	1	2	1	-	2	-	-	-	-	-	-
2	1	-	-	-	-	-	-	-	-	-	-	-	-
5	5	5	2	5	-	1	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-
1	2	2	1	1	1	-	-	-	-	-	-	-	-
-	1	1	-	1	1	-	-	-	-	-	-	-	-
1	2	-	-	-	-	-	-	-	-	-	-	-	-
4	3	2	4	3	1	-	-	-	-	-	-	-	-
-	2	1	-	-	-	-	-	-	-	-	-	-	-
-	4	3	2	2	1	1	-	1	-	-	-	-	-
9	4	2	2	-	2	1	-	-	1	-	-	-	-
3	1	1	2	2	-	1	-	-	-	-	-	-	-
6	6	4	3	-	1	-	-	1	-	-	-	-	-
4	3	2	5	1	1	-	1	-	-	-	-	-	-
1	3	1	-	1	-	-	-	-	-	-	-	-	-
3	5	3	1	2	1	-	-	-	-	1	-	-	-
3	-	3	-	-	2	1	-	-	-	-	-	-	-
1	-	1	-	-	1	-	-	-	-	-	-	-	-
4	1	2	1	2	-	2	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	1	-	-	-	-	-	-	-	-	-	-
67	60	46	31	30	15	11	6	3	1	1	-	-	= 559
1	3	1	-	-	-	-	-	-	-	-	-	-	= 30
3	1	-	1	1	-	-	-	-	-	-	-	-	= 17
-	2	-	-	-	-	-	-		-	-	-	-	= 8
3	1	2	-	-	-	1	-	-	-	-	-	-	= 22
5	1	2	2	1	-	-	1	1	-	-	-	-	= 26
79	68	51	34	32	15	12	7	4	1	1	-	-	= 662

Hos den norske befolkning av 164 cm. høide er hodets største længde 19,19 cm. eller 11,71 % av legemshøiden, idet hodets længde altid er relativt større hos smaa folk end hos høie folk.

For de norske kvæners vedkommende vil det av tabel 15, kolonne 9 og 10 sees, at der er fuld overensstemmelse med hvad Westerlund har fundet hos de finske kvæner. Hos 36,6 % av de norske og 37,4 % av de finske kvæner ligger hodets længde mellem 18,6 og 19,1 cm. Hos 36,6 % norske og 38,8 % finske kvæner er hodets længde større og hos 27,5 % norske og 33,8 % finske kvæner er hodets længde under 18,6 cm. De finske kvæner har litt længere hode end nordmændene, og det samme er tilfældet med de norske kvæner.

Tabel 15. Hodets største længde.

1	2	3	4	5	6	7	8	9	10
	I Troms fylke	Angivelig rent norske i Troms fylke	Angivelig rene lapper i Troms fylke	Angivelig rene kvæner i Troms fylke	I Troms fylke	Angivelig rent norske i Troms fylke	Angivelig rene lapper i Troms fylke	Angivelig rene kvæner i Troms fylke	Kvæner i Finland efter Westerlund
168—169	-	-	-	-					
170—171	0,15	0,18	-	-	0,8	0,2	13,2	3,0	1,0
172—173	0,7	-	13,2	3,0					
174—175	1,2	1,2	-	-					
176—177	0,6	0,7	-	-	3,5	3,3	-	6,1	7,3
178—179	1,7	1,4	-	6,1					
180—181	2,7	2,4	9,9	-					
182—183	5,5	5,0	6,6	6,1	16,3	14,6	36,3	18,3	25,5
184—185	8,1	7,2	19,8	12,2					
186—187	8,8	9,3	9,9	6,1					
188—189	8,1	7,9	9,9	12,2	33,1	31,4	33,0	36,6	37,4
190—191	16,2	14,2	13,2	18,3	a				b
192—193	11,8	11,8	3,3	18,3					
194—195	10,2	10,7	9,9	6,1	29,7	30,7	16,5	24,4	20,9
196—197	7,7	8,2	3,3	-					
198—199	5,1	5,6	-	6,1					
200—201	4,8	5,4	-	6,1	12,2	13,7	-	12,2	5,9
202—203	2,3	2,7	-	-					
204—205	1,8	2,0	-	-					
206—207	1,1	1,1	-	-	3,5	3,6	-	-	1,0
208—209	0,6	0,5	-	-					
210—211	0,15	0,18	-	-	0,3	0,3	-	-	1,0
212—213	0,15	0,18	-	-					

2. Hodets største bredde.

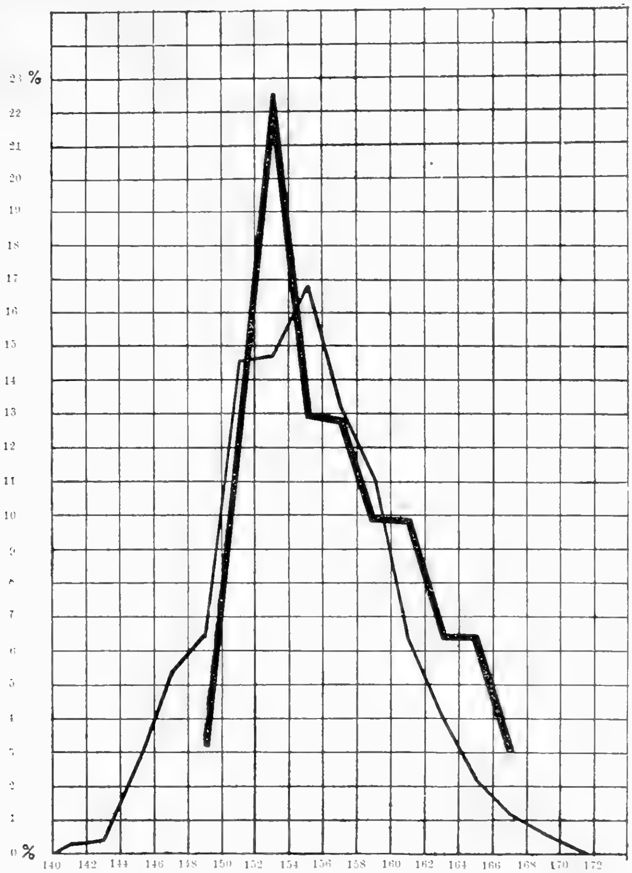
Hodets største bredde varierer fra 14,0 til 17,1 cm. Middelbredden er 15,41 cm. Det er en for norske forhold svær hodebredde, som utvilsomt beror paa den store tilblanding av lapper, og sandsynligvis bidrar ogsaa kvænene endel.

Hos lappene har jeg fundet at hodets bredde gjennemsnitlig er 15,6 cm., hos kvænene 15,4 cm. Kurven har en ganske utpræget spids ved 15,5 og en mindre ved 15,1. Den samler et meget stort antal individer fra størrelsen 15,0 til 15,7 cm. Av samtlige 662 har ikke mindre end 388 (= 57,5 %) en bredde som ligger mellem de nævnte tal.

Hos de finske kvæner samler de samme tal ifølge Westerlund 54,7 %, medens man i Norges sydligere amter som regel finder adskillig færre — saaledes til eks. i Bratsberg amt 49,5 %. Det gir straks et fingerpek om at hodebredden i fylket er overmaade stor.

3. Index cephalicus.

Betydelig større interesse end hodets enkeltmaal har forholdstallet mellem dem: index cephalicus. Dennes gjennemsnitlige størrelse i hele



——— for samtlige undersokte. ▬▬▬ For de angivelig rene lapper.

Fig. 7. Kurve for hodets største bredde i Troms fylke.

fylket er 80,77. Det er præcis samme middelindex som til eks. i Søndre Søndmøre *sorenskriveri*. Men det er meget faa fylker som har en saa høi index.

For Trøndelagens fylke er den saaledes kun 78,0. Der er i denne henseende ikke saa liten forskjel paa de forskjellige herreder (se fig. 8). Lavest er index i de to herreder Bardu og Maalselv med en index paa henholdsvis 79,3 og 79,1. Av de fra Bardu undersøkte kunde 55 % oplyse at deres forfædre var indflyttet til Bardu fra Gudbrandsdalen. Av de fra Maalselv undersøkte kunde ca. 20 % meddele at deres slegt skrev sig fra Østerdalen og 10 % fra Gudbrandsdalen.

I det hele tat er der, som allerede før nævnt, kun faa herreder i Troms fylke hvor ikke en større eller mindre del av bygdens befolkning kan skrive sin herkomst fra disse sydnorske store dalfører. Og dette har utvilsomt en meget stor indflydelse paa størrelsen av index cephalicus. Jo flere indflyttede Østerdølinger eller Gudbrandsdølinger, des lavere er index cephalicus. I motsat retning virker lappene. Jo flere lapper, des høiere index.

Tabel 16.

	132 133	134 135	136 137	138 139	140 141	142 143	144 145	146 147	148 149
Kvæfjord	-	-	-	-	-	-	-	1	-
Harstad og Trondenes	-	-	-	-	-	-	1	2	6
Bjarkøy	-	-	-	-	-	-	-	-	-
Salangen	-	-	-	-	-	1	1	-	2
Bardu	-	-	-	-	-	-	-	-	1
Lavangen	-	-	-	-	-	-	1	2	2
Ibestad	-	-	-	-	-	-	-	2	3
Tranøy	-	-	-	-	-	1	1	1	2
Sørreisa	-	-	-	-	-	-	-	-	-
Dyrøy	-	-	-	-	-	-	4	3	3
Berg	-	-	-	-	-	-	-	1	-
Torsken	-	-	-	-	-	-	1	1	1
Lenvik	-	-	-	-	-	-	2	3	2
Hillesøy	-	-	-	-	-	-	-	-	-
Maalselv	-	-	-	-	-	-	-	2	1
Balsfjord	-	-	-	-	1	-	-	1	1
Malangen	-	-	-	-	-	-	1	3	3
Tromsøysund	-	-	-	-	-	-	3	3	2
Tromsø	-	-	-	-	-	1	1	2	1
Sørfjord	-	-	-	-	-	-	-	-	-
Lyngen	-	-	-	-	-	-	-	1	2
Karlsøy	-	-	-	-	-	-	-	1	3
Helgøy	-	-	-	-	-	-	-	1	2
Skjervøy	-	-	-	-	-	-	-	3	3
Nordreisa	-	-	-	-	-	-	-	-	-
Kvænangen	-	-	-	-	-	-	-	-	-
	-	-	-	-	1	3	16	33	40
Lapper	-	-	-	-	-	-	-	-	1
Kvæner	-	-	-	-	1	-	-	-	1
Lapper × kvæner	-	-	-	-	-	-	-	1	1
Lapper × norske	-	-	-	-	-	-	1	-	1
Kvæner × norske	-	-	-	-	-	-	1	2	-
					2	3	18	36	44

Tabel 17. Hodets største bredde.

Hodets største bredde	0/0 i Troms fylke	Lapper i Troms fylke
140—141	0,3	-
142—143	0,4	-
144—145	2,6	-
146—147	5,4	-
148—149	6,5	3,2
150—151	14,5	12,9
152—153	14,7	22,5
154—155	16,8	12,9
156—157	13,2	12,9
158—159	11,0	9,7
160—161	6,4	9,7
162—163	4,1	6,5
164—165	2,2	6,5
166—167	1,2	3,2
168—169	0,6	-
170—171	0,1	-

Hodets bredde.

150 151	152- 153	154 155	156 157	158 159	160 161	162 163	164- 165	166 167	168 169	170 171	172 173
1	1	3	2	4	1	1	-	1	-	-	-
8	6	8	11	5	2	4	-	1	1	-	-
1	1	1	2	1	1	-	-	-	-	-	-
2	5	2	3	3	1	1	-	-	-	-	-
4	1	2	3	1	1	-	-	-	-	-	-
3	4	1	-	1	-	-	1	-	-	-	-
2	1	6	7	4	3	2	4	-	1	-	-
8	10	4	3	3	3	2	2	-	-	-	-
1	1	-	-	-	-	-	-	-	-	-	-
2	2	2	3	3	1	-	-	-	-	-	-
1	-	2	1	1	1	-	1	-	-	-	-
-	1	1	-	2	1	1	-	-	-	-	-
4	4	3	6	4	1	3	-	-	-	-	-
-	2	1	-	1	-	-	-	-	-	-	-
2	6	5	2	2	2	1	-	-	-	-	-
5	6	7	5	4	-	1	1	1	-	-	-
4	2	3	4	3	3	-	-	2	-	-	-
8	4	10	5	5	4	-	1	-	-	-	-
6	4	7	-	2	4	2	-	1	-	-	-
4	3	1	1	-	-	1	-	-	2	-	-
3	3	4	8	8	3	2	-	-	-	1	-
5	1	3	5	2	2	2	1	-	-	-	-
1	3	1	1	3	-	-	-	-	-	-	-
4	6	9	1	1	1	1	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	1	1	-	-	1	-	-	-	-
82	77	86	74	64	35	24	12	6	4	1	-
4	7	4	4	3	3	2	2	1	-	-	-
1	4	3	3	3	-	-	1	-	1	-	-
-	3	1	1	-	-	-	-	-	-	-	-
4	3	5	3	3	2	-	-	-	-	-	-
5	4	7	3	-	2	1	-	1	-	-	-
96	98	106	88	73	42	27	15	8	5	-	-

Hoiest index har jeg fundet i herredene Salangen, Lavangen, Lyngen, Sørfjord og Tórsken. Hvad Torsken angaar, saa er de undersøktes antal saa lite at jeg indtil videre vil sætte et spørsmaalstegn ved de for dette herred fundne middeltal. Det samme gjælder Berg herred. Men for de andre herreder er antallet saa stort at jeg tor anse de fundne middeltal for ialfald tilnærmelsesvis rigtige.

I disse 4 herreder er middelværdien av cephalindex omkring 82. I alle disse herreder utgjør imidlertid lappene en ganske stor del av befolkningen. Og gjennem indgifte med den norske befolkning har ogsaa denne for en god del lappeblod i sine aarer. Dette er utvilsomt hovedaarsaken til den høie cephalindex i disse 4 herreder.

Nogen særlig liten index findes ikke i noget herred. I Østerdalen, Gudbrandsdalen og Trøndelagen vil man ialfald støte paa endel herreder med en saa liten index som 76 à 77. Dette er altsaa ikke tilfældet i Troms fylke. I saa henseende minder dette fylke om forholdene paa Vestlandet og Sørlandet.

Tabel 18. Cephalindexene ordnet

	67	68	69	70	71	72	73	74	75	76	77	78
Kvæfjord	-	-	-	-	-	-	-	-	-	-	1	-
Harstad og Trondenes	-	-	-	-	-	-	-	1	3	4	9	3
Bjarkoy	-	-	-	-	-	-	-	-	-	-	1	-
Ibestad	-	-	-	-	-	-	-	-	-	2	1	5
Salangen	-	-	-	-	-	-	-	-	1	-	-	1
Bardu	-	-	-	-	-	-	-	-	1	3	1	-
Lavangen	-	-	-	-	-	-	-	-	1	1	-	2
Tranøy	1	-	-	-	-	-	-	2	-	5	3	5
Sørreisa	-	-	-	-	-	-	-	-	-	-	-	1
Dyrøy	-	-	-	-	-	-	-	-	2	1	4	3
Berg	-	-	-	-	-	-	-	-	1	-	-	1
Torsken	-	-	-	-	-	-	-	-	-	1	1	1
Lenvik	-	-	-	-	-	-	-	3	2	1	3	2
Hillesøy	-	-	-	-	-	-	-	-	-	-	-	1
Maalselv	-	-	-	-	-	-	-	1	2	3	1	2
Balsfjord	-	-	-	-	-	-	-	-	-	4	4	4
Malangen	-	-	-	-	-	-	1	2	-	2	2	2
Tromsøysund	-	-	-	-	-	-	-	2	2	2	2	2
Tromsø	-	-	-	-	-	-	-	2	3	3	3	4
Sørfjord	-	-	-	-	-	-	-	-	1	-	3	-
Lyngen	-	-	-	-	-	-	-	-	1	3	3	6
Karlsøy	-	-	-	-	-	-	1	-	-	-	1	4
Helgøy	-	-	-	-	-	-	-	-	-	-	3	1
Skjervøy	-	-	-	-	-	-	1	1	1	1	7	7
Nordreisa	-	-	-	-	-	-	-	-	-	-	-	-
Kvænangen	-	-	-	-	-	-	-	-	-	-	-	2
Antal	1	-	-	-	-	-	3	14	21	36	53	59
Procent	0,15	-	-	-	-	-	0,45	1,66	3,17	5,43	8,00	8,91

Kurven for index cephalicus har, som det vil sees av fig. 9, en tydelig spids ved index 80. Paa det opadstigende ben finder man en liten knæk i kurven ved index 77. Paa det nedadgaaende ben finder man to tydelige spidser, en ved index 84 og en ved index 87. At denne sidste er fremkaldt av lappene, behøver man her ikke at være i tvil om. Tar man ut av serien de rene lapper samt de som er av lappisk herkomst, forsvinder denne spids helt. Spidsen ved index 83 svarer helt til hvad man ogsaa ofte ellers finder i Norge.

Spidsen ved index 80 antar jeg er den samme som man ellers som regel finder ved index 78, men som her er trukket længere mot hoire paa grund av de mange brachycephale elementer som indgaar i denne befolkning. Den samme forrykning av denne spids finder man ogsaa i andre fylker med en sterkt brachycephal befolkning. Til sammenligning har jeg efter Arbo paa fig. 9 antegnet kurven for Jæderens sterkt brachycephale befolkning. Sammenligner man de to kurver, vil man straks se at befolkningen i Troms fylke er ganske anderledes sterkt dolicho-mesocephal end Jæderens befolkning.

Hele den befolkning, som befinder sig indenfor det omraade som markeres ved bogstavene a—b—c—d, mangler helt i Troms fylke. Middel-i serier for hver hel index.

79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	
1	7	2	-	3	-	-	1	-	-	-	-	-	-	-	15
6	6	6	3	1	3	2	1	3	3	3	-	1	-	-	58
1	3	1	-	-	2	-	-	-	-	-	-	-	-	-	8
4	5	5	2	6	6	-	1	2	-	2	-	-	-	-	41
5	4	1	2	4	3	2	1	-	1	-	1	-	-	-	26
3	1	3	-	-	1	-	-	-	-	-	-	-	-	-	13
2	2	1	2	-	2	2	-	1	1	-	-	-	-	-	17
2	5	5	5	4	2	3	-	-	-	-	-	-	-	-	41
-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2
1	5	2	-	-	2	2	1	-	-	-	-	-	-	-	23
2	-	-	1	-	1	1	-	1	-	-	-	-	-	-	8
-	-	2	-	1	-	1	1	-	1	-	-	-	-	-	9
8	1	6	3	1	1	1	-	1	-	-	-	-	-	-	33
2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	5
5	3	4	2	-	-	-	-	-	-	-	-	-	-	-	23
4	4	3	3	4	2	2	-	-	-	-	-	-	-	-	34
4	1	3	3	2	2	4	-	1	-	-	-	-	-	-	28
9	7	3	5	2	6	-	1	2	1	-	-	-	-	-	46
1	3	5	1	2	2	1	-	-	-	-	1	-	-	-	30
-	3	1	1	2	-	-	1	1	-	1	-	-	-	-	14
5	10	9	9	11	5	1	4	2	-	1	-	1	-	1	72
3	4	6	2	4	2	-	1	1	1	-	-	-	-	-	30
1	2	1	2	-	-	-	1	1	-	-	-	-	-	-	12
5	6	11	4	5	2	-	2	1	1	-	-	-	-	-	55
1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
4	3	2	2	2	-	2	-	-	-	-	-	-	-	-	17
79	88	82	52	55	44	24	16	17	9	7	2	2	-	1	662
11,93	13,29	12,38	7,85	8,30	6,64	3,62	2,41	2,57	1,36	1,06		0,30		0,15	

indexen for disse er 77,7, og hovedmassen av dem tilhorer utvilsomt den nordiske race. Disse er i Jæderens sorenskriveri erstattet med den befolkning som er markeret ved omraadet d—e—f, og hvis middelindex er 84,7. Allerede herav kan man slutte sig til at befolkningen i Troms fylke er en betydelig mere nordisk race end befolkningen paa Jæderen.

Naar jeg beregner middelindexen særskilt for norske lapper og kvæner (finner), da finder jeg følgende middeltal:

Lapper (30)	84,3
Kvæner (17)	78,9
Norske fra Troms fylke (100)	79,3
Lapper × norske (22)	81,1
Kvæner × norske (26)	80,6
Lapper × kvæner (8)	81,9

Den lave index for kvænene (finnene) forbauset mig. Hvor den ene av forældrene er norsk, den anden kvæn, er imidlertid ogsaa cephalindex lav. Ifølge Westerlund er index cephalicus hos de egentlige finner 79,4. Hos karelene har han derimot fundet en betydelig høiere index, 82,2. Nu er jo forholdet med vore norske kvæner det, at de selv kun har lite rede

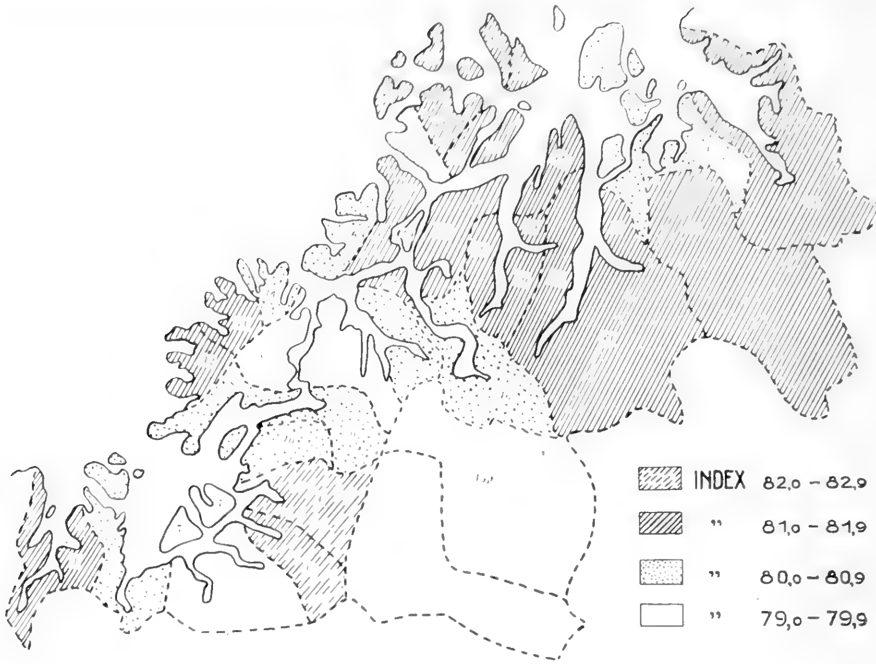


Fig. 8. Kart over index cephalicus.

1. Kvæfjord.
2. Trondenes.
3. Bjarkoy.
4. Salangen.
5. Bardu.
6. Lavangen.
7. Ibestad.
8. Tranøy.
9. Sørreisa.
10. Dyrøy.
11. Berg.
12. Torsken.
13. Lenvik.
14. Hillesøy.
15. Maalselv.
16. Balsfjord.
17. Malangen.
18. Tromsoysund.
19. Tromsø.
20. Sørfjord.
21. Lyngen.
22. Karlsøy.
23. Helgøy.
24. Skjervøy.
25. Nordreisa.
26. Kvænangen.

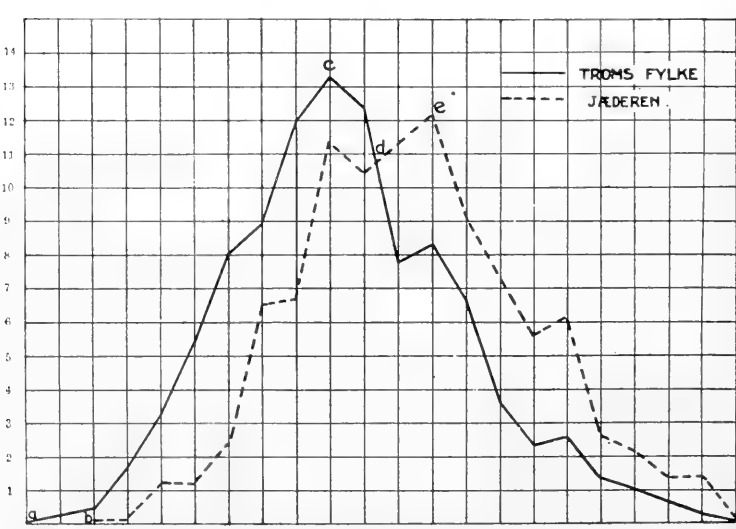


Fig. 9. Kurve for index cephalicus i Troms fylke.

Tabel 19.

		Antal					Procent		
		D.	M.	Br.	H. B.	U. B.	D.	M.	B.
		67,0—75,9	76,0 80,0	81,0 85,2	86,0 90,2	91,0 95,9	67,0 75,0	76,0 80,0	81
Kvæfjord	15	-	9	5	1	-	-	60,0	40,0
Harstad og Trondenes	58	4	28	15	10	1	6,9	48,3	44,8
Bjarkøy	8	-	5	3	-	-	-	62,5	37,5
Salangen	26	1	10	12	3	-	3,85	38,5	57,7
Bardu	13	1	8	4	-	-	7,7	61,5	30,8
Lavangen	17	1	7	7	2	-	5,9	41,1	53,0
Ibestad	41	-	17	19	5	-	-	41,5	58,5
Tranøy	41	2	20	19	-	-	4,88	48,8	46,4
Sørreisa	2	-	1	1	-	-	8,0	60,0	32,0
Dyrøy	23	2	14	6	1	-	8,0	61,6	30,4
Berg	8	1	3	3	1	-	12,5	37,5	50,0
Torsken	9	-	3	4	2	-	-	33,4	66,6
Lenvik	33	5	15	12	1	-	15,1	45,5	39,4
Hillesøy	5	-	5	-	-	-	-	100,0	-
Maalselven	23	3	14	6	-	-	13,0	61,0	26,0
Balsfjord	34	-	20	14	-	-	-	58,9	41,1
Malangen	28	2	11	14	1	-	7,15	39,3	53,6
Tromsøysund	46	4	22	16	4	-	8,7	47,8	43,5
Tromsø	30	4	14	11	1	-	13,4	46,6	40,0
Sørfjord	14	1	6	4	3	-	7,15	42,9	50,0
Lyngen	72	1	27	35	7	2	1,4	37,5	61,1
Karlsøy	30	1	12	14	3	-	3,2	40,0	56,8
Helgøy	12	-	7	3	2	-	-	58,4	41,6
Skjervøy	55	3	26	22	4	-	5,45	47,3	47,3
Nordreisa	2	-	2	-	-	-	-	-	-
Kvænangen	17	-	9	8	-	-	-	53,0	47,0
Antal	662	39	316	256	51	3			
Procent		5,8	47,4	38,9	7,7	0,6			

paa fra hvilken del av Finland de skriver sig. Ialfald kunde jeg saa godt som aldrig faa sikre oplysninger herom. Den av mig fundne lave index kan da tyde paa at de norske kvæner for en del er vestfinner. Herpaa tyder ogsaa den av mig fundne relativt store legemshøide hos de norske finner.

Ifølge WESTERLUND har vestfinnene nemlig en betydelig større legemshøide og lavere cephalindex end de finske kvæner og kareler. Saa meget synes at være sikkert, at „kvænene“ ikke i nogen som helst nævneværdig grad har bidrat til at forøke brachycephalien i Troms fylke.

Blandt samtlige undersøkte fandtes av

Dolichocephaler (66,0—75,9)	5,4 %
Mesocephaler (76,0—80,9)	47,4 %
Brachycephaler (81,0—85,9)	38,9 %
Hyperbrachycephaler (86,0—90,9) ...	7,7 %
Ultrabrachycephaler (91,0—95,9)	0,6 %

Paa vedføiede tabel har jeg til sammenligning anført hvorledes forholdet er i nogen andre norske distrikter.

Tabel 20 a.

	Dolichocephaler	Mesocephaler	Brachycephaler	Hyperbrachycephaler	Ultrabrachycephaler
a. Troms fylke	5,4	47,4	38,9	7,7	0,6
b. Lapper i Troms fylke	-	19,4	44,0	34,2	2,4
c. Troms fylke med fradrag av lappene	5,8	49,5	38,8	6,0	0,3
d. Jæderen	1,4	17,1	61,1	17,8	1,6
e. Selbu	7,0	51,3	37,1	4,6	-
f. Tydalen	34,4	53,0	12,6	-	-
g. Lyngen herred	1,4	37,5	48,5	9,8	2,8

Som det vil sees av denne tabel, svarer forholdet i Troms fylke nogenlunde nær til forholdene i Selbu, naar man ikke medtar i beregningen lappene. Men selvfølgelig lar det sig ikke gjøre helt at eliminere lappenes indflydelse. Som allerede nævnt har de gjennem generationer giftet sig ind i den norske befolkning, og en hel del av de angivelig norske har nok en god del lappeblod i sine aarer. Men ogsaa i Selbu har man mistanke om at der flyter ikke saa lite lappeblod i den nulevende befolknings aarer, og det har da sin interesse at se likheten mellem de to distrikter i den her omhandlede henseende.

Men det er paa den anden side et meget langt sprang mellem Troms fylke og Jæderen. Jæderen svarer med hensyn til graden av brachycephali omtrent til hvad tilfældet er hos de nulevende lapper i Troms fylke.

MANTEGAZZA og SOMMIER fandt hos fjeldlappene at cephalindex gjennemsnitlig var noget over 87. Den laveste index de fandt hos nogen voksen mandlig lap, var 82, og den høieste var 95. Av de 56 voksne mænd som deres serie omfatter, hadde 32 en index paa 88 eller høiere og kun 23 en index paa 87 eller derunder. Sammenholder man disse tal med hvad jeg har fundet i Troms fylke, og med hvad der ellers er fundet i de mest brachycephale distrikter i Norge, vil man finde følgende: Fra Troms fylke har jeg i alt 21 mand med en index høiere end 88,0, det blir i alt 2,7 % av samtlige undersøkte.

I de sterkeste brachycephale Vestlands-distrikter, til eks. i Møre fylke, hvor man ikke vet av nogen tilblanding av lapper i historisk tid, har jeg kun fundet 0,5 % med en index 88,0 eller høiere. Differensen mellem disse to tal kan man vel da med tryghet tilskrive lappenes indflydelse i Troms fylke; det utgjør i alt 2,2 %. I MANTEGAZZAS serie hadde, som nævnt, kun 23 mand en index høiere end 88,0. For Troms fylkes vedkommende skulde dette utgjøre litt under 2 %, og jeg kommer da til det resultat, at omtrent 4 % av de av mig undersøkte har en cephalindex som skyldes arv fra lappene.

Men disse tal svarer selvfølgelig lite til det oprindelige forhold mellem typene. Man maa jo ta i betragtning at hyperbrachycephali efter al sandsynlighet dominerer over brachycephali, som igjen dominerer over dolichomesocephali. — Der maa da blandt disse phænotypiske brachycephaler og hyperbrachycephaler være en god del heterozygoter. Den dolicho-mesocephale gruppe har derfor været betydelig større end det fremgaar av denne beregning. Og et tilsvarende fradrag maa der da gjøres i de to andre gruppers størrelse. Dette spørsmaal vil jeg nærmere behandle i et følgende avsnit.

4. Legemshøidens forhold til hodets dimensioner.

Jeg har i Anthropologia nidarosiensis paavist at forholdet mellem hodets dimensioner og legemshøiden ikke er noget fast og uforanderligt forhold. Inden en relativt ren norsk befolkning kan man paavise at hodets længde ganske vist tiltar med legemshøiden, men ikke proportionalt med denne. Smaa folk har derfor et relativt længere hode end høie folk. Hos mænd av 160 cm. høide utgjør hodets længde gjennemsnitlig 11,91 % av legemshøiden. Hos mænd av over 190 cm. høide utgjør derimot hodets længde bare 10,37 % av legemshøiden. Hvis jeg nu undersøker hvorledes befolkningen i Troms fylke forholder sig i denne henseende, da vil jeg begynde med at gjøre rede for forholdet hos *lappene*. Nu har man desværre ingen høie lapper. De høieste lapper som jeg har kunnet skaffe nogenlunde sikre gjennemsnitstal for, har en høide paa 169 cm. Hos disse finder jeg at hodets gjennemsnitlige længde er 18,40 cm. Hos en rent norsk befolkning av denne høide fandt jeg i Trøndelagen at hodets længde var betydelig større, nemlig 19,29. Herav fremgaar da tydelig nok at det ikke er legemshøiden som er den væsentlige faktor ved bestemmelsen av hodets længde. Det er en utpræget raceeiendommelighet. Hos lappene av 169 cm. høide svarer hodets længde til 10,89 % av legemshøiden, hos norske derimot til 11,41 %.

Tabel 20 b.

Forhold mellem hodets proportioner og legemshøiden hos lapper og norske.

Legemshøide	Folketype	Hodets største bredde	Hodets største længde	Index cephalicus	Hodebredde i % av legemshøiden	Hodelængde i % av legemshøiden
157	Lap	15,55	17,97	86,6	9,90	11,44
157	Trønder . .	15,17	19,04	79,69	9,66	12,12
162	Lap	15,58	18,30	84,7	9,61	11,28
162	Trønder . .	15,21	19,14	79,58	9,38	11,81
169	Lap	15,60	18,40	83,7	9,23	10,89
169	Trønder . .	15,28	19,29	79,27	9,03	11,41

Ser man derefter paa hvorledes forholdet er hos lapper av 157 cm. høide, vil man se at hos disse har hodet gjennemsnitlig en længde av 17,97 cm. eller 11,44 % av legemshøiden. Jeg antar at lappenes gjennemsnitshøide er omkring 155 cm., og at den trønderske befolknings gjennemsnitshøide er omkring 172 cm. Ogsaa hos individer som har typens gjennemsnitshøide, er der altsaa en tydelig forskjel paa hodets længde regnet i % av legemshøiden. Den norske befolkning blir mere langhodet end den lappiske befolkning.

Undersøker jeg saa forholdet mellem hodets bredde og legemshøiden, saa finder jeg at hodets bredde er endnu mindre avhængig av legemshøiden, baade hos lapper og hos norske. Hos lapper av 169 cm. høide er hodet gjennemsnitlig 15,60 cm. bredt. Hos en trønder av samme høide er hodet derimot bare 15,28 cm. bredt. Hos en lap av 157 cm. høide er hodets bredde 15,55 cm., hos en trønder av samme høide derimot betydelig smalere, kun 15,17 cm. Hos lapper av 155 cm. høide utgjør hodebredden temmelig nøiagtig 9,72 % av legemshøiden, hos trøndere 9,6 % av legemshøiden.

Hvis jeg gaar ut fra at lappenes gjennemsnitshøide er 150—155 cm., saa utgjør hodets bredde hos disse „typiske lapper“ ca. 9,72 % av legemshøiden.

Den typiske trønder har en legemshøide paa omtrent 172 cm. Den gjennemsnitlige hodebredde hos disse med hensyn til legemshøide typiske trøndere er 15,33 cm. eller kun 8,91 % av legemshøiden.

Hos lappene vokser index cephalicus meget raskt med en avtagende legemshøide. Hos 169 cm. høie lapper er index cephalicus 83,7. Hos 157 cm. høie lapper er index cephalicus 86,6 cm.

Hos trøndere tiltar ganske vist ogsaa index cephalicus naar legemshøiden avtar, men i langt mindre grad. Hos en trønder av 169 cm. høide er index cephalicus 79,27. Hos en trønder av 157 cm. høide er index cephalicus 79,69.

Medens gjennemsnitshøiden for samtlige undersøkte er 170,168, er den for dolichocephalene 168,856, for mesocephalene 170,561, for brachycephalene med index 81—83 169,897 og for hyperbrachycephalene med index 84—93 169,622.

V. Ansigtet.

1. Ansigtets høide, bredde og morfologiske index

Ansigtshøiden, maalt fra næseroten til hakens underkant, varierer fra 10,1 til 14,2 cm., og dens gjennemsnitlige størrelse er 12,05 cm.

Hos de undersøkte lapper varierer ansigtshøiden fra 10,1—12,9 og er gjennemsnitlig 11,67 cm. Hos finnene varierer den fra 10,3 til 13,5 cm. og er gjennemsnitlig 11,82 cm. Hos den rent norske befolkning har jeg fundet at den varierer fra 10,4 til 14,2 cm., og at dens gjennemsnitlige størrelse er 12,41 cm.

Ansigtsbredden (zy—zy) varierer inden samtlige undersøkte fra 12,2 til 15,3 cm. og er gjennemsnitlig 14,14 cm. Hos lappene varierer den fra 13,0 til 15,0 cm. og er gjennemsnitlig 14,11 cm. Hos finnene varierer den fra 12,5 til 15,3 cm. og er gjennemsnitlig 14,04 cm. Hos den rent norske befolkning har jeg fundet som minimum 12,2 og som maximum 15,3 og middelbredde 13,97 cm.

Den morfologiske ansigtsindex varierer fra 72—100. Dens gjennemsnitlige størrelse er 85,11. I de enkelte herreder varierer den fra 82,0 til 88,9. Det er altsaa en overmaade værdifuld index, naar det gjælder at karakterisere befolkningen.

Av det medfølgende kart (fig. 10) vil man se at de smaleste ansigter findes i de to herreder Bardu og Maalselv, hvor man ogsaa finder den reneste norske befolkning.

De bredeste ansigter finder man i Helgøy, Sørfjord, Kvæfjord, Bjarkøy og Nordreisa. For Nordreisas vedkommende har jeg paa kartet sat et spørsmaalstegn, da jeg kun hadde 2 mand til undersøkelse fra dette distrikt. Men de øvrige distrikter er sikre nok. Og som man vil se av kartet, er et ødistrikt som Helgøy et rent utstraalingscentrum for denne ansigtstype. Saa meget merkeligere er dette, som der blandt de av mig undersøkte fra Helgøy ikke fandtes nogen som mente sig at nedstamme fra lapper. Det samme gjælder Kvæfjord og Bjarkøy. En befolkning som anser sig selv for rent norsk, har altsaa i disse distrikter en ansigtstype som er helt fremmed for den nordiske race.

Paa fig. 11 har jeg nedtegnet kurven for ansigtsindex i Troms fylke. Den har, som man vil se, 3 spidser, en central spids ved index 85 og to perifere spidser ved indexene 83 og 88. Hos den brachycephale befolkning i Møre fylke fandt jeg at ansigtsindex var 83.

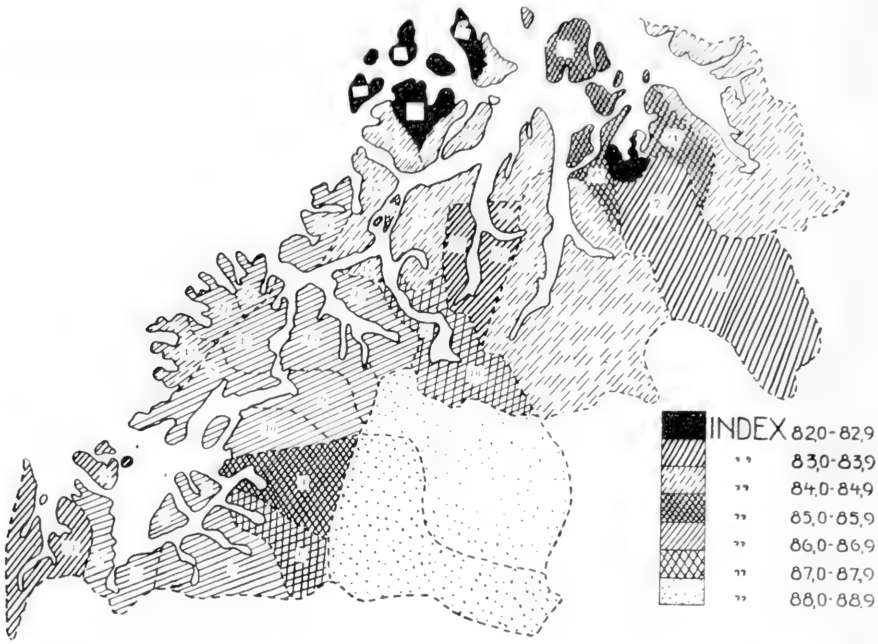


Fig. 10. Kart over index facialis morphologicus.

1. Kvæfjord.
2. Trondenes, Harstad.
3. Bjarkøy.
4. Salangen.
5. Bardu.
6. Lavangen.
7. Ibestad.
8. Tranøy.
9. Sørreisa.
10. Dyrøy.
11. Berg.
12. Torsken.
13. Lenvik.
14. Hillesoy.
15. Maalselv.
16. Balsfjord.
17. Malangen.
18. Tromsøysund.
19. Tromsø.
20. Sorfjord.
21. Lyngen.
22. Karlsoy.
23. Helgoy.
24. Skjervoy.
25. Nordreisa.
26. Kvænangen.

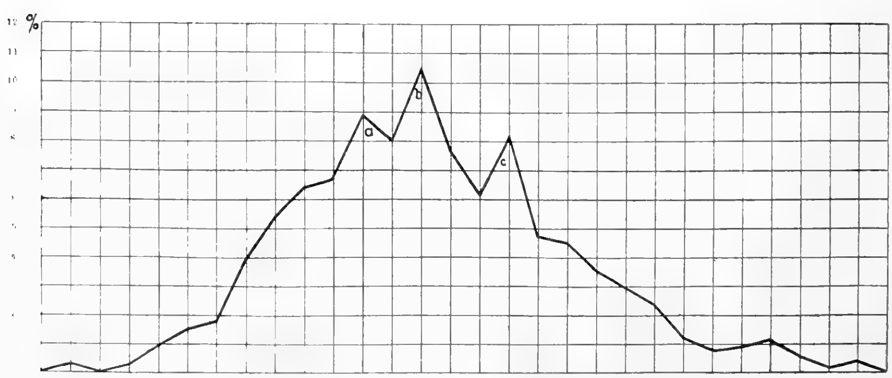


Fig. 11. Kurve for ansigtsindex (index morphologicus) i Troms fylke.

Tabel 21. Morfologisk ansigtsindex for Troms fylke, ordnet i serier for hver hel index.

	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Kvæfjord	-	-	-	-	-	1	1	1	2	2	1	-	1	2	1	-	-	1	2	-	-	-	-	-	-	-	-	-	-
Harstad og Trondenes	-	-	-	1	-	1	1	-	2	5	4	6	1	7	4	7	3	5	2	2	2	2	2	-	-	-	-	-	1
Bjarkøy	-	-	-	-	-	1	-	-	1	1	1	1	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
Ibestad	-	-	-	-	-	-	2	2	2	-	3	2	7	-	3	1	8	3	-	2	2	2	-	1	-	1	-	-	-
Salangen	-	-	-	-	-	-	-	-	1	2	3	1	-	5	3	3	3	2	1	-	1	-	-	1	-	-	-	-	-
Bardu	-	-	-	-	-	1	-	-	1	1	-	-	-	-	2	2	2	2	-	-	-	-	-	-	1	-	1	-	-
Lavangen	-	-	-	-	-	1	-	1	-	-	-	1	2	4	-	2	2	1	-	-	-	1	-	-	-	2	-	-	-
Tranøy	-	-	-	-	1	-	-	2	-	2	1	4	5	4	5	2	4	-	4	2	2	-	1	-	-	1	-	-	1
Sørreisa	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Dyrøy	-	-	-	-	-	-	1	1	1	2	2	2	-	3	-	2	3	-	3	-	1	-	-	1	-	-	1	-	-
Berg	-	-	-	-	-	-	1	-	-	2	-	-	-	1	1	-	-	-	-	-	1	1	-	-	-	-	1	-	-
Torsken	-	-	-	-	-	-	-	-	2	-	2	-	1	-	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-
Lenvik	-	-	-	-	-	-	-	1	1	-	2	4	3	4	5	2	3	2	-	2	3	-	1	-	-	-	-	-	-
Hillesøy	-	-	-	-	1	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Maalselv	-	-	-	-	-	-	-	-	-	1	2	2	1	2	1	2	1	1	2	1	3	1	-	-	2	1	-	-	-
Balsfjord	-	-	-	-	-	-	1	1	2	2	1	3	4	2	-	1	3	1	2	3	-	4	1	1	1	1	-	-	-
Malangen	-	-	-	-	1	-	-	1	-	2	3	1	2	4	3	1	3	3	1	1	-	1	-	-	1	-	-	-	-
Tromøysund	-	-	-	-	1	1	-	4	1	5	4	8	2	4	3	3	2	1	3	1	-	1	1	-	-	-	1	-	-
Tromsø	-	1	-	-	-	-	1	3	2	1	2	2	2	2	2	1	1	2	2	2	3	1	-	-	-	-	-	-	-
Sorfjord	-	-	-	-	1	-	1	1	-	-	1	3	1	2	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-
Lyngen	-	-	-	1	2	2	1	3	7	4	6	6	8	7	6	3	3	1	1	1	-	1	1	-	-	2	-	-	-
Karlsøy	-	-	-	-	-	-	1	2	4	3	-	4	2	1	4	-	3	-	-	1	-	-	1	-	-	-	-	1	-
Helgøy	1	-	-	-	-	-	1	1	2	1	-	-	1	1	2	-	1	1	-	-	-	-	-	-	-	-	-	-	-
Skjervøy	-	1	-	-	-	2	-	1	4	2	4	6	7	7	3	1	7	1	-	4	2	1	-	1	1	-	-	-	-
Nordreisa	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kvænangen	-	-	-	-	-	-	-	2	-	3	2	1	1	1	1	1	2	-	2	1	-	-	-	-	-	-	-	-	-
Antal	1	2	-	2	7	10	12	27	36	42	44	58	53	68	51	40	54	31	30	23	20	16	8	5	6	8	4	1	3
Procent	0,15	0,3	-	0,3	1,0	1,5	1,8	4,1	5,4	6,4	6,7	8,8	8,0	10,5	7,7	6,1	8,2	4,7	4,5	3,5	3,0	2,4	1,2	0,75	0,9	1,2	0,6	0,15	0,45

Av tabel 22 fremgaar, at jeg hos lappene i Troms fylke har fundet at ansigtsindex er 83 (82,98). Det kan da heller ikke være tvil om at denne spids skyldes fylkets „lappebefolkning".

Tabel 22.

	Ansigtshøide n gn			Ansigtsbredden zy—zy			Morfologisk ansigtsindex		
	M.	Min.	Max.	M.	Min.	Med.	M.	Min.	Max.
I Troms fylke	12,05	10,1	14,2	14,14	12,2	15,3	85,11	72	100
Lappene	11,67	10,1	12,9	14,11	13,0	15,0	82,98	72	92
Finnene	11,82	10,3	13,5	14,04	12,5	15,3	84,29	-	-
Rent norske	12,41	10,4	14,2	13,97	12,2	15,3	88,91	-	-

Tabel 23.

Ansigtstyper i Troms fylke.

	Antal	Antal			Procent		
		Euryprosoper 70—83	Mesoprosoper 84—87	Leptoprosoper 88—100	E.	M.	L.
Kvæfjord	15	8	4	3	53,4	26,6	20,0
Harstad og Trondenes	58	20	19	19	34,4	32,8	32,6
Bjarkøy	8	5	2	1	62,5	25,0	12,5
Salangen	26	7	11	8	26,9	42,3	30,8
Bardu	13	3	4	6	23,1	30,7	46,2
Lavangen	17	3	8	6	17,6	47,1	35,3
Ibestad	41	11	11	19	26,8	26,8	46,4
Tranøy	41	10	16	15	24,4	39,0	36,6
Sorreisa	2	-	2	-	36,0	28,0	36,0
Dyrøy	23	9	5	9			
Berg	8	3	2	3	37,5	25,0	37,5
Torsken	9	4	4	1	44,4	44,4	11,2
Lenvik	33	8	14	11	24,2	42,5	33,3
Hillesøy	5	2	2	1	40,0	40,0	20,0
Maalselv	23	5	6	12	21,4	26,2	52,4
Balsfjord	34	10	7	17	29,4	20,6	50,0
Malangen	28	8	10	10	28,6	35,7	35,7
Tromsøysund	46	24	12	10	52,2	26,1	21,7
Tromsø	30	12	7	11	40,0	23,3	36,7
Sørfjord	14	7	6	1	50,0	42,9	7,1
Lyngen	72	32	24	16	44,5	33,2	22,3
Karlsøy	30	14	10	6	46,6	33,4	20,0
Helgøy	12	6	4	2	50,0	33,4	16,6
Skjervøy	55	20	18	17	36,3	32,7	31,0
Nordreisa	2	2	-	-	52,6	21,1	26,3
Kvænangen	17	8	4	5			
Absolute tal	662	241	212	209			
Procent		36,8	32,6	30,6			

Ansigtsindex hos den nordiske race er antagelig omkring 88 à 90. Det er da sandsynlig at den anden perifere spids skyldes distriktets nordiske befolkning. Hos de i Troms fylke boende kvæner har jeg fundet at ansigtsindex er 84,29. Det kunde da ligge nær at tro at den centrale spids ved index 85 skyldes den tilstedeværende kvænbefolkning. Denne er imidlertid saa liten at den kun kan yde et lite bidrag til denne spids. Det sandsynlige er vel at den for en meget stor del er et summationsfænomen.

Hvis jeg nøier mig med at inddele befolkningen efter ansigtsindex i 3 typer: euryprosoper (70—80), mesoprosoper (84—87) og leptoprosoper (88—100), da finder jeg inden hele fylket 36,8 % euryprosoper, 32,6 mesoprosoper og 30,6 leptoprosoper.

Tabel 24.

	Euryprosoper	Mesoprosoper	Leptoprosoper
Troms fylke	36,8	32,6	30,6
Nidaros bispedømme	15,8	24,2	60,0
Nordmør sorenskriveri	8,3	28,4	63,3
Søndre Søndmør	27,4	30,7	41,9
Lebediner, efter KAARLO HILDÉN	60,7	29,5	9,9
Tubularer, — — —	44,0	35,2	10,8
Telengeter — — —	93,1	6,9	-

Som man vil forstaa av ovenstaaende tabel 24, er Troms fylke sterkt euryprosopt efter norske forhold.

Man finder utvilsomt intet fylke længere syd i Norge som kan maale sig med det i denne henseende. Nordmør sorenskriveri, som paa en typisk maate repræsenterer den nordiske race, er en kras motsætning til Troms fylke.

Gaar man derimot østover, finder man en jevn økning av europrosopien. Sammenligner man Troms fylkes befolkning med de typiske euryprosope folk i Centralasien (Telengetene til eks.), da blir jo antallet av euryprosoper hos os ganske lite.

Ser man saa paa forholdet i de enkelte distrikter, da falder det straks i øinene, at euryprosopene findes i et overmaade stort antal i de samme kystdistrikter som har vist sig som repræsentanter for liten legemshøide, mørkt haar, mørke øine og brachycephali. Bjarkøy, Kvæfjord, Tromsøysund, Helgøy og Kvænangen er saadanne sterkt euryprosope distrikter.

2. Næsen.

Den gjennemsnitlige størrelse av index nasalis er 68,55. Vi har distrikter her i landet med betydelig høiere næseindex, til eks. Jæderen med 72,1, Søndmør med 69,4, Vestagders kystbygder med 70,9. Men saa har vi ogsaa, især i de dolichocephale landsdeler, distrikter med langt lavere index, til eks. Nordmør med 65,4, Sørtrøndelagens dalfører med 66,9.

Tabel 25.

Næseindex i Troms fylke, ordnet i 5-tals serier.

	50,0—54,9	55,0—59,9	60,0—64,9	65,0—69,9	70,0—74,9	75,0—79,9	80,0—84,9	85,0—89,9	90,0—94,9	95,0—99,9	100,0—104,9	105,0—109,9	110,0—114,9	115,0—119,9
Kvæfjord	-	1	2	8	3	1	-	-	-	-	-	-	-	-
Harstad og Trondenes ...	1	6	12	15	15	6	2	-	1	-	-	-	-	-
Bjarkøy	-	-	1	4	2	1	-	-	-	-	-	-	-	-
Ibestad	-	1	6	13	11	7	3	-	-	-	-	-	-	-
Salangen	-	-	6	5	8	3	2	1	-	-	-	-	-	1
Bardu	1	1	3	2	1	5	-	-	-	-	-	-	-	-
Lavangen	-	-	3	8	4	1	-	-	1	-	-	-	-	-
Tranøy	1	3	8	16	9	3	-	1	-	-	-	-	-	-
Sørreisa	-	-	1	-	-	1	-	-	-	-	-	-	-	-
Dyrøy	-	1	8	6	3	4	-	1	-	-	-	-	-	-
Berg..........	1	1	2	3	1	-	-	-	-	-	-	-	-	-
Torsken	-	1	-	1	3	4	-	-	-	-	-	-	-	-
Lenvik	-	1	6	12	7	5	1	1	-	-	-	-	-	-
Hillesøy	-	1	1	1	1	1	-	-	-	-	-	-	-	-
Maalselv.......	-	1	5	7	4	5	1	-	-	-	-	-	-	-
Balsfjord	3	3	3	6	12	4	1	1	1	-	-	-	-	-
Malangen	-	1	7	7	5	7	1	-	-	-	-	-	-	-
Tromsøysund ...	1	4	9	15	9	5	1	2	-	-	-	-	-	-
Tromsø	2	1	8	8	8	2	1	-	-	-	-	-	-	-
Sørfjord	-	2	1	6	1	3	1	-	-	-	-	-	-	-
Lyngen	1	5	12	23	13	10	4	3	-	-	1	-	-	-
Karlsøy	1	2	5	7	7	5	3	-	-	-	-	-	-	-
Helgøy........	-	1	-	4	3	2	1	1	-	-	-	-	-	-
Skjervøy	-	5	9	21	16	1	2	-	-	-	1	-	-	-
Nordreisa	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Kvænangen	3	2	2	5	2	3	-	-	-	-	-	-	-	-
	15	44	121	203	149	89	24	11	3	-	2	-	-	1

Der er ogsaa i Troms fylke stor forskjel paa de forskjellige herreder. Høiest index er der i Salangen (73,1), Torsken (71,8) og Helgøy (72,5). I disse distrikter er altsaa index nasalis omtrent av samme størrelse som i de brachycephale distrikter paa Vestlandet: Jæderen og Søndmør. Det er vel sandsynlig at lappene bidrar til den høie næseindex.

Hos 30 lapper fandt jeg nemlig at næseindex var 73,91, hos 17 kvæner derimot 67,35 og hos norske gjennemsnitlig 68,61.

Av samtlige undersøkte er 56,9 leptorhiner, 40,3 mesorhiner, 2,8 chamærhiner. Av lappene var 9 (30,0 %) leptorhiner, 19 (63,4 %) mesorhiner og 2 (6,6 %) chamærhiner. Rette næser har jeg fundet hos 69 % og konkave hos 24 %.

Til sammenligning meddeles at hos den trønderske befolkning fandt jeg 70 % rette og 28,6 % konkave.

Tabel 26.
Næsetyper i Troms fylke.

Herredets navn	Antal	Antal: Leptorhine 50—69	Antal: Mesorhine 70—84	Antal: Chamærhine 85—110	Procent: Leptorhine	Procent: Mesorhine	Procent: Chamærhine
Kvæfjord	15	11	4	-	73,4	26,6	-
Harstad og Trondenes	58	34	23	1	58,6	39,7	1,75
Bjarkøy	8	5	3	-	62,5	37,5	-
Salangen	26	11	13	2	42,3	50,0	7,7
Bardu	13	7	6	-	53,8	56,2	-
Lavangen	17	11	5	1	64,7	29,4	5,9
Ibestad	41	20	21	-	48,8	51,2	-
Tranøy	41	28	12	1	68,3	29,3	2,44
Sørreisa	2	1	1	-	} 64,0	32,0	4,0
Dyrøy	23	15	7	1			
Berg	8	7	1	-	87,5	12,5	-
Torsken	9	2	7	-	22,2	77,8	-
Lenvik	33	19	13	1	57,5	39,4	3,3
Hillesøy	5	3	2	-	60,0	40,0	-
Maalselv	23	13	10	-	56,5	43,5	-
Balsfjord	34	15	17	2	44,1	50,0	5,9
Malangen	28	15	13	-	53,5	46,5	-
Tromsøysund	46	29	15	2	63,0	32,7	4,35
Tromsø	30	19	11	-	63,4	36,6	-
Sørfjord	14	9	5	-	64,3	35,7	-
Lyngen	72	41	27	4	57,0	37,5	5,5
Karlsøy	30	15	15	-	50,0	50,0	-
Helgøy	12	5	6	1	41,7	50,0	8,35
Skjervøy	55	35	19	1	63,6	34,6	1,82
Nordreisa	2	1	1	-	} 68,5	31,5	-
Kvænangen	17	12	5	-			
Absolute tal	662	383	262	17			
Procent	-	56,9	40,3	2,8			

3. Bredden mellem de indre øienvinkler.

Som gjennemsnit for samtlige undersøkte har jeg fundet 32,96 mm. avstand mellem de indre øienvinkler.

I distrikter med stor ansigtsbredde kan den gaa op til 34 à 35 mm. Paa den anden side har jeg i de mest typiske nordiske distrikter, som Bardu, fundet som middeltal kun 31,15 mm.

4. Jugo-frontal index,

ɔ: Forholdet mellem pandebredde og kindbredde.

En liten index kan bero paa særlig stor kindbredde eller særlig liten pandebredde. Da inden vor befolkning pandebredden er relativt lite variabel, medens kindbredden er sterkt variabel, vil en liten jugo-frontal index som regel bety at kindbredden er stor.

Tabel 27. Næsens form.

Herredets navn	Antal under-søkte	Næseryggen: Kon-kav	Næseryggen: Ret-linjet	Næseryggen: Kon-veks	Næseryggen: Bølge-formet	Næsens underkant: Opad-rettet	Næsens underkant: Hori-sontal	Næsens underkant: Nedad-rettet	Næseroten: Høitlig-gende	Næseroten: Middels	Næseroten: Dypt-lig-gende	Næsevingene: Sterkt tillig-gende	Næsevingene: Middels	Næsevingene: Sterkt utstaa-ende
		1 og 2	3	4	5	1,2	3	4	1	2	3	1	2	3
Kvæfjord	15	4	10	1	-	8	6	1	2	13	-	3	9	3
Harstad og Trondenes	58	8	45	4	1	20	37	1	7	51	-	17	33	8
Bjarkøy	8	1	6	1	-	3	5	-	1	7	-	1	4	3
Salangen	26	5	20	1	-	8	18	-	1	21	4	3	11	12
Bardu	13	1	11	1	-	5	7	1	4	8	1	4	7	2
Lavangen	17	7	10	-	-	9	7	1	1	15	1	3	11	3
Ibestad	41	8	28	2	3	19	21	1	2	38	1	2	25	14
Tranøy	41	9	31	1	-	14	25	2	2	36	3	3	32	6
Sørreisa	2	1	1	-	-	1	1	-	-	2	-	-	1	1
Dyrøy	23	1	22	-	-	8	15	-	3	17	3	4	15	4
Berg	8	1	7	-	-	4	4	-	1	7	-	4	4	-
Torsken	9	2	5	1	1	3	6	-	1	6	2	1	6	2
Lenvik	33	6	25	2	-	9	24	-	1	30	2	9	15	9
Hillesøy	5	1	3	-	1	2	2	-	1	3	-	1	2	1
Maalselv	23	4	19	-	-	13	10	-	1	22	-	4	17	2
Balsfjord	34	10	22	2	-	12	22	-	5	26	3	11	17	6
Malangen	28	6	17	4	1	11	14	3	3	24	1	7	15	6
Tromsøysund	46	11	29	4	2	16	27	3	4	41	1	9	31	6
Tromsø	30	7	20	2	1	18	12	-	4	24	2	8	17	5
Sørfjord	14	5	9	-	-	6	8	-	-	13	1	-	9	5
Lyngen	72	28	41	2	1	35	34	-	10	53	9	12	31	29
Karlsøy	30	12	16	-	2	16	13	-	2	25	2	4	16	9
Helgøy	12	3	9	-	-	7	4	1	-	12	-	5	3	4
Skjervøy	55	13	39	2	1	22	33	-	1	52	2	12	32	11
Nordreisa	2	1	1	-	-	1	-	-	-	1	-	-	-	1
Kvænangen	17	3	11	2	1	7	9	1	-	17	-	4	10	3
Antal	662	158	457	32	15	277	364	15	57	564	35	128	373	115
Procent		24,0	68,3	4,7	2,3	42,4	55,3	2,3	8,5	85,0	6,5	19,4	56,5	25,1

Tabel 28. Jugo-frontalindexer i Troms fylke, ordnet i serier for hver hel index.

Herredets navn	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	89	93
Kvæfjord	-	-	-	-	1	-	1	2	-	1	3	5	1	1	-	-	-	-	-	-
Harstad og Trondenes	-	-	3	-	4	2	5	3	8	11	10	6	5	-	1	-	-	-	-	-
Bjarkøy	-	-	-	-	-	2	-	1	1	2	2	-	-	-	-	-	-	-	-	-
Ibestad	-	-	-	-	1	2	3	2	7	4	10	5	3	2	2	-	-	-	-	-
Bardu	-	-	-	-	-	1	1	1	4	2	1	1	2	-	-	-	-	-	-	-
Salangen	-	-	-	1	1	1	1	5	7	1	2	3	2	2	-	-	-	-	-	-
Lavangen	-	-	-	2	-	2	-	3	1	4	2	-	-	1	-	-	1	-	-	1
Tranøy	-	-	1	1	3	10	4	8	2	3	1	2	3	-	2	-	1	-	-	-
Sørreisa	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Dyrøy	-	-	-	1	-	4	-	1	2	5	3	3	2	1	-	1	-	-	-	-
Berg	-	-	-	-	-	-	3	1	1	-	2	1	-	-	-	-	-	-	-	-
Torsken	-	-	-	-	1	1	2	2	-	-	1	1	1	-	-	-	-	-	-	-
Lenvik	-	-	-	1	1	-	6	2	5	3	4	5	6	-	-	-	-	-	-	-
Hillesøy	-	-	-	-	-	-	2	1	1	-	1	-	-	-	-	-	-	-	-	-
Maalselv	-	-	-	1	-	3	1	5	4	-	4	2	1	1	1	-	-	-	-	-
Balsfjord	-	-	-	2	3	3	4	3	8	3	3	4	-	-	1	-	-	-	-	-
Malangen	-	1	-	-	-	4	3	5	6	4	4	1	-	-	-	-	-	-	-	-
Tromsøysund	-	-	2	-	1	2	5	1	11	6	9	3	1	4	-	1	-	-	-	-
Tromsø	-	-	-	1	-	2	2	4	5	2	5	4	2	1	-	1	-	-	1	-
Sørfjord	-	-	-	-	1	1	-	4	3	2	2	-	1	-	-	-	-	-	-	-
Lyngen	-	-	-	1	-	7	7	6	17	8	10	5	5	4	2	-	-	-	-	-
Karlsøy	-	-	-	-	1	1	2	3	4	4	9	3	1	2	-	-	-	-	-	-
Helgøy	-	1	-	-	-	-	1	2	2	1	4	1	-	-	-	-	-	-	-	-
Skjervøy	-	-	1	-	1	2	7	8	6	8	9	6	5	1	-	1	-	-	-	-
Nordreisa	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-
Kvænangen	-	-	-	-	-	-	3	4	4	1	1	2	1	1	-	-	-	-	-	-
	-	2	7	11	19	51	64	78	109	75	102	63	43	21	9	4	2	-	1	1

Liten jugo-frontal index 70—77 betegnes senere ved l., middels jugo-frontalindex 78—80 ved m., og stor jugo-frontal index 81—93 ved st.

En høi jugo-frontal index betyr av samme grund som regel at kindbredden er liten. Imidlertid varierer denne index fra 71 til 93 med to meget utprægede maxima ved index 78 og 80.

Inden de enkelte herreder varierer denne index ikke særdeles meget. Naar jeg ser bort fra Hillesøy og Sørreisa (paa grund av det ringe antal undersøkte), er den lavest i Tranøy, 77,8 (41 mand), høiest i Kvæfjord. Hos finner og norske har denne index omtrent ens størrelse. Hos lapper er den noget mindre.

5. Øvre øienlok.

(Plica marginalis, epicanthus, mongolfold).

Øvre øienlok og især indre øienvinkel har hos den her beskrevne befolkning et meget vekslende utseende. Ved en mere overfladisk betragtning faar man det indtryk, at en stor del av befolkningen har skjæve øienspalter. En nærmere undersøkelse bringer snart paa det rene at forskjellige foldedannelser er aarsak til denne tilsynelatende skjævhet. Hos hovedmassen av befolkningen (87,2 %) finder man intet abnormt. Øvre øienlok og indre øienvinkel er saaledes som vanlig hos den nordiske race. Hos de øvrige 12,8 % støter man paa forskjellige avvikelser.

Den hyppigst forekommende er en liten, men vel utviklet, stram, meget tynd hudfold, som begynder litt nedenfor nedre øienloks mediale del og herfra gaar skraat opover og utad og forsvinder saa i øvre øienlok, ikke saa ret langt fra indre øienvinkel (fig. 12 b). Denne uregelmæssighet har jeg fundet hos 9,5 %. Jeg kalder denne abnormitet for mongolfold nr. 1. Hos et betydelig mindre antal, 2,2 %, er denne fold saa stor at den strækker sig helt forbi øienspaltens midtparti. Jeg har ogsaa anset dette for en mere ekstrem form av foregaaende type og har kaldt den mongolfold nr. 2. Men mellem disse er overgangen saa umaadelig fin at man ikke kan trække nogen skarp grænse. Fælles for begge disse er at folden begynder nedenfor nedre øienlok og fortaper sig likesom i det øvre øienlok.

Saa findes en tredje gruppe hvor hudfolden er tykkere, og som medialt ikke gaar nedenfor nedre øienlok. I dette tilfælde er cilierne ofte dækket av folden (se fig. 12 d). Jeg har fundet denne type hos 0,9 %. Enkelte (Eugen Fischer, Balz) skiller skarpt mellem 2 og 3 og regner denne sidste som egte mongolfold (plica marginalis) og de andre to som epicanthus.

Saa finder man endelig endel individer, 0,2 %, hos hvem det øvre øienlok i midtpartiet danner en fold (fig. 12 e) som hænger nedenfor som et slags forhæng og derved kan dække cilierne paa øvre øienlok. Fischer siger at han hos „die Rehobother Bastards" aldrig fandt denne sidste abnormitet, som han kalder „dækfold", sammen med epicanthus, men nok sammen med egte mongolfold. Noget saadant har jeg ikke bemerket blandt

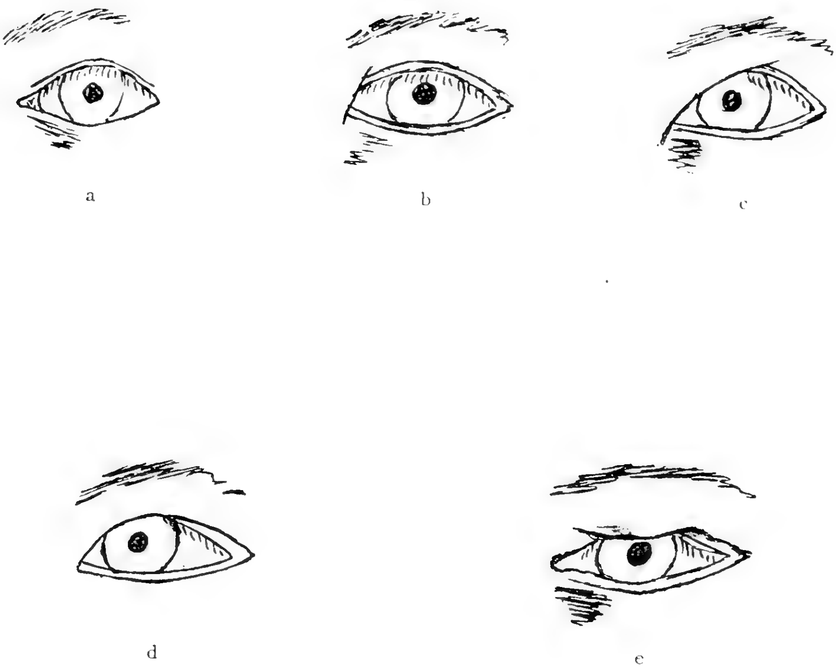


Fig. 12.

denne bastardbefolkning. Tvertimot forekommer det mig at de altid umerkelig gaar over i hinanden.

Det egte mongoloie findes neppe blandt denne befolkning. Men høist sandsynlig er det vel at alle de her beskrevne „typer" er remiscenser av det egte mongoloie.

Dettes utstraalingscentrum er vel i Sydkina, hvor det findes hos 100 %. Allerede naar man kommer til Japan, er antallet minsket til 70 %, og jo længere man kommer vestover, des mere synker antallet av de egte mongoloine. Men saa optrær til gjengjæld alle de her beskrevne typer, som jo hver for sig repræsenterer endel av de for det egte mongoloie karakteristiske træk.

Angaaende utbredelsen skal jeg her kun bemerke at den synes at følge lappene.

Paa hovedtabellen har jeg anført hvor mange mænd jeg har fundet denne eiendommelighet hos i hvert enkelt herred.

Under avsnit VIII, Affinitetsundersøkelser, kommer jeg nærmere ind paa hvorfra vor befolkning har denne eiendommelighet.

VI. Om forholdet mellem ansigtets og hodets dimensioner.

1. Den mindste pandebredde.

Den mindste pandebredde varierer individuelt fra fra 10,0 til 12,3 med en gjennemsnitlig størrelse av 11,09. Dette er en meget stor pandebredde i forhold til hvad man finder hos andre folk. Det svarer temmelig præcis til hvad man finder hos lithauere. Den store pandebredde kunde tænkes at staa i forbindelse med befolkningens relative store legemshøide. Pandebredden har imidlertid hos denne befolkning den samme gjennemsnitlige størrelse hos store som hos smaa mænd.

Jeg finder saaledes hos de av mig undersøkte med legemshøide

157	en pandebredde	paa	11,18
165	—	—	10,90
170	—	—	11,03
175	—	—	11,31
180	—	—	11,12
185	—	—	11,22

Heller ikke staar pandebredden i et fikst forhold til hodets største bredde. Forholdet mellem disse to benævnes som bekjendt

2. Den transversale fronto-parietale index.

Denne index varierer, som man vil se av tabel 29, inden den her beskrevne befolkning mellem 64 og 81. En liten index vil si at panden er

Tabel 29. Transversal fronto-parietal index ordnet i serier for hver hel index.

Herredets navn	Stenometopi						Metriometopi			Eurymetopi										Sum	Steno-metopi	Metrio-metopi	Eury-metopi	Steno-metopi	Metrio-metopi	Eury-metopi
	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81							
Kvæfjord	-	-	-	-	1	-	-	2	2	3	-	3	1	-	2	1	-	-	-	15	1	4	10	6,7	26,6	66,7
Harstad og Trondenes	-	-	3	2	1	2	6	9	11	7	4	6	4	1	1	-	1	-	-	58	8	26	24	13,8	44,8	41,4
Bjarkøy	-	-	-	-	-	1	1	2	1	1	2	-	-	-	-	-	-	-	-	8	1	4	3	12,5	50,0	37,5
Salangen	-	-	1	-	2	1	1	6	3	3	3	3	2	1	-	-	-	-	-	26	4	10	12	15,3	38,7	46,0
Bardu	-	-	-	-	1	1	1	1	2	4	1	-	1	1	-	-	-	-	-	13	2	4	7	15,4	30,8	53,9
Lavangen	-	-	-	-	1	1	3	2	3	2	4	1	-	-	-	-	-	-	-	17	2	8	7	11,7	47,2	41,1
Ibestad	-	-	-	2	1	4	4	3	8	6	1	5	1	5	-	1	-	-	-	41	7	15	19	17,0	34,7	46,3
Tranøy	-	1	1	-	-	5	7	8	6	2	4	1	2	1	2	1	-	-	-	41	7	21	13	17,0	51,4	31,6
Sørreisa	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	2	1	1	-	8,0	36,0	56,0
Dyrøy	-	-	-	-	-	1	-	4	4	1	6	3	1	3	-	-	-	-	-	23	1	8	14			
Berg	-	-	-	-	1	-	2	1	-	3	-	-	-	-	1	-	-	-	-	8	1	3	4	12,5	37,5	50,0
Torsken	-	-	-	-	1	1	3	2	-	-	-	1	-	1	-	-	-	-	-	9	2	5	2	22,1	55,8	22,1
Lenvik	-	-	-	-	3	-	2	3	7	4	6	3	2	2	-	-	1	-	-	33	3	12	18	9,1	36,4	54,5
Hillesøy	-	-	-	-	1	1	1	-	1	-	-	-	1	-	-	-	-	-	-	5	2	2	1	40,0	40,0	20,0
Maalselv	-	-	-	-	-	5	3	1	6	4	-	1	1	1	1	-	-	-	-	23	5	10	8	21,7	43,6	34,7
Balsfjord	-	-	-	1	2	3	3	5	1	8	6	2	1	1	1	-	-	-	-	34	6	9	19	17,7	26,4	55,9
Malangen	-	-	2	1	1	4	1	6	3	4	3	2	1	-	-	-	-	-	-	28	8	10	10	28,6	35,7	35,7
Tromsøysund	-	-	-	-	2	2	4	2	9	7	10	1	3	3	3	-	-	-	-	46	4	15	27	8,7	32,6	58,7
Tromsø	-	-	1	-	-	3	2	7	3	4	2	4	-	1	-	1	1	-	1	30	4	12	14	13,4	40,0	46,6
Sørfjord	-	-	-	-	1	3	1	1	2	1	1	2	1	-	1	-	-	-	-	14	4	4	6	28,6	28,6	42,8
Lyngen	-	-	2	-	1	7	8	10	9	10	11	8	4	2	-	-	-	-	-	72	10	27	35	13,9	37,6	48,5
Karlsøy	-	-	-	1	-	1	3	3	4	3	9	2	4	-	-	-	-	-	-	30	2	10	18	6,7	33,3	60,0
Helgøy	-	-	-	-	2	1	-	-	1	-	2	2	1	1	1	1	-	-	-	12	3	1	8	25,0	8,3	66,7
Skjervøy	-	-	-	-	1	3	1	8	9	4	5	8	9	6	1	-	-	-	-	55	4	18	33	7,3	32,7	60,0
Nordreisa	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	2	-	1	1	5,3	36,7	58,0
Kvænangen	-	-	-	-	-	1	2	2	2	4	3	-	1	1	1	-	-	-	-	17	1	6	10			
	-	1	10	7	23	52	59	88	99	85	83	59	41	31	15	5	3		1	662	93	246	323	14,0	37,5	48,5

Stenometopi 63—70 betegnes senere ved a, mesometopi 71—72 ved b og eurymetopi 73—81 ved c.

smal i forhold til hodets bredde, en hoi index vil si at enten er panden bred eller hodet relativt smalt.

Hvis jeg for at faa rede paa korrelationsforholdet mellem hodets største bredde og mindste pandebredde inddeler materialet efter hodebredden i 3 grupper og efter pandebredden i 4 grupper, da findes følgende naar jeg kun medtar den saakaldte norske befolkning:

Tabel 30. Mindste pandebredde.

Hodets bredde.	10,0—10,5	10,6—11,0	11,1—11,5	11,6—12,5	
14,0—14,9	1 26 = 4,5 0/0 index = 71	4 43 = 7,5 0/0 index = 74	7 27 = 4,7 0/0 index = 78	10 5 = 0,9 0/0 index = 82	101 = 17,6
15,0—15,9	2 45 = 7,6 0/0 index = 66	5 147 = 25,6 0/0 index = 70	8 147 = 25,6 0/0 index = 73	11 54 = 9,4 0/0 index = 77	393 = 68,2
16,0—16,9	3 6 = 1,1 0/0 index = 62	6 24 = 4,2 0/0 index = 65	9 30 = 5,2 0/0 index = 68	12 21 = 3,7 0/0 index = 73	81 = 14,2
	77 = 13,2	214 = 37,3	204 = 35,7	80 = 14,0	575 = 100,0

Det fremgaar av denne tabel at liten pandebredde forekommer sammen med stor hodebredde hos 5,3 0/0.

Stor pandebredde og meget stor hodebredde forekom hos 9,1 0/0.

Disse to grupper utgjør tilsammen befolkningens brachycephale halvdel. Stor pandebredde forekom, som rimelig kan være, sjelden sammen med liten hodebredde (5,6 0/0); hyppigere er kombinationen liten pandebredde og liten hodebredde, 12,1 0/0. Muligens kan en korrelationsundersøkelse bringe større klarhet i disse vanskelige spørsmaal.

Man skulde efter hvad jeg her har utviklet, vente at finde en liten transversal fronto-parietal index fornemmelig i de mest brachycephale distrikter. Dette er imidlertid kun delvis tilfældet. I en del av de brachycephale distrikter er denne index tvertimot meget hoi.

Brachycephale distrikter med liten transversal fronto-parietal index er følgende: Sorreisa 69,9, Hillesoy 70,3, Lavangen 71,3, Berg 71,4 og Torsken 71,4.

De ovrige brachycephale distrikter har en endog meget høi transversal fronto-parietal index: Kvæfjord 73,3, Tromsoysundet 72,4, Karlsøy 72,4, Helgøy 73,0, Skjervoy 73,2, Nordreisa 73,0 og Kvænangen 72,4. Hvad dette beror paa, er det forelobig umulig at si. Det kan, som allerede nævnt, bero paa at der er forskjelligartede brachycephale typer i Troms fylke.

Av tabel 29 vil man se at av de forskjellige folketyper i Troms fylke har lappene den laveste transversale fronto-parientale index og finnene den høieste. Den norske befolkning staar midt imellem.

Men en meget høi index finder man merkelig nok hos enkelte bastarder. Særlig høi er den hos dem hvis forældre er lap og norsk. Disse bastarder har ogsaa en usedvanlig stor pandebredde. Pandebredden er større end baade hos lapper og norske, mens derimot hodets bredde ligger midt imellem hvad den er hos norske og lapper.

Det tør da hænde at en almindelig krydsningsundersøkelse kan gi en forklaring paa den høie transversale fronto-parietale index i endel brachycephale distrikter.

Forholdet mellem cephalindex og pandebredde fremgaar av følgende tabel:

Tabel 31. Cephalindex.

	Under 75,9	Mellem 78,0 og 79,9	Mellem 82,0 og 84,9	Over 85
Pandebredde	11,01	10,82	11,10	11,04
Transversal fronto-parietal index	74,50	71,95	71,60	70,23

Det fremgaar herav, at pandebredden er paa det aller nærmeste av samme størrelse hvad enten index cephalicus er liten eller stor.

En naturlig følge herav er da at en høi transversal fronto-parietal index hovedsakelig maa findes sammen med en lav index cephalicus og omvendt.

Hvis jeg kun medtar alle mænd av middelhøide (fra 169—171 cm.), da finder jeg følgende forhold mellem index cephalicus og den transversale fronto-parietale index.

Tabel 32. Transversal fronto-parietal index.

	Dolichocephal	Mesocephal	Brachycephal
63—69	-	29,2	70,8
70—71	8,3	62,5	29,2
72—74	13,3	50,0	37,7
75—85	35,4	35,4	29,2

Den mulighet kan derfor ikke utelukkes, at der blandt til eks. brachycephalene kan være 2 typer hvad pandebredde angaar: én type med meget stor pandebredde og en med meget liten pandebredde.

Hvis saa er tilfældet, blir det let at forstaa at pandebredden tilsynelatende ikke staar i noget bestemt forhold til hodets bredde. Da blir det ogsaa forstaaelig at pandebredden tilsynelatende er like stor hos høie som hos lave folk. Ti man kan vel med sikkerhet gaa ut fra at forholdet her er som andensteds i Norge, at brachycephali hører sammen med liten legemshøide og dolichocephali med stor legemshøide. Og hvis man nu her har en *brachycephal type* med *stor* pandebredde, men liten legemshøide, saa er det klart at ogsaa pandebreddens avhængighet av legemshøiden maa bli utvisket.

VII. Kombination av øienfarven og haarfarven.

Paa tabel 33 og 34 har jeg utregnet hvor ofte de forskjellige farvenuancer av haar og øine forekommer blandt samtlige undersøkte og blandt hver av de 4 grupper av hodetyper.

De to største grupper er, som man vil se, blaa øine i forbindelse med brunt haar og blondt haar. Det er her værd at lægge merke til at blandt hyperbrachycephalene forekommer blaa øine dobbelt saa hyppig sammen med blondt haar som sammen med brunt haar. Det er lappene som gir den hyperbrachycephale gruppe sit præg, og blandt disse forekommer den lyseste øientype relativt hyppigere end den lyseste haartype.

Disse to første kombinationer er begge rent blonde. De tre næste er ogsaa paa det nærmeste helt blonde. Ialfald vil de vistnok bli regnet for helt blonde i Syd- eller Mellemeuropa.

Tilsammen utgjør disse 5 relativt rene blonde kombinationer blandt dolichocephalene 72,50 %, blandt mesocephalene 76,34 %, blandt brachycephalene 67,30 % og blandt hyperbrachycephalene 64,90 %. Den mesocephale gruppe er altsaa den største.

De næste 3 grupper indeholder hovedmassen av de mørke kombinationer.

Kombination nr. 8 er her av særlig interesse, da den jo er den for alle ikke-leucoderme racer vanlige kombination. Den forekommer, som det vil sees, hyppigst blandt brachycephalene.

Man kan vel med temmelig stor sikkerhet gaa ut fra at de to første kombinationer i denne række er specifike for den blonde race. De øvrige kombinationer fjerner sig mer eller mindre fra denne type, idet de indeholder mer pigment. Man kan til en viss grad gradere pigmentmængden og derigjennem gi et uttryk for i hvilken grad kombinationen fjerner sig fra det for den blonde race typiske forhold.

Jeg maa da gi de forskjellige øientyper og haartyper en bestemt værdi i forhold til den pigmentmængde typen indeholder.

Jeg vil da i det følgende regne med 4 øientyper, som jeg gir følgende pigmentværdi:

blaa og graa øine	= 0
lyst melerte øine	= 1
mørkt melerte øine	= 2
brune øine	= 3

Tabel 33. Korrelation mellem øienfarve, haarfarve og index cephalicus blandt samtlige undersøkte.

		1 1	1 2	1 3	1 4	1 5	2 1	2 2	2 3	2 4	2 5	3 1	3 2	3 3	3 4	3 5	4 1	4 2	4 3	4 4	4 5	
Blandt samtlige undersøkte	Antal	128	6	139	112	11	21	1	50	50	6	3		20	29	8	5	1	12	36	28	662
	0/0	19,31	0,91	21,00	17,00	1,66	3,29	0,15	7,55	7,55	0,91	0,45		3,02	4,40	1,21	0,75	0,15	1,81	5,45	4,25	100,0
Blandt dolichocephaler . . .		22,5	-	30,0	10,0	-	2,5	-	7,5	2,5	-	-	-	2,5	7,5	-	-	-	2,5	10,0	2,5	
Blandt mesocephaler		19,60	1,58	20,60	20,60	0,95	3,46	-	7,29	8,25	1,26	0,63	-	3,10	3,10	0,95	0,32	-	1,20	4,44	2,53	
Blandt brachycephaler		20,0	0,40	19,20	13,60	1,60	2,80	0,40	7,25	7,25	0,80	-	-	3,20	5,21	1,00	1,00	0,40	2,40	5,04	0,45	
Blandt hyperbrachyceph. .		12,30	-	24,6	8,75	7,00	3,50	-	10,50	8,75	-	1,75	-	1,75	5,25	1,75	-	-	1,75	7,00	5,25	

Paa tabellens øverste linje betegner de to tal i hver rubrik øienfarve og haarfarve. Det første tal betegner øienfarven, det andet haarfarven. Tallene har følgende betydning:

1. Blaa og graa øine (MARTIN 13—16).
2. Lyst melerte øine (— 9—12).
3. Mørkt melerte øine (— 6—8).
4. Brune øine (— 4—5).

1. Blondt haar.
2. Rødt haar.
3. Lysebrunt og cendréfarvet haar.
4. Mørkebrunt haar.
5. Brunsort haar og sort haar.

For haarets vedkommende regner jeg ogsaa med 4 typer, som jeg gir følgende pigmentværdi:

lyst haar (blondt, rødt)	=	0
cendré og lysebrunt	=	1
mørkebrunt	=	2
sort	=	3

Tabel 34.

	Blandt samtlige undersøkte	Blandt dolichocephalene	Blandt mesocephalene	Blandt brachycephalene	Blandt hyperbrachycephalene
1. Blaa—graa øine, lysebrunt haar	21,00	30,00	20,60	19,20	24,60
2. Blaa—graa øine, blondt haar	19,31	22,50	19,60	20,00	12,30
3. Blaa—graa øine, mørkebrunt haar...	17,00	10,00	20,60	13,60	8,75
4. Lyst melerte øine, lysebrunt haar ...	7,55	7,50	7,29	7,25	10,50
5. Lyst melerte øine, mørkebrunt haar .	7,55	2,50	8,25	7,25	8,75
6. Brune øine, mørkebrunt haar.......	5,45	10,00	4,44	5,64	7,00
7. Mørkt melerte øine, mørkebrunt haar	4,40	7,50	3,16	5,21	5,25
8. Brune øine, sort haar	4,25	2,50	2,52	6,45	5,25
9. Lyst melerte øine, blondt haar	3,29	2,50	3,40	2,80	3,50
10. Mørkt melerte øine, lysebrunt haar..	3,02	2,50	3,16	3,20	1,75
11. Brune øine, lysebrunt haar	1,81	2,50	1,26	2,40	1,75
12. Blaa—graa øine, sort haar.........	1,66	-	0,95	1,60	7,00
13. Mørkt melerte øine, sort haar	1,21	-	0,95	1,60	1,75
14. Blaa øine, rødt haar	0,91	-	1,58	0,40	-
15. Lyst melerte øine, sort haar	0,91	-	1,26	0,80	-
16. Brune øine, blondt haar	0,75	-	0,31	1,00	-
17. Mørkt melerte øine, blondt haar	0,45	-	0,63	-	1,75
18. Lyst melerte øine, rødt haar	0,15	-	-	0,40	-
19. Brune øine, rødt haar............	0,15	-	-	0,40	-
20. Mørkt melerte øine, rødt haar	-	-	-	-	-

Gruppenes størrelse blir da saaledes som anført paa tabel 35. Længst tilhøire paa denne tabel har jeg anført de forskjellige kombinationers pigmentværdi.

Paa tabel 36 har jeg saa summert sammen de grupper som har pigmentværdi 0, 1, 2, 3, 4, 5 og 6. Nul betegner altsaa her den rene blonde types størrelse, 1, 2, 3, 4, 5, 6 indeholder jevnt økende pigment, 6 er den helt mørke type.

Tilnærmelsesvis kan man da si at 1ste gruppe indeholder 1 mørk kvantitet og 5 lyse.

2	gruppen	indeholder	2	mørke	og 4	lyse	kvantiteter
3	—	—	3	—	3	—	—
4	—	—	4	—	2	—	—
5	—	—	5	—	1	—	—
6			6		0		

Tabel 35.

	Blandt samtlige undersøkte	Blandt dolichocephalene	Blandt mesocephalene	Blandt brachycephalene	Blandt hyperbrachycephalene	
1. Blaa—graa øine, lysebrunt haar...	21,00	30,00	20,60	19,20	24,60	0 + 1 = 1
2. Blaa—graa øine, blondt haar.....	20,22	22,50	21,18	20,40	12,30	0 + 0 = 0
3. Blaa—graa øine, mørkebrunt haar.	17,00	10,00	20,60	13,60	8,75	0 + 2 = 2
4. Lyst melerte øine, lysebrunt haar.	7,55	7,50	7,29	7,25	10,50	1 + 1 = 2
5. Lyst melerte øine, mørkebrunt haar	7,55	2,50	8,25	7,25	8,75	1 + 2 = 3
6. Brune øine, mørkebrunt haar.....	5,45	10,00	4,44	5,64	7,00	3 + 2 = 5
7. Mørkt melerte øine, mørkebrunt haar	4,40	7,50	3,16	5,21	5,25	2 + 2 = 4
8. Brune øine, sort haar...........	4,25	2,50	2,52	6,45	5,25	3 + 3 = 6
9. Lyst melerte øine, blondt haar ...	3,44	2,50	3,46	2,80	3,50	1 + 0 = 1
10. Mørkt melerte øine, lysebrunt haar	3,02	2,50	3,16	3,20	1,75	2 + 1 = 3
11. Brune øine, lysebrunt haar	1,81	2,50	1,26	2,40	1,75	3 + 1 = 4
12. Blaa—graa øine, sort haar.......	1,66	-	0,95	1,60	7,00	0 + 3 = 3
13. Mørkt melerte øine, sort haar	1,21	-	0,95	1,60	1,75	2 + 3 = 5
14. Lyst melerte øine, sort haar	0,91	-	1,26	0,80	-	1 + 3 = 4
15. Brune øine, blondt haar.........	0,90	-	0,31	2,00	-	3 + 0 = 3
16. Mørkt melerte øine, blondt haar ..	0,45	-	0,63	-	1,75	2 + 0 = 2

Blaa—graa øine = 0	Blondt og rødt haar = 0
Lyst melerte øine = 1	Lysebrunt haar = 1
Mørkt melerte øine = 2	Mørkebrunt haar = 2
Brune øine = 3	Sort haar = 3

Tabel 36.

	Blandt samtlige undersøkte	Blandt dolichocephalene	Blandt mesocephalene	Blandt brachycephalene	Blandt hyperbrachycephalene
0 =	20,22	22,50	21,18	20,40	12,30
1 =	24,44	32,50	24,06	22,00	28,10
2 =	25,00	17,50	28,52	20,85	21,02
3 =	13,13	5,00	12,67	14,05	17,50
4 =	6,30	10,00	5,06	9,01	7,08
5 =	6,66	10,00	5,39	7,24	8,75
6 =	4,25	2,50	2,52	6,45	5,25
	100,00	100,00	100,00	100,00	100,00

Beregner jeg paa denne maate værdien av hver pigmentgrad og samler de lyse kvantiteter for sig og de mørke for sig, blir resultatet som anført paa tabel 37.

Jeg kommer da til det resultat, at den lyse blok i denne befolkning utgjør 66,05 % og den mørke 33,95 % av den samlede befolkning.

Tabel 37.

	Blandt samtlige undersokte		Blandt dolichocephaler		Blandt mesocephaler		Blandt brachycephaler		Blandt hyperbrachycephaler	
	% lyse	% morke	% lyse	% morke	% lyse	% morke	% lyse	% morke	% lyse	% morke
0	20,22	0,00	22,50	0,00	21,18	0,00	20,40	0,00	12,30	0,00
1	10,39	5,05	27,00	5,41	20,05	4,01	18,34	3,66	23,42	4,68
2	10,07	8,33	11,07	5,83	20,00	8,50	14,00	6,85	14,00	7,00
3 =	6,56	6,57	2,50	2,50	6,34	6,33	7,03	7,02	8,75	8,75
4 =	2,10	4,20	3,33	6,67	1,88	3,78	3,00	6,00	2,30	4,72
5 =	1,11	5,55	1,62	8,38	0,89	4,50	1,20	6,04	1,46	7,29
6 =	0,00	4,25	0,00	2,50	0,00	2,52	0,90	6.45	0,00	5,25
	66,05	33,05	68,71	31,20	70,34	29,66	63,97	36,03	62,20	37,71

Den lyse blok er avgjort storst blandt mesocephalene. Den er kun litt mindre blandt dolichocephalene. Blandt brachycephalene og hyperbrachycephalene er den derimot betydelig mindre, henholdsvis $6^{1}/_{2}$ % og 8 % mindre end blandt mesocephalene.

VIII. Affinitetsundersøkelser.

Den fremgangsmaate, som i de senere aar av antropologene har været anvendt for at finde hvilke træk som er biologisk samhorige, er beregning av korrelationskoefficienten efter Bravais' formel. Det forekommer mig imidlertid, at de resultater man har høstet, ikke egentlig frister til fortsat anvendelse av denne metode.

Professor Fischer kommer i sit verk „Die Rehobother Bastards" til det resultat, at „in einer seit Generationen bestehenden Bastardpopulation zwischen den meisten Rassenmerkmalen keine feste Korrelation bezüglich der Vererbung besteht".

Dr. Kaarlo Hildén har nylig utgit en storre avhandling „Anthropologische Untersuchungen über die Eingeborenen des russischen Altai". Han benytter sig ogsaa av Bravais' formel i dette oiemed. Og resultatet er det samme: „jedoch läßt sich aus den Ziffern mit Bestimmtheit schließen, daß eine wirkliche Korrelation nicht existiert" (side 79).

Og i Meddelelser om Danmarks Antropologi, Bd. I, p. 275, har man av C. Burrau en meget detaljert matematisk granskning av det av den danske komité indsamlede materiale. Det synes mig at ogsaa hans vidtløftige metode gir et noksaa magert resultat. I sin avhandling „To grundracer i det danske folk" siger dr. Andr. M. Hansen om denne metode: „Det viser sig ogsaa at den matematiske sikkerhet, den kvantitative noiagtighet, som skulde vindes ved de overhaands møisommelige og haarfint beregnede størrelser, til syvende og sidst svigter. Det avløses i virkeligheten av et temmelig løst skjøn, naar de begrepsuklare hjælpestørrelser endelig skal anvendes som grundlag for de slutninger som overhodet har nogen positiv værd for den antropologiske undersøkelse."

„Den uhyre besværlige og meget kostbare beregningsmetode *svigter baade i begrepsmæssig klarhet og i kvantitativ præcisjon. Den har videre endnu en avgørende mangel i praktisk bruk. Den gir vistnok et almindelig uttryk for hyppighetstabellernes samlede korrelasjonsforhold. Men den er fuldstændig ute av stand til at gi overblik over kendsgerningernes vekslende forhold utover observasjonsfeltets forskellige deler.* Det ubetingede maal for en virkelig biologisk analyse av de observerede antropologiske forhold som gjengis i tabellerne, er med lethet og sikkerhet at finde og skille ut hvor det særegne, det typiske optrær utskilt i kombinasjonerne, eller hvor den efter almindelig sandsynlighetsberegning givne regelmæssige fordeling av tallene avbrytes av kombinasjoner av bestemte karakterer, som optrær hyppigere end de efter sandsynlighetsberegningen skulde ventes mellem uavhængig variable, som altsaa maa være betinget av bestemte biologiske faktorer, av racebestemt korrelasjon."

Jeg er tilbøielig til at tro, at den skarpe dom som dr. ANDREAS M. HANSEN her fælder over den vanlige korrelationsberegnings værdi, er fuldt berettiget.

„Ved den superfine høimatematiske beregningsteknik blir man efter et umaatelig vitløftig arbeide staaende ved tal hvis vegt eller logiske indhold er fuldstændig dunkelt, man har intet nærliggende forstaaelig middel til at avgøre hvor stor affinitet $r = \div 0.09$ svarer til, om det angir en reel rase-faktor eller ikke. Kvantiteten hos de rent abstrakte hjælpestørrelser gir som vist ikke engang grundlag for et blot nogenlunde sikkert skøn" (A. M. H., p. 226).

Den ovennævnte letvinte fremgangsmaate, efter den mest elementære sandsynlighetsberegning, som jeg i denne avhandling skal gjøre nærmere rede for, tillater os at overse med største lethet forholdene i det store og likeledes at skille ut og præcisere spørsmaalene i detalj, og gir os direkte aritmetiske maal til forstaaelse av koefficientenes logiske vegt.

For 16 aar siden offentliggjorde dr. ANDR. M. HANSEN i sin bok „Landnåm i Norge", 1904, sin metode for denne slags undersøkelser. Senere har han i sin avhandling „To grundracer i det danske folk"[1] nærmere gjort rede for denne sin metode.

I denne avhandling paaviser han ogsaa den vanlige korrelationsberegnings mange mangler, dens ufuldkommenhet, dens besværlighet.

[1] Trykt i Nyt Magazin for Naturvidenskaberne, bd. 53, 1915, s. 203—267.

Man kan paa en langt enklere maate tilveiebringe langt klarere uttryk for korrelationsforholdene gjennem hans affinitetsmetode.

Hvis en bestemt egenskap, til eks. dolichocephali, er fundet et bestemt antal gange (d) blandt et visst antal undersøkte (S), saa er utsigten til at støte paa denne egenskap inden befolkningen i sin almindelighet $\frac{d}{S}$. Likeledes til eks. med blaaøiede individer $\frac{b}{S}$.

Det er nu umiddelbart logisk indlysende, at hvis der ikke er nogetsomhelst biologisk sammenhæng mellem disse to egenskaper, saa vil man ogsaa blandt de $\frac{b}{S}$ blaaøiede finde kun en brøkdel $\frac{d}{S}$ dolichocephaler, altsaa $\frac{d}{S} \times \frac{b}{S}$. Er nu den brøkdel $\frac{a}{S}$, som undersøkelsen gir til resultat, merkbart større end $\frac{d}{S} \times \frac{b}{S}$, saa taler dette for at der er et naturlig, biologisk, racebestemt sammenhæng, for antropologisk „affinitet" mellem disse to egenskaper.

Og et maal for styrken av denne affinitet faar man simpelthen ved at finde forholdet mellem den *fundne* brøkdel og den ved sandsynlighetsberegningen under forutsætning av fuldstændig uafhængighet mellem egenskaperne *givne* brøkdel:

$$\frac{\frac{a}{S}}{\frac{d}{S} \times \frac{b}{S}} = \frac{a \cdot S}{d \cdot b}.$$

Denne hans affinitetsformel er jo meget letvint og grei. Selv fremhæver dr. ANDR. M. HANSEN som en stor fordel ved formelen at den er fortrinlig logaritmisk.

Men bruken av logaritmetabellen er jo aldeles ikke nogen a b c for alle antropologer.

Og man kan ogsaa finde de samme affinitetstal paa en efter min mening betydelig enklere maate end den av dr. ANDR. M. HANSEN paaviste.

Jeg sætter at jeg i en given befolkning har fundet til eks. 10,8 % brunøiede individer.

Hvis der nu ikke eksisterer nogen biologisk sammenhæng mellem brunøiethet og kortskallethet, saa bør jeg ogsaa blandt de kortskallede finde ca. 10,8 % brunøiede. Hvis jeg nu istedenfor 10,8 % finder til eks. 17,0 % blandt de kortskallede, mens jeg kun finder til eks. 6,5 % blandt de langskallede, og dette samme forhold gjentar sig flere steder og til flere tider, saa kan dette kun forklares gjennem en biologisk sammenhæng mellem disse to egenskaper. Hvis jeg nu dividerer det førstnævnte procenttal med det sidstnævnte, saa har jeg affinitetstallet.

Og dette kan uten vanskelighet utføres av hver og en, simplest ved hjelp av en almindelig regnestok.

Min formel er altsaa, naar jeg anvender de samme bokstaver som ovenfor er anvendt i ANDREAS M. HANSENS formel, følgende:

$$\frac{\frac{a}{d}}{\frac{b}{s}} \text{ hvilken brøk ved at multiplicere baade tæller og nævner med } \frac{d}{s} \text{ blir } \frac{a\,s}{b\,d}$$

Der er altsaa i realiteten ingen forskjel paa dr. ANDREAS M. HANSENS metode og denne. Men mens han regner med absolute tal og logaritmer, regner jeg med to procenttal som divideres. Det er altsaa kun en forenkling av hans metode jeg har benyttet i det følgende, ti procenttallene har man allerede av andre grunde utregnet. Det ved beregningen fundne affinitetstal kan defineres saaledes:

Affinitetstallet er forholdet mellem den fundne brokdel av undersøkte hos hvem de to egenskaper findes kombinert, og det efter sandsynlighetsberegningen givne, naar de to egenskaper varierer uavhængig av hverandre.

Hensigten med affinitetsundersøkelsen er altsaa at utpeke mellem hvilke antropologiske eiendommeligheter der kan antages at herske nogen biologisk sammenhæng. Denne biologiske sammenhæng gir sig paa affinitetstabellen tilkjende gjennem størrelsen av affinitetstallene. Et stort affinitetstal som støtter sig til store absolute tal, taler for en biologisk sammenhæng mellem de to træk som har det store tal. Omvendt tyder et litet tal paa at der ikke er noget biologisk sammenhæng.

Selv om et affinitetstal ikke er særlig stort (meget større end 1), kan det dog peke paa en biologisk sammenhæng, hvis det hviler paa meget store absolute tal. Endvidere vil jeg peke paa, at man maa gaa ut fra en biologisk sammenhæng naar der i flere undersøkelsesrækker fra forskjellige distrikter findes tilsvarende affinitetstal.

Paa tabel 38 vil det sees at jeg har inddelt efter index cephalicus i 5 grupper. Jeg har saaledes opstykket brachycephalene i to grupper, en fra 81—84 og en anden fra 85—93. Det har jeg gjort, fordi den somatiske undersøkelse av befolkningen gjør det sandsynlig at der findes to genotyper av brachycephaler inden befolkningen. Det vil da være av stor betydning om affinitetsundersøkelsen støtter denne antagelse.

Muligens kan ogsaa affinitetsundersøkelsen bidra til, at man faar rede paa hvilke eiendommeligheter som er særegne for hver av de to typer.

Jeg har ogsaa samlet dolichocephalene i en gruppe for sig, fordi undersøkelser fra andre kanter av vort land tyder paa at der ogsaa indgaar en eller muligens to dolichocephale genotyper i vor befolkning, om end begge meget sparsomt.

Saa har jeg ogsaa delt mesocephalene i to grupper. Denne gruppe er saa talrik at en saadan opstykning med lethet lar sig gjøre. Grænsen mellem paa den ene side dolichocephaler og mesocephaler og paa den anden side mellem brachycephaler og mesocephaler er jo svævende. De

Tabel 38. Affinitetsundersøkelser efter index cephalicus inden den norske befolkning i Troms fylke.

a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s
	Absolute tal						Procenttal						Affinitetstal				
Index cephalicus.	67—75	76—78	79—80	81—84	85—93	Sum	67—75	76—78	79—80	81—84	85—93	0/0 av samtl. unders.	67—75	76—78	79—80	81—84	85—93
Antal	37	136	139	194	53	559	6,5	24,6	24,8	34,8	9,5						
1. Meget smaa 145—165 cm.	12	23	19	29	11	94	32,2	16,9	13,7	14,8	20,4	16,8	1,91	1,01	0,81	0,89	1,21
2. Smaa 166—168 —	6	24	22	42	11	105	16,2	18,4	15,8	21,8	20,4	18,8	0,86	0,97	0,84	1,16	1,08
3. Middels høie 169—170 —	4	23	18	23	3	71	10,8	16,9	12,9	11,9	5,8	12,7	0,85	1,33	1,02	0,94	0,46
4. Høie 171—176 —	10	32	49	86	22	199	27,0	23,2	35,5	44,3	41,6	35,6	0,75	0,65	0,99	1,25	1,15
5. Meget høie 177—200 —	5	35	31	14	6	90	13,5	25,3	22,1	7,2	11,2	16,1	0,84	1,57	1,38	0,45	0,70
1. Blondt haar	9	27	42	47	13	138	24,2	19,6	30,2	24,1	24,6	24,8	0,98	0,79	1,21	0,98	0,99
2. Rødt haar	2	2	1	3	1	8	5,4	1,5	0,7	1,55	1,8	1,6	3,40	1,80	0,43	0,97	1,12
3. Lysebrunt	15	50	41	64	22	192	40,5	36,4	29,7	33,0	41,6	34,2	1,26	1,09	0,87	0,97	1,22
4. Mørkebrunt haar	10	50	48	64	16	198	27,0	36,4	54,3	33,0	30,2	35,6	0,76	1,02	1,06	0,93	0,87
5. Sort haar	1	7	7	16	1	32	2,7	5,1	5,1	8,4	1,8	5,7	0,49	0,89	0,89	1,47	0,37
1. Euryprosopi	7	31	51	75	13	187	18,9	22,8	36,8	38,6	43,6	33,5	0,56	0,67	1,10	1,15	1,30
2. Mesoprosopi	12	35	48	67	19	181	32,2	25,8	34,4	34,6	35,9	32,5	1,06	0,80	1,06	1,06	1,10
3. Leptoprosopi	18	70	40	52	11	191	48,5	51,4	28,8	26,8	20,5	34,0	1,51	1,50	0,85	0,79	0,61
1. Liten transv. fr.-pariet. index	6	37	50	81	35	209	16,2	27,2	35,8	41,7	66,0	37,4	0,43	0,72	0,96	1,11	1,56
2. Middels —„— —„—	7	34	40	68	8	157	18,9	25,3	28,7	35,0	15,1	28,2	0,71	0,88	1,02	1,24	0,58
3. Stor —„— —„—	24	65	49	45	10	193	64,9	47,5	35,5	23,3	18,9	34,4	1,95	1,42	1,03	0,68	0,55
1. Liten jugo-frontal index	8	40	46	78	26	198	21,6	29,4	33,1	40,2	49,1	35,6	0,64	0,82	0,93	1,13	1,38
2. Middels — —	16	59	70	84	16	245	43,2	43,5	50,4	43,3	30,1	44,0	0,98	0,99	1,14	0,99	0,69
3. Stor — —	13	37	23	32	11	116	36,2	27,1	16,5	16,5	20,8	20,4	1,82	1,31	0,82	0,82	1,03
1. Blaa øine	24	84	95	108	33	344	64,9	61,5	68,5	56,0	62,4	61,8	1,09	0,99	1,11	0,91	1,01
2. Lyst melerte øine	5	31	27	36	11	110	13,5	22,8	19,5	18,5	20,8	19,7	0,69	1,16	0,99	0,94	1,06
3. Mørkt melerte øine	4	11	7	23	2	47	10,8	8,1	5,0	11,8	3,8	8,4	1,29	0,92	0,60	1,40	0,45
4. Brune øine	4	10	10	27	0	58	10,8	7,6	7,2	13,0	17,0	10,8	1,00	0,68	0,66	1,28	1,56

gaar selvfølgelig gjensidig ind paa hinandens omraade. Derfor har jeg anset en saadan opstykning av mesocephalene heldig.

For de øvrige egenskapers vedkommende har jeg ogsaa foretat en tilsvarende opstykning i 3, 4 eller 5 grupper. Derved faar man fra 15 til 25 grupper med likesaa mange affinitetstal.

Enkelte grupper kan derved bli meget smaa og affinitetstallene i samme grad usikre. Hvor dette viser sig at være tilfældet, har jeg sammendrat til større grupper, som paa tabel 39, hvor jeg samtidig har medtat alle de av mig undersøkte i Troms fylke.

For derefter at belyse fremgangsmaaten ved et eksempel vil jeg henvise til tabel 38. Denne undersøkelse omfatter i alt 559 mand.

Jeg vil undersøke affinitetsforholdene, idet jeg lægger index cephalicus til grund. Den av mig anvendte inddeling efter index cephalicus findes i øverste linje. I næste linje findes opført hvor mange individer der falder paa hver index cephalicus, først i absolute tal, dernæst i procent.

Jeg har altsaa nu opdelt materialet i 5 grupper.

Hver av disse 5 grupper opdeles saa videre efter legemshøiden i de 5 undergrupper som sees anført øverst tilvenstre paa tabellen.

For hver enkelt indexgruppe tælles op hvor mange individer som findes i hver av de anførte høidegrupper. Ogsaa dette omberegnes til procenttal. Disse findes opført i kolonnene *h* til *m*. I kolonne *g* og *n* findes opført hvor mange der blandt samtlige undersøkte falder paa hver av de anførte høidegrupper, i hele tal og i procent.

Dermed har jeg alt hvad der behøves til beregning av affinitetstallene for legemshøide og cephalindex.

Jeg vet nu at der blandt alle de av mig her undersøkte findes 16,8 % med en legemshøide mellem 145 og 165 cm. Blandt dolichocephalene er der derimot 32,2 % av denne legemshøide. Misforholdet er jo her rent iøinefaldende. Men matematisk finder det klarest sit uttryk ved at dividere det sidstnævnte tal med det første, saaledes:

$$\frac{32{,}2}{16{,}8} = 1{,}91$$

Paa samme maate gaaes saa frem med alle de andre fundne procenttal. Derved fremkommer de længst tilhøire paa tabellen anførte affinitetstal, hvorved man unegtelig faar et letvint og, efter min mening med visse forbehold, ogsaa meget paalidelig overblik over affinitetsforholdene inden en given befolkning.

Jeg skal i det følgende gi en fremstilling av de resultater jeg er kommet til ved en affinitetsundersøkelse av en nordnorsk befolkning. Alle de undersøkte er mænd i 21-aarsalderen, bosat i Troms fylke i Nordnorge. Middelhøiden hos de undersøkte var 170,168 cm. Den gjennemsnitlige størrelse av cephalindex var 80,77. Av de undersøkte opgav 83,2 % at

Tabel 39. Affinitetsundersøkelser efter index cephalicus, omfattende samtlige undersøkte.

		Antal					Affinitetstal				
		Index cephalicus					Index cephalicus				
		67—75	76—78	79—80	81—84	85—93	67—75	76—78	79—80	81—84	85—93
A	1. Meget smaa 145—165 cm.	13	27	32	45	28	**1,43**	0,87	0,87	0,89	**1,63**
	2. Smaa 166—168 —	7	26	29	48	14	0,98	0,95	0,93	**1,12**	0,96
	3. Middels 169—170 —	4	28	19	32	4	0,80	**1,25**	0,86	1,04	0,78
	4. Høie 171—176 —	10	33	54	93	22	0,82	0,70	1,01	**1,25**	0,88
	5. Meget høie 177—200 —	5	35	33	15	6	0,92	**1,69**	**1,39**	0,49	0,55
B	1. Blondt og rødt haar	9	36	48	59	13	0,94	0,93	**1,15**	1,02	0,81
	2. Lysebrunt haar	17	52	49	74	34	**1,23**	**1,04**	0,86	0,93	**1,30**
	3. Mørkebrunt haar	12	54	60	77	22	0,29	**1,09**	0,77	0,97	0,84
	4. Sort haar	1	7	10	23	5	0,36	0,75	0,83	**1,36**	0,91
C	1. Blaa øine	24	91	110	125	39	1,04	1,03	**1,14**	0,94	0,85
	2. Lyst melerte øine	5	38	29	43	18	0,65	**1,29**	0,85	0,89	1,19
	3. Mørkt melerte øine	4	11	11	27	5	1,19	0,86	0,75	**1,32**	0,73
	4. Brune øine	6	9	17	38	12	**1,24**	0,47	0,78	**1,14**	**1,59**
D	1. Euryprosopi 70—83	8	30	64	96	37	0,50	0,70	1,11	**1,13**	**1,31**
	2. Mesoprosopi 84—87	11	39	57	80	24	0,82	0,84	1,03	1,07	1,13
	3. Leptoprosopi 88—100	20	70	50	57	13	**1,75**	**1,52**	0,91	0,88	0,52
E	1. Stenometopi 63—70	5	39	57	92	45	0,44	0,74	0,95	**1,08**	**1,61**
	2. Mesometopi 71—72	7	34	45	82	18	0,60	0,77	0,89	**1,16**	0,75
	3. Eurymetopi 73—81	27	73	65	59	15	**1,94**	**1,49**	**1,15**	0,85	0,57
F	1. Liten jugo-frontal index 70—77	9	43	53	94	33	0,67	0,84	0,91	**1,15**	**1,36**
	2. Middels — — 78—80	14	64	81	99	28	0,83	1,01	**1,12**	0,99	0,83
	3. Stor — — 81—93	16	39	33	40	17	**1,80**	**1,22**	0,91	0,79	0,76

Tabel 40.

		D.	M.	B.	H. B.	Total	D.	M.	B.	H. B.	Total	D.	M.	B.	H. B.
	Antal	39	316	233	74	662									
	Index cephalicus	67—75	76—80	81—84	85—93										
A	1. Lave 145—170 cm.	22	158	125	46	351	56,5	50,0	54,0	63,0	53,1	1,06	0,94	0,92	1,18
	2. Høie 171—200 —	17	158	108	28	311	43,5	50,0	46,0	37,0	46,9	0,92	1,07	0,98	0,70
B	1. Blondt, rødt og lysebrunt haar	26	185	133	47	391	67,8	59,0	57,0	64,5	59,1	1,15	0,00	0,00	1,08
	2. Mørkebrunt haar	12	114	77	22	225	31,8	35,6	33,0	30,0	34,0	0,94	1,05	1,07	0,88
	3. Sort haar	1	17	23	5	46	2,4	5,4	10,0	5,5	6,9	0,35	0,78	1,45	0,80
C	1. Blaa og graa øine	24	201	125	39	389	61,5	64,0	53,8	53,0	58,8	1,08	1,00	0,94	0,92
	2. Lyst melerte øine	5	67	43	18	133	12,8	21,1	18,5	24,0	20,0	0,95	1,05	0,93	1,20
	3. Mørkt melerte øine	4	22	27	5	58	10,3	7,0	11,6	6,8	8,7	1,32	0,80	1,34	0,78
	4. Brune øine	6	26	38	12	82	15,4	7,9	16,1	16,2	12,5	1,23	0,93	1,20	1,20
D	1. Euryprosopi	8	100	96	37	241	20,6	31,6	41,0	50,0	36,2	0,57	0,82	1,13	1,30
	2. Mesoprosopi	11	96	80	24	211	82,2	30,4	34,4	32,4	32,2	0,88	0,94	1,17	1,01
	3. Leptoprosopi	20	120	57	13	210	51,2	38,0	24,6	17,0	31,6	1,02	1,20	0,78	0,50

være rent norsk, 4,5 % opgav at være rene lapper, 2,4 % rene kvæner. Resten var av blandet norsk, lappisk-kvænsk herkomst.

Jeg gaar derefter over til en nærmere gjennemgaaelse av de her utarbeidede affinitetstabeller og begynder da med tabel 39, som omfatter alle de av mig i Troms fylke undersøkte. Jeg vil her først se paa affinitetstallene for den hyperbrachycephale gruppe længst tilhøire paa tabellen. Det vil da straks sees av denne tabel at der er en meget utpræget affinitet mellem denne index og *meget liten legemshøide*. Inden alle de øvrige høidegrupper er affiniteten negativ, og der er med engang et vældig sprang fra laveste til næstlaveste høidegruppe (1,63—0,96). Denne samme index viser ogsaa en utpræget affinitet til *lysebrunt haar* (1,30), men negativ affinitet til alle de øvrige haartyper. Endvidere har samme index en meget sterk affinitet til *euryprosopi* (1,31).

Likeledes har den meget høie affinitetstal for *stenometopi* (ɔ: en meget smal pande i forhold til hodets bredde) og *liten jugo-frontal index*. Dette betyr at denne type maa ha relativt *meget liten pandebredde*. Endelig viser det sig at samme index har stort affinitetstal for *brune øine*, medens den heller ikke er uten affinitet til lyst melerte øine. Alle disse affinitetstal er saa store og hviler paa saavidt store tal, at man maa ha lov til at gaa ut fra at de kun kan tydes som bevis for en biologisk sammenhæng mellem denne index og de anførte eiendommeligheter. At denne index samtidig har et høit affinitetstal for brune øine og et lavere tal for lyst melerte øine, medens affinitetstallet for mørkt melerte øine er litet, kan bero paa vanskeligheten eller umuligheten av at trække op skarpe grænser mellem de lyst og de mørkt melerte øine.

Hvis der nu kun er *én* brachycephal genotype inden vor befolkning, saa maa man vente at finde ialfald tilnærmelsesvis lignende affinitetstal inden den ovennævnte brachycephale gruppe med index 81—84. Denne gruppes tal kan ikke ventes at være saa rene som den førstes. Den ligger nemlig klemt mellem 2 andre. Det er uundgaaelig at saavel endel +-avvikere av den mesocephale type som endel ÷-avvikere av den hyperbrachycephale gruppe kommer med her, og begge vil de gjøre sit til at utviske affinitetsforholdene. En nærmere undersøkelse bringer dog straks paa det rene at denne index har sine egne affiniteter, helt uavhængig av begge nabotypenes.

Særlig naar det gjælder legemshøiden, gjør nabotypenes indflydelse sig dog sterkt gjældende. Denne index viser 3 positive affinitetstal, 1,12, 1,04 og 1,25, for de 3 mellemhøie grupper. Det er da sandsynlig at dens affinitetstal maa ligge indenfor dette omraade fra 166 til 176 cm.

For at bringe dette nærmere paa det rene har jeg paa tabel 40 inddelt efter høiden i kun to grupper, 145 til 168 cm. og 169 til 200 cm., likesom jeg her kun har medtat de som selv regner sig for norske. Som man vil se, er der da et sikkert positivt affinitetstal for den mindste av disse legemshøider. Man kan da i høiden slutte herav at typens høide ligger mellem 145 og 168 cm.; men da det allerede før er bragt paa det rene at denne type ikke har affinitet til meget liten legemshoide (ɔ: 145—165 cm.), er det sandsynlig at typens affinitet kan begrænses til hoide 166 à 168 cm.

Er denne index's affinitetsforhold til legemshoiden litt uklar, saa er affinitetsforholdet til haarfarven saa meget desto tydeligere. Den har et meget hoit affinitetstal til *sort haar*, 1,36, og her kan ikke nogen naboindflydelse ha gjort sig gjældende. Det er ogsaa den eneste index som viser affinitet til sort haar. Der er saa meget mindre grund til at tvile her som den samme index ogsaa paa Sondmor utvilsomt har affinitet til sort haar[1].

Den har fremdeles en tydelig affinitet til euryprosopi. Affinitetstallene er jevnt og typisk synkende mot leptoprosopi. Men det er dog tydelig at denne index *ikke har saa sterk affinitet* til euryprosopi som indexgruppe 85—93.

Det samme er tilfældet med denne index's forhold til den transversale fronto-parietalindex og den jugo-frontale index. Alt dette staar i god samklang og finder sin forklaring deri, at den type som har denne cephalindex,

Tabel 41.

Index cephalicus	Antal			Affinitetstal		
	67—80	81—84	85—93	67—80	81—84	85—93
1. Smaa 145—168....	106	71	31	0,95	1,03	1,17
2. Hoie 169—200....	206	123	22	1,03	0,98	0,91
1. Blaa oine	203	108	33	1,06	0,91	1,01
2. Melerte oine.......	85	59	13	0,97	1,08	0,87
3. Brune oine	24	27	9	0,74	1,28	1,27

maa ha en relativt *storre pandebredde end den anden brachycephale type*. Endelig viser denne index sig at ha tydelig *affinitet til brune og morkt melerte oine*. Dens forhold til oientypene trær endnu tydeligere frem av tabel 41. Av denne tabel fremgaar nemlig at dens affinitet til brune og melerte oine er sterkere end den anden brachycephale gruppes.

I det hele tat kan man vel si at affinitetsundersokelsene meget tydelig peker i den retning, at man her i Troms fylke har med to brachycephale typer at gjøre. Den ene, hvis index cephalicus ligger mellem 85 og 93, har *meget* liten legemshoide, lysebrunt haar, er meget sterkt euryprosop, har meget liten transversal fronto-parietalindex og meget liten jugo-frontalindex, altsaa en relativt smal pande. Typen synes at ha affinitet baade til brune og lyst melerte oine. At dette ikke kan være andet end de egte fjeldlapper, samene, derom kan heller ingen være i tvil.

[1] Se herom Møre fylkes antropologi, Vid.-Selsk. Skrifter, Kristiania 1920, klasse I, nr. 7.

Den anden brachycephale type er ogsaa liten av vekst, dog hoiere end foregaaende, har sort haar og brune oine, er euryprosop, men i mindre grad end foregaaende; den har en middels transversal fronto-parietalindex og en liten jugo-frontalindex, den sidste dog storre end hos foregaaende gruppe.

Denne gruppe svarer i alle karaktertræk til den brachycephale type som jeg for har skildret fra Søndmor, og som jeg der har betegnet som en nordlig utloper av den centraleuropæiske alpine race.

Som man vil se, er den her i Troms fylke ganske talrik. Hvis samtlige individer med index 81—84 tilhorte denne gruppe, saa skulde gruppen utgjore 34,8 % av samtlige undersøkte. Sandsynlig er det vel at den store mesocephale gruppe har endel +-avvikere med her, og sandsynligvis nogen flere end den anden har av ÷-avvikere i mesocephalenes rækker. Mesocephalenes gruppe er nemlig 50 % storre.

Paa den anden side har selvfolgelig denne subbrachycephale gruppe avgit en god del +-avvikere til den hyperbrachycephale gruppe, som ogsaa derved er blit noget for stor. Men man er vel ialfald ikke meget langt fra det rigtige tal, naar man regner med at den lappoide gruppe utgjør henimot 4 % og den alpine gruppe omkring 30 % av den nuværende befolkning.

Et blik paa indextallene for de to mesocephale grupper viser straks at der ikke er nogen væsensforskjel paa dem. De gaar i samme retning i begge grupper, men tegner sig dog tydeligst i gruppen 76—78. Gruppen 76—78 omfatter jo ogsaa netop kjernen av den nordiske race, medens gruppen 79—80 er dens +-avvikere, som selvfølgelig vil være forurenset med endel ÷-avvikere fra den alpine brachycephale gruppe.

Fælles for begge disse grupper er at de har hoie affinitetstal for meget stor legemshoide (177—200). Men som det vil sees, har ogsaa index 76—78 meget hoie affinitetstal for den middels legemshøide.

Jeg har i Trøndelagens Antropologi fremholdt som sandsynlig at vi her i Trøndelagen har en type av denne legemshøide. Den er efter al sandsynlighet hvad tyskerne kalder en „Verschmelzungsgenotypus". Den er en krydsningstype. For at bli klar over dens antropologiske eiendommeligheter forovrig maa selvfølgelig legemshøiden lægges til grund for affinitetsundersokelsen. Denne tabel peker kun hen paa typens sandsynlige existens.

Disse to mesocephale grupper har fremdeles høie indextal for blondt og rodt haar.

Index 76—78 har meget hoit affinitetstal for leptoprosopi, stor transversal fronto-pariental index og stor jugo-frontal index. Begge mesocephale grupper har hoie indextal for blaa og for lyst melerte øine.

Den laveste index omfatter kun 39 individer. Naar disse skal fordeles paa 5 grupper, blir tallene saa smaa at man maa være ytterst varsom med at dra slutninger av affinitetstallene. Tilfældighetene faar altfor rik anledning til at spille med.

Tabel 42. Affinitetsundersøkelser av den lappiske befolkning i Troms fylke, efter index cephalicus.

	Absolute tal				Procenttal				Affinitetstal		
Index cephalicus . . .	67—80	81—84	85—93	Sum	67—80	81—84	85—93	0/0 av samlige undersøkte	67—80	81—84	85—93
Antal	16	21	15	52	30,5	40,5	20,0				
1. Meget smaa 145—165[1]	8	11	0	28	50,0	52,4	00,0	54,0	0,93	0,97	1,11
2. Smaa 166—170	5	5	6	16	31,2	23,8	40,0	30,8	1,01	0,77	1,30
3. Høie 171—200	3	5	-	8	18,8	23,8	-	15,4	1,22	1,54	-
1. Blondt haar	2	5	2	9	12,5	23,8	13,3	17,3	0,72	1,37	0,77
2. Lysebrunt haar.	5	3	7	15	31,2	14,3	46,7	29,0	1,13	0,50	1,61
3. Mørkebrunt haar	7	9	5	21	43,8	42,9	33,3	40,5	1,08	1,06	0,82
4. Sort haar	2	4	1	7	12,5	19,0	6,7	13,2	0,95	1,44	0,51
1. Euryprosoper 70— 83.	10	12	10	32	62,5	57,0	66,6	61,4	1,01	0,93	1,08
2. Mesoprosoper 84— 87.	2	6	2	10	12,5	28,6	13,3	19,3	0,65	1,43	0,78
3. Leptoprosoper 88—100.	4	3	3	10	25,0	14,4	20,1	19,3	1,30	0,85	1,04
1. Stenometopi 63—70	2	8	7	17	12,5	38,0	46,8	32,4	0,39	1,17	1,44
2. Mesometopi 71—72	3	6	4	13	18,8	28,6	26,6	25,0	0,75	1,15	1,06
3. Eurymetopi 73—81	11	7	4	22	68,7	33,4	26,6	42,6	1,61	0,78	0,70
1. Liten jugo-frontal index.	3	10	5	18	18,8	47,6	33,3	34,7	0,54	1,37	0,97
2. Middels — —	7	8	5	20	43,8	38,0	33,3	38,7	1,13	0,98	0,86
3 Stor	6	3	5	14	37,4	14,4	33,3	26,6	1,40	0,54	1,25
1. Blaa øine	5	7	5	17	31,3	33,4	33,3	32,4	0,97	1,03	1,02
2. Lyst melerte øine	4	5	6	15	25,0	23,8	40,0	28,8	0,86	0,80	1,38
3. Mørkt melerte øine	1	1	2	4	6,3	4,8	13,3	7,8	0,80	0,62	1,70
4. Brune øine.	6	8	2	16	37,4	38,0	13,3	30,8	1,21	1,23	0,43

[1] Der fandtes ingen under 145 cm.

Imidlertid er disse affinitetstal særdeles utprægede, og jeg vil tilføie særdeles karakteristiske. Index 67—75 har nemlig et meget høit affinitetstal til en liten legemshøide. Fremdeles har den et meget høit affinitetstal for brune øine.

Den har det høieste affinitetstal som findes paa hele tabellen, for leptoprosopi, eurymetopi og stor jugo-frontal index. Det er vanskelig at komme forbi disse tal. (Det synes som den betegner et utstraalingscentrum for smale ansigter med en relativt stor pandebredde). Naar hertil kommer at denne type maa være meget liten av vekst og har mørke øine, saa har man alle de træk som er karakteristiske for sydeuropæerne. Og at der findes isprængt vor befolkning ikke saa ganske faa elementer av sydeuropæiske racer, derom kan der ikke være tvil. Særlig er dette tilfældet langs kysten. Saa liten som den dolichocephale blok er i Troms fylke, skal der selvfølgelig ikke saa ret mange typiske individer til før det kan merkes ved en undersøkelse som denne.

Den befolkning som i Troms fylke benævnes lapper, er som allerede nævnt av en meget heterogen oprindelse. Der er blandt den samer som er krydset med russere, finner, svenske og norske. Kanske kommer der ind under denne gruppe endel individer av alpin race. Det vilde jo være av stor interesse om en affinitetsundersøkelse her kunde gi nogen veiledning. Blandt de av mig undersøkte var der kun 52 som mente sig helt eller delvis at være av lappisk herkomst. Det er et meget litet antal til denne slags undersøkelser.

For at bringe det mest mulige ut av dette lille materiale har jeg her, som det vil sees av tabel 42, anvendt en anden gruppeinddeling. Det fremgaar av denne tabel, at affinitetstallene for lappenes vedkommende peker i ganske samme retning som de gjorde for den norske befolknings vedkommende.

Index 85—93 viser høie affinitetstal for liten legemshøide, lysebrunt haar, mørkt melerte øine og liten tvansversal fronto-parietal index.

Der er i denne gruppe tydelig nok affinitet baade til europrosopi og leptoprosopi. Den anden brachycephale gruppe med index 81—84 viser tilsvarende indextal til de som fandtes inden den norske befolkning, med særlig utprægede tal for sort haar og mesoprosopi.

Den tredje gruppe av lapper med index 67—80 har høie indextal for alle de træk som særpræger den nordiske race: stor legemshøide, lysebrunt haar, leptoprosopi, stor transversal fronto-parietal index og stor jugofrontal index. Denne index har desuten et stort affinitetstal for brune øine, hvilket, som det vil erindres, ogsaa var tilfældet inden den norske befolknings dolichocephale gruppe.

Dette viser tydelig nok at de saakaldte lapper er av meget heterogen oprindelse.

De viser affinitet i 3 retninger:

a. til de eiendommeligheter som maa antages at være særegne for de egentlige fjeldlapper (samene), *b.* til de eiendommeligheter som er karakteristiske for den alpine race,

c. til de eiendommeligheter som er karakteristiske for den nordiske race.

Lappene er med andre ord utprægede bastarder. Og det er jo let forstaaelig. Ti historien fortæller os, at deres kvinder har krydset sig med andre folketyper hvor de har færdedes. Men avkommet har fulgt lappene (mødrene).

Der er en eiendommelighet som her i Norge er saa at si specifik for den nordnorske befolkning; den forekommer ialfald kun rent sporadisk hos voksne individer i de 5 sydligste bispedømmer.

Det er den eiendommelige foldedannelse mellem nedre og øvre øienlok som findes i den indre øienvinkel, og som i almindelighet kaldes plica marginalis. Der har været megen strid om denne foldedannelse har noget at gjøre med den saakaldte egte mongolfold.

Jeg skal ikke komme nærmere ind paa dette gamle stridsspørsmaal her. Jeg vil blot si at hos den her omhandlede befolkning finder man alle overganger fra typisk epicanthus til vel utviklet plica marginalis. Og man vil utvilsomt mange ganger være i tvil om man skal henregne en foldedannelse til forstnævnte eller til sidstnævnte gruppe.

Nu er det jo sikkert nok at egte mongolfold, saadan som den findes hos sydkineserne, vel hører til de store sjeldenheter hos os.

Men hvis man vil trække grænsen saaledes som prof. Eugen Fischer gjør i sit verk „Die Rehobother Bastards“, da finder man i mange tilfælder en egte mongolfold hos denne befolkning. Han hævder at epicanthus griper over paa nedre øienlok, plica marginalis gjør det aldrig.

Man finder denne eiendommelighet hos alle forskjellige folketyper i Troms fylke, hos nordmænd, lapper, kvæner og sjøfinner. Er det nu mulig gjennem en affinitetsundersøkelse at si noget om hvor dette karaktertræk har sine røtter, fra hvilken urtype vor befolkning har faat denne eiendommelighet?

Jeg har paa tabel 43 a inddelt alle de undersøkte efter index cephalicus i 4 grupper: dolichocephaler, mesocephaler, brachycephaler og hyperbrachycephaler. Jeg har for hver index opført hvor mange individer som har plica marginalis, hvor mange som mangler samme, og paa den foran beskrevne maate utregnet procenttallene. Længst tilhøire har jeg saa opført de fundne affinitetstal.

Det vil da sees at affinitetstallet for hyperbrachycephali og plica marginalis er overmaade stort, 1,48, medens alle andre indexer har negative tal.

Der kan efter min mening ikke være tvil om, at dette beviser at der eksisterer en biologisk sammenhæng mellem plica marginalis og hyperbrachycephali. Jeg har i det foregaaende avsnit fremholdt at denne index er specifik for lappene, og man skulde da være berettiget til at gaa ut fra, at det er lappene som har tilført vor befolkning denne eiendommelighet.

For at bringe dette endnu nærmere paa det rene har jeg paa tabel 43 b utregnet affinitetstallene for legemshøide og plica marginalis. Legemshøiden

Tabel 43.

a. Index cephalicus.

	Absolute tal					Procent					Affinitetstal			
Index cephalicus...	65—75	76—80	81—84	85—93	Sum	65—75	76—80	81—84	85—93	Gjennemsnitlig procent	65—75	76—80	81—84	85—93
Antal..........	38	313	233	78	662	5,7	47,5	35,1	11,7					
Plica marginalis findes hos	3	40	27	15	85	7,9	12,7	11,6	19,0	12,8	0,62	0,99	0,91	1,48
„ mangler hos..........	3	273	206	63	577	92,1	87,3	88,4	81,0	87,2	1,06	0,99	1,01	0,92

b. Legemshoide.

	Absolute tal							Procent							Affinitetstal					
	145—160	161—165	166—168	169—170	171—176	177—200	Sum	145—160	161—165	166—168	169—170	171—176	177—200	Gjennemsnit hos alle undersøkte	145—160	161—165	166—168	169—170	171—176	177—200
Antal...	31	112	124	87	214	94	662													
Plica marginalis findes hos	9	19	16	10	23	8	85	29,0	17,0	14,3	11,5	10,8	8,5	12,8	2,23	1,31	1,10	0,90	0,85	0,67
„ mangler hos	22	93	108	77	191	86	577	71,0	83,0	85,7	88,5	89,2	91,5	87,2	0,82	0,95	0,97	1,00	1,02	1,05

kan jo umulig i og for sig ha nogen indflydelse paa tilstedeværelsen av plica marginalis. Hvis der derfor her findes nogen sammenhæng, maa den være beroende paa, at den bestemte legemshoide er knyttet til en bestemt folketype som igjen er beheftet med plica marginalis.

Det vil da med én gang sees av tabellen at der er et meget høit affinitetstal for den mindste hoidegruppe (145–160). Men denne høidegruppe er netop den som er karakteristisk for lappene.

Jeg kommer derfor gjennem denne affinitetsundersokelse til det resultat, at vor befolkning har faat den her omhandlede eiendommelighet fra krydsning med lappene.

Resumé.

Med en til visshet grænsende sandsynlighet tror jeg man kan si at der indgaar i den nulevende befolkning i Troms fylke mindst 3 forskjelligartede raceelementer, som nærmere kan karakteriseres saaledes:

1. En stor mesocephal blok, leptoprosop, av stor legemshøide, eurymetop, med stor jugo-frontal index, leptorhin, blond av haar og blaaoiet.

2. En mindre brachycephal blok, euryprosop, av liten legemshøide, mesometop, med liten jugo-frontal index, mesorhin, sorthaaret og brunøiet.

3. En endnu mindre, men hyperbrachycephal blok, sterkere euryprosop og av endnu mindre legemshoide end foregaaende grupper, høigradig stenometop, chamærhin, brunhaaret og med lysere brune øine end foregaaende gruppe, samt med plica marginalis.

Ved undersøkelse av „lappene“ findes de samme 3 grupper igjen ogsaa hos dem, men i et andet blandingsforhold, idet det alpine raceelement blandt dem er det mest fremtrædende (40 %), medens hver av de to andre grupper er omtrent like sterkt repræsentert (med ca. 30 % hver).

IX. Hovedlinjene i befolkningens mosaikbillede.

Jeg har i det foregaaende avsnit git en fremstilling av hvad der karakteriserer Troms' befolkning, træk for træk.

Jeg skal her prøve at gi en fremstilling av hvorledes disse træk er kombinert. Billedet blir da ganske overordentlig broget.

Vi har av foregaaende avsnit set at der med hensyn til legemshøide sandsynligvis er mindst 3 genotyper. Foruten de meget smaa lapper og de meget høie av nordisk race har vi muligens 1 eller 2 mellemtyper. Den alpine type er ialfald sikker nok.

Med hensyn til cephalindex har vi ogsaa lært at kjende 3 sikre genotyper; den 4de er mere tvilsom. Av ansigtstyper kan vi sikkert paavise 2 forskjellige.

Av næsetyper er der ogsaa mindst 2 utpræget forskjellige.

Av øientyper er der vel i virkeligheten kun 2 genetisk forskjellige typer, de blaaøiede og de mer eller mindre brunøiede. De melerte øines forhold kan endnu ikke siges at være helt opklaret. Meget tyder paa at der i tidens løp virkelig er opstaat en melert øientype av genetisk art, „ein Verschmelzungsgenotypus".

Man kan inden den her undersøkte befolkning ikke utelukke den mulighet, at dette kan være tilfældet med lappenes lyse øine. Egte brunøiede, som man finder dem hos de xanthoderme og melanoderme racer, findes i det hele tat ikke hos os. Man maa derfor nødvendigvis regne med 3 eller 4 øientyper.

Det samme gjælder haarfarven. Her har der vel oprindelig kun været 2 typer, blondt og sort. De brune og cendréfarvede typer er vel sandsynligvis krydsningsfarver. Men deres store utbredelse i den nuværende befolkning gjør at man ved en bastardundersøkelse maa regne med mindst 4 haartyper.

Men herved er ikke den nulevende befolknings karaktertræk medtat i sin helhet. Der er en hel mængde andre træk som skiller de enkelte individer fra hverandre. Men om jeg nøier mig med at medta de her nævnte træk, saa vil allikevel bastardformenes antal bli altfor stort til at man med nogetsomhelst utbytte kan arbeide med dem. Da hvert av de her nævnte træk ved krydsning kan løsrives fra sine forbindelser, vil der nemlig være skapt mulighet for følgende antal bastarder:

$$4 \times 4 \times 3 \times 2 \times 4 \times 4 = 1536.$$

Skal man faa nogen oversigt, maa man nøie sig med færre træk, ialfald til at begynde med. Jeg vil til at begynde med kun regne med 2 øientyper, 2 haartyper, likesom jeg for legemshøidens vedkommende kun vil regne med høie og lave. Jeg faar da 192 forskjellige typer, og jeg vil her prøve at gi et lite billede av hvorledes disse 192 typer er fordelt inden denne befolkning.

Et av de spørsmaal som først melder sig, naar man vil prøve at finde rede i en saadan broget menneskemasse som den jeg her har skildret, er karaktertrækkene hos de urtyper hvorav den nuværende befolkning er utgaat.

Affinitetsundersøkelsene har bragt endel klarhet over dette spørsmaal. Jeg vil her prøve en anden fremgangsmaate. Der er vel ingen tvil om, at 2 av de træk som er mest konstante, er hodets og ansigtets form. I anden række kommer næsens form, øinenes og haarets pigmentering.

Alle de her nævnte træk er helt uavhængige av ydre forhold, livskaar o. l. Der er en viss likhet mellem dem indbyrdes; men denne deres indre sammenhæng er dog ikke større end at de ved krydsning kan løses fra sine oprindelige forbindelser.

Men det er dog høist sandsynlig at man ved en detaljert undersøkelse av en population kan finde de oprindelige forbindelseskjeder igjen som en kontinuerlig kjede av de samhørige træk.

Jeg har da paa 4 tabeller (44—47) ordnet samtlige av mig undersøkte individer gruppevis efter hver av de ovennævnte karaktertræk.

Jeg lar i denne undersøkelse legemshøiden komme som sidste karaktertræk. Selv om nemlig ogsaa denne er konstant og uforanderlig, saa er den dog i høiere grad end de øvrige træk foranderlig med livskaarene og derfor vanskeligere at benytte som racemerke.

For tabellene 44—47 gjælder følgende:

Ved inddeling efter hodetype, ansigtstype og næsetype er her fulgt samme princip som i hele avhandlingen forøvrig.

Som *lysøiede* regnes alle med blaa, graa eller lyst melerte øine (type 1. 2).

Som *mørkøiede* regnes alle med mørkt melerte og brune øine (type 3. 4. 5).

Som *lyshaarede* regnes alle med blondt, cendré, rødt og lysebrunt haar (type 1. 2. 3).

Som *mørkhaarede* regnes alle med mørkebrunt og sort haar (type 4. 5).

Som *lave* regnes alle med høide 170 cm. eller mindre.

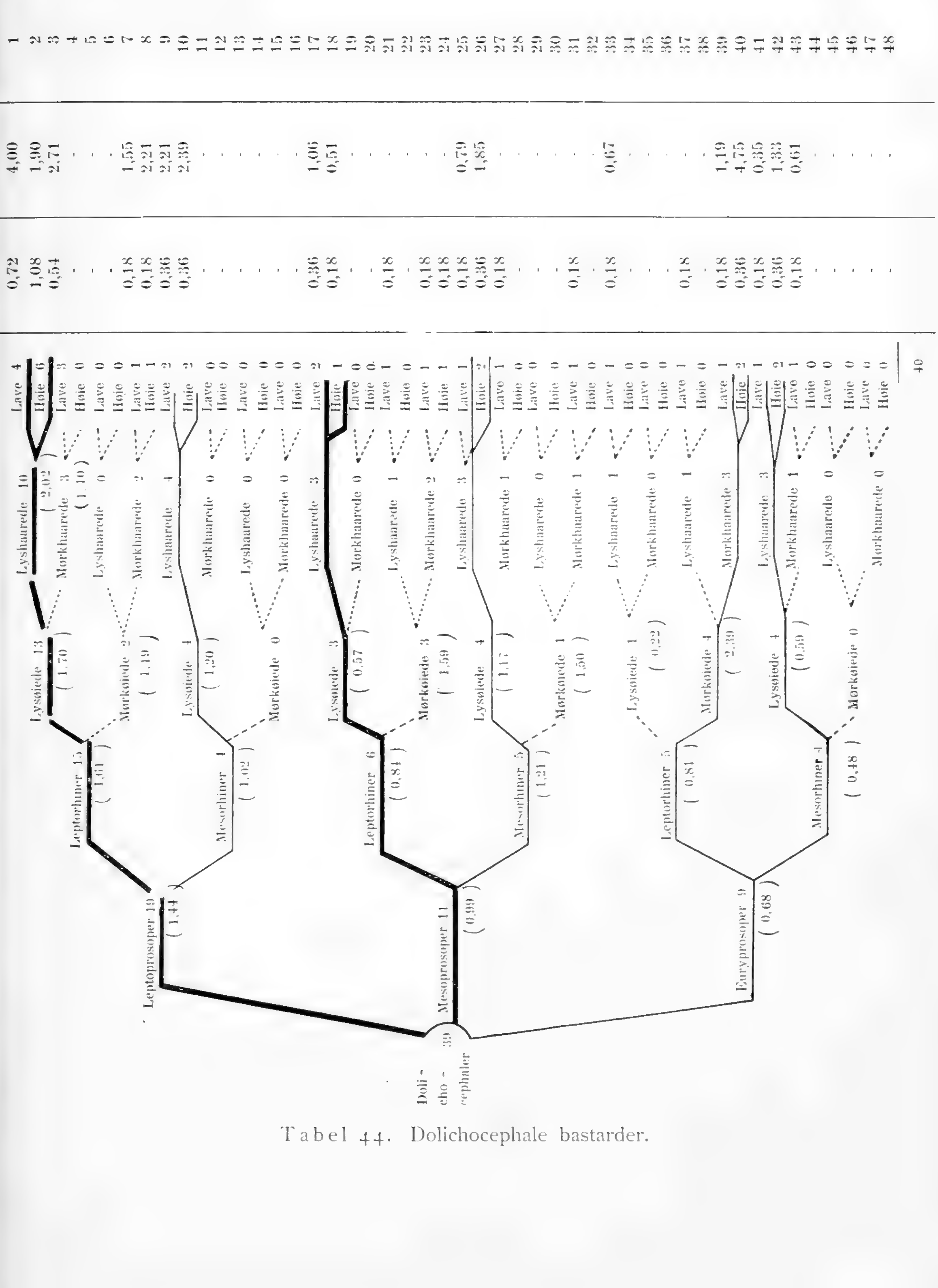
Som *høie* regnes alle med høide 171 cm. eller mere.

Paa tabel 44 har jeg samlet alle de av mig undersøkte dolichocephaler. Jeg har saavel paa denne som paa de øvrige tabeller foretat inddelingen saaledes:

Jeg har efter index cephalicus's størrelse inddelt samtlige i 4 hodegrupper: dolichocephaler, mesocephaler, brachycephaler og hyperbrachycephaler. Hver av disse er saa igjen inddelt efter ansigtsformen i 3 underavdelinger: leptoprosoper, mesoprosoper og euryprosoper. Disse igjen efter næsens form i leptorhiner og meso-chamærhiner. Saa videre i lysøiede og mørkøiede; disse igjen i lyshaarede og mørkhaarede og endelig til slut i lave og høie. Jeg har derved i alt 192 grupper. Man skulde jo tro at der ikke kunde findes nogen klare linjer gjennem denne brogede masse. Men det er ikke tilfældet.

Man vil med én gang paa tabel 44 se at dolichocephalenes hovedmasse følger en meget markert linje, som er følgende: dolichocephali — leptoprosopi — leptorhini — lyse øine — lyst haar. Hele denne linje samler uforholdsmæssig mange individer, saa mange, at man ikke kan være i tvil om at der maa være en biologisk sammenhæng mellem disse træk. Under hvert av de absolute tal er anført affinitetstallene, som fortæller os hvor mange flere individer kombinationen samler om sig end den vilde gjøre hvis kun kombinationenes matematiske mængdeforhold var det avgjørende.

Og denne linje samler til slut 6 høie, men hun 4 lave individer. Det lægger jeg mindre bret paa, da som nævnt livskaarene her kan veie betydelig mere end de øvrige karaktertræk. (Men da de tidligere refererte



Tabel 44. Dolichocephale bastarder.

affinitetsundersøkelser tilfulde godtgjør at stor legemshøide har sterk affinitet til alle de her nævnte karaktertræk, er det ogsaa sandsynlig at denne linje med et endnu større materiale tydelig vilde ende i stor legemshøide).

Der er paa denne tabel 46 andre bastardtyper, men ingen samler nær til saa mange individer som denne. 25 av dem ender ogsaa blindt, ɔ: uten en eneste repræsentant. Og av disse 46 er der heller ingen som markerer sig ved særlig mange individer. Det ser ut som dolichocephalene kun evner at samle individer paa denne ene linje.

Paa tabel 45 har jeg samlet alle mesocephalene. Den linje som her samler de fleste individer, er nøiagtig den samme: mesocephali — leptoprosopi — leptorhini — lyse øine — lyst haar — stor legemshøide. Der er blot den forskjel, at linjene er *kraftigere* tegnet blandt dolichocephalene end blandt mesocephalene. Dette fremgaar ogsaa av de i parentes anførte affinitetstal.

Da dette blandt dolichocephalene var den eneste linje som var markert og kontinuerlig, er der heller ingen grund til at tro at dolichocephalene inden denne befolkning repræsenterer nogen særskilt type. Forskjellen paa dolichocephalene og mesocephalene er kun den, at dolichocephalene repræsenterer *en renere linje*; de er ÷-avvikere inden den store dolicho-mesocephale gruppe. Da der ikke inden vor befolkning findes nogen ultra-dolichocephal gruppe, som kan utviske det av naturen selv istandbragte utvalg, vil de nødvendigvis holde sig mere typerene end mesocephalene.

Der synes derfor heller ikke at være nogen anden grund til ved raceologiske undersøkelser inden denne befolkning at holde dem utskilt fra mesocephalene end den, at man derved lettere kan faa tak i de for den fælles dolicho-mesocephale gruppe karakteristiske træk, som ganske utvilsomt synes at være: leptoprosopi — leptorhini — lyse øine — lyst haar — stor legemshøide.

Hvorledes forholder nu de mesoprosope mesocephaler sig? De forholder sig stort set ganske paa samme maate som de mesoprosope dolichocephaler. I alt er 31 % av mesocephalene mesoprosope. Blandt dolichocephalene findes 27 % mesoprosope.

Blandt mesoprosopene er der igjen flere leptorhiner end mesorhiner, flere lysøiede end mørkøiede, flere lyshaarede end mørkhaarede, flere høie end lave. Linjene er her fælles for dolichocephaler og mesocephaler, og de er fælles for leptoprosoper og mesoprosoper. Det er med andre ord ikke mulig at øine nogen særskilt mesoprosop gruppe. Mesoprosopene er kun at betragte som +-avvikere av den store leptoprosope gruppe. Hovedmassen av mesoprosopene har karaktertræk fælles med leptoprosopene, og det skal vi senere se vedvarer selv naar vi kommer over i brachycephalenes og hyperbrachycephalenes hovedgrupper.

Jeg mener saaledes, at denne tabel taler for at den store dolicho-mesocephale gruppe har som karaktertræk: leptomesoprosopi, leptorhini, lyse øine, lyst haar og stor legemshøide. Naar vi derefter gaar over til

						Antal	Procent	Affinitetstal	Bastard no.
Meso-cephaler 316	Leptoprosoper 120 (1,14)	Leptorhiner 92 (1,25)	Lysøiede 76 (1,26)	Lyshaarede 45 (1,16)	Lave	19	3,40	1,50	49
					Høie	26	4,68	1,06	50
				Mørkhaarede 31 (1,44)	Lave	11	1,98	1,30	51
					Høie	20	3,60	1,53	52
			Mørkøiede 16 (1,19)	Lyshaarede 5	Lave	3	0,54	-	53
					Høie	2	0,36	-	54
				Mørkhaarede 11	Lave	8	1,44	1,55	55
					Høie	3	0,54	0,75	56
		Mesorhiner 28 (0,90)	Lysøiede 24 (0,92)	Lyshaarede 17	Lave	8	1,44	1,11	57
					Høie	9	1,62	1,28	58
				Mørkhaarede 7	Lave	1	0,18	-	59
					Høie	6	1,08	1,20	60
			Mørkøiede 4 (0,84)	Lyshaarede 0	Lave	0	-	-	61
					Høie	0	-	-	62
				Mørkhaarede 4	Lave	0	-	-	63
					Høie	4	0,72	1,34	64
	Mesoprosoper 96 (1,01)	Leptorhiner 59 (1,05)	Lysøiede 49 (1,18)	Lyshaarede 27	Lave	15	2,70	0,96	65
					Høie	12	2,16	0,73	66
				Mørkhaarede 22	Lave	11	1,98	1,55	67
					Høie	11	1,98	1,31	68
			Mørkøiede 10 (0,67)	Lyshaarede 5	Lave	3	0,54	-	69
					Høie	2	0,36	-	70
				Mørkhaarede 5	Lave	1	0,18	-	71
					Høie	4	0,72	-	72
		Mesorhiner 37 (0,96)	Lysøiede 34 (1,01)	Lyshaarede 22	Lave	13	2,16	0,86	73
					Høie	9	1,62	1,00	74
				Mørkhaarede 12	Lave	7	1,26	-	75
					Høie	5	0,90	-	76
			Mørkøiede 3 (0,57)	Lyshaarede 1	Lave	0	-	-	77
					Høie	1	0,18	-	78
				Mørkhaarede 2	Lave	1	0,18	-	79
					Høie	1	0,18	-	80
	Euryprosoper 100 (0,87)	Leptorhiner 40 (0,83)	Lysøiede 31 (0,88)	Lyshaarede 22	Lave	11	1,98	0,83	81
					Høie	11	1,98	0,85	82
				Mørkhaarede 9	Lave	8	1,44	1,25	83
					Høie	1	0,18	-	84
			Mørkøiede 9 (0,69)	Lyshaarede 3	Lave	1	0,18	-	85
					Høie	2	0,36	-	86
				Mørkhaarede 6	Lave	4	0,72	0,57	87
					Høie	2	0,36	-	88
		Mesorhiner 60 (0,90)	Lysøiede 56 (1,04)	Lyshaarede 33	Lave	20	3,60	0,85	89
					Høie	13	2,34	1,26	90
				Mørkhaarede 23	Lave	12	2,16	0,88	91
					Høie	11	1,98	1,66	92
			Mørkøiede 4 (0,31)	Lyshaarede 0	Lave	0	-	-	93
					Høie	0	-	-	94
				Mørkhaarede 4	Lave	4	0,72	0,50	95
					Høie	0	-	-	96
						316			

Tabel 45. Mesocephale bastarder.

at se paa de mesocephale euryprosoper, møter os straks et nyt billede. Her er ingen sluttede linjer; affinitetstallene er gjennemgaaende under 1. Der er ingen biologisk sammenhæng mellem mesocephali og euryprosopi; endnu mindre sammenhæng er der mellem euryprosopi og leptorhini. Av euryprosopene er saaledes kun 40 % leptorhiner, medens der var 77 % leptorhine leptoprosoper.

Der er med andre ord ogsaa inden mesocephalenes store gruppe *kun én linje* som er biologisk fastbygget; det er den ovenfor nævnte.

Av de i alt 96 kombinationer som findes opført paa disse 2 tabeller, blir der kun *én*, som markerer sig ved det store antal individer den samler om sig. Vi gjenkjender straks alle disse træk som karakteristiske for den nordiske race. Jeg vil i det følgende benævne denne type *homo nordicus*. Der findes 32 høie og 23 lave individer av denne type. Da grænsen mellem høie og lave i dette tilfælde er sat til 170 cm., og da den nordiske races gjennemsnitshøide kun ligger lite over denne grænse, sier det sig selv at de lave individer i dette tilfælde hovedsagelig er ÷-avvikere for legemshøidens vedkommende.

Der blir saaledes i alt 85 individer = 12,8 % av samtlige undersøkte som samtidig er bærere av disse 6 for den nordiske race karakteristiske træk.

Jeg gaar derefter over til den store brachycephale gruppe, hvis forgreninger findes opført paa tabel 46. Det falder her straks i øinene at leptoprosopi og brachycephali gaar daarlig sammen. Brachycephalene har jo utvilsomt gammel hjemstavnsret her i fylket. De har ogsaa utvilsomt gjennem aarhundreder krydset sig med den norske leptoprosope befolkning. Men der er blit langt færre leptoprosope brachycephaler end det skulde blit efter den forholdsvise mængde av begge typer, hvis kun det matematiske mængdeforhold av disse træk gjorde sig gjældende.

Vi tør derfor med tryghet gaa ut fra at der hersker et *biologisk motsætningsforhold mellem leptoprosopi og brachycephali*.

Omvendt er der aabenbart en stor biologisk samhørighet mellem brachycephali og meso-euryprosopi (affinitetstal henholdsvis 1,13 og 1,12).

Følger jeg nu linjene videre fremover, saa viser det sig at der *er en sammenhængende biologisk velbegrundet række: brachycephali — mesoeuryprosopi — mesorhini — mørke øine — mørkt haar — liten legemsbygning.*

Brachy**meso**prosopene maa utvilsomt kun betragtes som ÷-avvikere av selve hovedgruppen. Der er paa alle punkter fuld overensstemmelse mellem disse linjer.

De træk, som her findes forbundne ved tal som tyder paa biologisk samhørighet, gjenkjender vi som de for den alpine race karakteristiske træk. Jeg benævner i det følgende den type som *homo alpinus*. Der er i alt 10 av denne type, ɔ: 1,5 % av samtlige undersøkte, som er indehavere av alle de her nævnte 6 for den alpine race karakteristiske træk.

Paa tabel 47 har jeg opført hyperbrachycephalene med deres forgreninger. Nederst paa denne tabel finder man en ved høie affinitetstal

Brachycephaler 233					Antal	Procent	Affinitetstal	Bastard no.
Leptoprosoper 57 (0,74)	Leptorhiner 38 (0,70)	Lysøiede 29 (0,65)	Lyshaarede 20	Lave	4	0,72	0,37	97
				Høie	16	2,88	0,89	98
			Mørkhaarede 9	Lave	3	0,54	0,48	99
				Høie	6	1,08	0,63	100
		Mørkøiede 9 (0,91)	Lyshaarede 4	Lave	1	0,18	-	101
				Høie	3	0,54	-	102
			Mørkhaarede 5	Lave	2	0,36	0,50	103
				Høie	3	0,54	1,08	104
	Mesorhiner 19 (0,84)	Lysøiede 13 (0,68)	Lyshaarede 6	Lave	4	0,72	0,85	105
				Høie	2	0,36	-	106
			Mørkhaarede 7	Lave	3	0,54	-	107
				Høie	4	0,72	1,12	108
		Mørkøiede 6 (1,73)	Lyshaarede 2	Lave	1	0,18	-	109
				Høie	1	0,18	-	110
			Mørkhaarede 4 (1,86)	Lave	2	0,36	-	111
				Høie	2	0,36	-	112
Mesoprosoper 80 (1,13)	Leptorhiner 45 (1,08)	Lysøiede 34 (1,11)	Lyshaarede 23	Lave	10	1,80	0,85	113
				Høie	13	2,34	1,13	114
			Mørkhaarede 11	Lave	4	0,72	-	115
				Høie	7	1,26	-	116
		Mørkøiede 11 (1,00)	Lyshaarede 2	Lave	1	0,18	-	117
				Høie	1	0,18	-	118
			Mørkhaarede 9	Lave	5	0,90	1,40	119
				Høie	4	0,72	-	120
	Mesorhiner 35 (1,21)	Lysøiede 29 (1,15)	Lyshaarede 18	Lave	13	2,34	1,31	121
				Høie	5	0,90	0,78	122
			Mørkhaarede 11	Lave	9	1,62	1,46	123
				Høie	2	0,36	1,26	124
		Mørkøiede 6 (1,56)	Lyshaarede 2 (1,77)	Lave	0	-	-	125
				Høie	2	0,36	1,77	126
			Mørkhaarede 4 (1,34)	Lave	2	0,36	1,34	127
				Høie	2	0,36	1,34	128
Euryprosoper 96 (1,12)	Leptorhiner 49 (1,36)	Lysøiede 36 (1,37)	Lyshaarede 27	Lave	14	2,56	1,42	129
				Høie	13	2,34	1,34	130
			Mørkhaarede 9	Lave	4	0,72	-	131
				Høie	5	0,90	2,32	132
		Mørkøiede 13 (1,21)	Lyshaarede 2	Lave	2	0,36	-	133
				Høie	0	-	-	134
			Mørkhaarede 11	Lave	8	1,44	1,62	135
				Høie	3	0,54	1,24	136
	Mesorhiner 47 (0,96)	Lysøiede 29 (0,73)	Lyshaarede 21	Lave	15	2,70	0,92	137
				Høie	6	1,08	0,70	138
			Mørkhaarede 8	Lave	6	1,08	0,68	139
				Høie	2	0,36	0,38	140
		Mørkøiede 18 (1,87)	Lyshaarede 6	Lave	3	0,54	-	141
				Høie	3	0,54	-	142
			Mørkhaarede 12 (1,70)	Lave	8	1,44	1,40	143
				Høie	4	0,72	2,80	144
					233			

Tabel 46. Brachycephale bastarder.

meget markert og biologisk set vel sammenhængende linje, som gaar gjennem *euryprosopi — mesorhini — mørke øine — mørkt haar til liten legemsbygning.* Denne linje mangler helt repræsentanter for stor legemshøide.

De 6 træk som er samlet paa denne linje, gjenkjender vi straks som karakteristiske for den menneskeype som av GIUFFRIDA-RUGERI er kaldt den palæoarktiske, og *som omfatter de oprindelige lapper og samojedene.*

Denne type har blandt de av mig undersøkte kun 5 repræsentanter, ɔ: 0,9 %. Det er vel høist sandsynlig at man her har for sig den hyperbrachycephale urtype. Jeg vil i det følgende benævne denne type som *homo palæoarcticus.* Det er vel hævet over enhver tvil at lappene oprindelig har hat sort haar og brune øine. LINNÉS beskrivelse av dem synes jo at tyde paa at dette var tilfældet endog paa hans tid. Nu er som bekjendt dette ikke længer tilfældet.

Paa tabel 47 finder vi at *den bedst besatte linje gaar fra hyperbrachycephali gjennem euryprosopi — mesorhini — lyse øine — lyst haar til liten legemsbygning.* Her har vi helt igjennem de nulevende norske lappers væsentligste træk.

Type no. 185—187 tør vi vistnok betragte som repræsenterende de reneste lapper, som de der staar urtypen nærmest.

Jeg betegner disse i det følgende som: *homo lapponicus.*

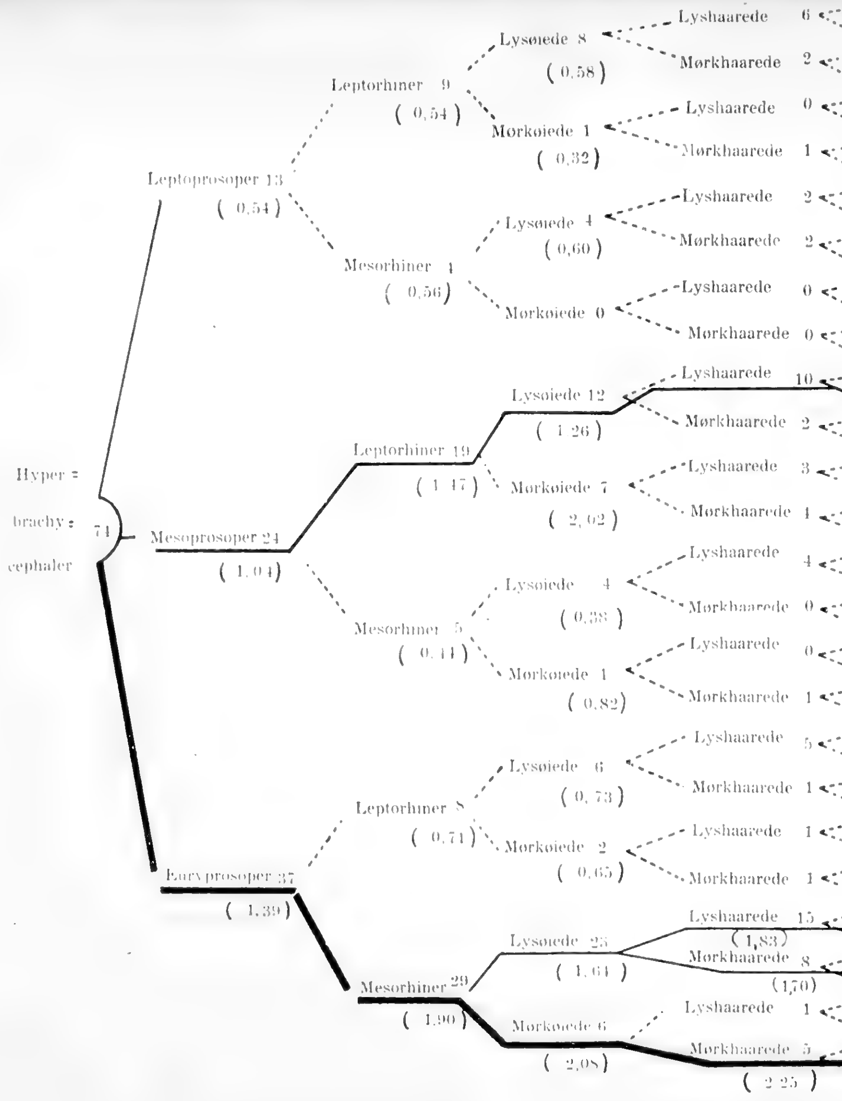
Den har, som det vil sees, 23 repræsentanter, ɔ: 4,1 % blandt samtlige av mig undersøkte. Denne gruppe har, som det videre vil sees, ogsaa repræsentanter for stor legemshøide, men de er endnu i mindretal. Paa 18 lave kommer kun 5 høie.

Disse „rene" lapper har kun faat pigmenteringen fra den nordiske race. De har beholdt urtypens træk med hensyn til hodets, ansigtets og næsens form; og som man kan forstaa av det store antal lave, har den ogsaa beholdt urtypens ringe legemshøide.

Der findes som bekjendt en del lapper som er leptorhine. Men som det fremgaar av tabel 47, har de fleste av disse kun lite igjen av de for urtypen karakteristiske træk. Ti lappenes karakteristiske ansigtsform, euryprosopien, gaar kun daarlig sammen med leptorhini. Der er derfor kun 8 av disse 2den grads bastarder mellem den nordiske race og lappene. Smalnæsede lapper har derfor i almindelighet ogsaa et betydelig mere avlangt ansigt. De har med andre ord kun beholdt et av urtypens træk, nemlig hyperbrachycephalien.

De maa betegnes som *3dje grads bastarder av homo palæoarcticus og homo nordicus.*

Inden denne bastardgruppe har, som det vil sees, de høie overtaket. Det er bastarden mellem lappen og norske, men hvor det norske element er helt dominerende. Disse bastarder findes hos mig repræsentert med i alt 24 individer, ɔ: 4,4 % (type 161—176). Denne type har akkurat samme størrelse som den forrige 1ste grads bastarder, de egentlige lapper.



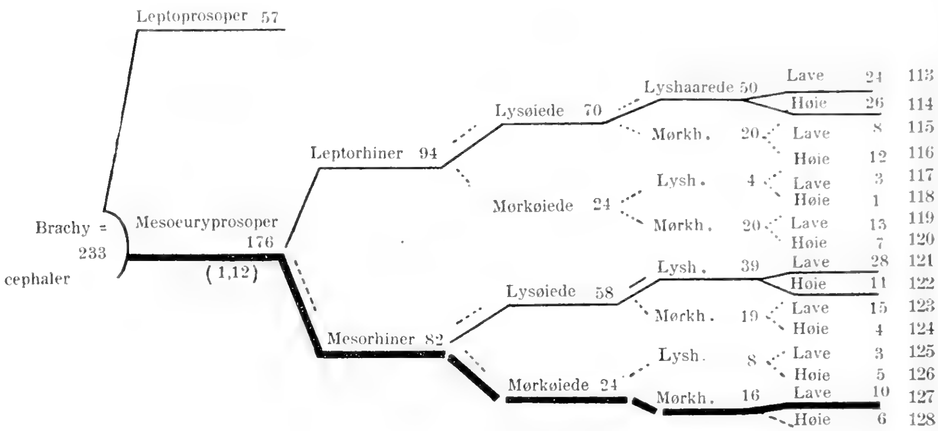
	Antal	Procent	Affinitetstal	Bastard no.
Lave	3	0,54	0,89	145
Høie	3	0,54	0,52	146
Lave	1	0,18	0,48	147
Høie	1	0,18	0,31	148
Lave	0	-	-	149
Høie	0	-	-	150
Lave	0	-	-	151
Høie	1	0,18	1,08	152
Lave	1	0,18	0,58	153
Høie	1	0,18	-	154
Lave	2	0,36	-	155
Høie	0	-	-	156
Lave	0	-	-	157
Høie	0	-	-	158
Lave	0	-	-	159
Høie	0	-	-	160
Lave	4	0,72	1,04	161
Høie	6	1,08	1,63	162
Lave	0	-	-	163
Høie	2	0,36	-	164
Lave	1	0,18	-	165
Høie	2	0,36	-	166
Lave	3	0,54	2,63	167
Høie	1	0,18	-	168
Lave	2	0,36	0,51	169
Høie	2	0,36	1,00	170
Lave	0	-	-	171
Høie	0	-	-	172
Lave	0	-	-	173
Høie	0	-	-	174
Lave	0	-	-	175
Høie	1	0,18	-	176
Lave	2	0,36	0,64	177
Høie	3	0,54	0,99	178
Lave	1	0,18	-	179
Høie	0	-	-	180
Lave	1	0,18	-	181
Høie	0	-	-	182
Lave	1	0,18	0,62	183
Høie	0	-	-	184
Lave	11	1,98	2,11	185
Høie	4	0,72	1,46	186
Lave	7	1,26	2,70	187
Høie	1	0,18	0,62	188
Lave	1	0,18	-	189
Høie	0	-	-	190
Lave	5	0,90	2,74	191
Høie	0	-	-	192
	73			

Tabel 47. Hyperbrachycephale bastarder.

Tilbake staar nu kun at omtale de bastarder mellem lapper og norske som har lappenes hodeform, men den nordiske races ansigtsform.

Disse findes paa tabel 47 opført som nr. 145—152. Man vil av denne tabel straks se at hyperbrachycephali gaar daarlig sammen med leptoprosopi. Affinitetstallene er for hele denne gruppe meget smaa. Hvis blandingen var skedd efter matematiske lover, vilde der været langt flere leptoprosope hyperbrachycephaler end der er. Dette beror vel for en væsentlig del paa at den leptoprosope befolkning kun i ringe utstrækning indgaar forbindelse med den hyperbrachycephale.

Tabel 48.



Men det faktiske forhold er altsaa at de *leptoprosope bastarder* hører til de sjeldnest forekommende bastarder. De utgjør omtrent 2 °/o av alle undersøkte.

Ganske anderledes talrike er den *brachycephale gruppes bastarder.* Ogsaa her viser det sig at med leptoprosoper har brachycephalene kun liten tendens til at danne bastarder. Hele den leptoprosope gruppe er svakt opbygget og meget lite talrik i betragtning av leptoprosopiens store utbredelse inden denne befolkning. Derimot har brachycephali omtrent like let for at forenes med mesoprosopi som med euryprosopi; der kan vel ikke være synderlig tvil om at type nr. 127 og type nr. 143 i alt væsentlig er ensartet. Den optrukne grænse mellem mesoprosopi og euryprosopi er for brachycephalenes vedkommende ikke hensigtsmæssig. Affinitetsundersøkelsene synes at tyde paa at der inden vor befolkning kun er to ansigtstyper: leptomesoprosoper og mesoeuryprosoper.

Gjennem arvelighetsundersøkelser kan muligens dette bringes helt paa det rene. Leptomesoprosopene skulde isaafald genetisk høre sammen med dolicho-mesocephaler; brachycephalene og hyperbrachycephalene skulde dermot begge være euryprosope.

Tabellene 44—47 synes ogsaa at peke i den retning.

Brachycephalenes forgrening vil isaafald være saaledes som fremstillet paa tabel 48.

Den alpine race er isaafald repræsentert gjennem de 10 individer som har nr. 127. De 39 individer som har nr. 121 og 122, er bastarder av den alpine race, og lappene og de 50 individer som har nr. 113 og 114, er bastarder av den alpine race med den nordiske race.

Alle disse linjer har høie affinitetstal. Alle de øvrige paa denne tabel opførte bastardformer er baade sparsomt repræsentert og har lave affinitetstal.

Av type nr. 127 og 128 opgav 50 % at være lapper eller finner, og av type nr. 121 og 122 opgav 30 % at være enten lapper eller finner.

Tilbake staar den dolichomesocephale gruppes bastarder. Som det vil sees, er der i alt 109 dolichomesocephale euryprosoper. 31 % av samtlige dolichomesocephaler er merkelig nok euryprosoper. Av disse euryprosoper er igjen 60 % mesorhiner. At disse hovedsagelig er bastarder av den nordiske race med den store brachycephale (alpine) gruppe, synes utvilsomt.

Hovedmassen (60 %) av disse bastarder er desuten lave av vekst. Dertimot er de i utpræget grad lysøiede og lyshaarede. Lysøiede er 87 % og lyshaarede 58 %.

Denne gruppes bastarder har med andre ord tat legemsproportionene fra den brachycephale type, men pigmenteringen fra den dolichomesocephale gruppe.

Jeg har i et foregaaende avsnit paavist, at man gjennem affinitetsundersøkelser kan finde frem de træk som biologisk hører sammen. Jeg paaviste der at mesocephali er sterkt knyttet til stor legemshøide, leptoprosopi, leptorhini, blondt haar og blaa øine. Dolichocephalenes ringe antal gjorde at det var vanskelig at bli helt klar over deres affinitetsforhold.

Av tabellene 44 og 45 fremgaar imidlertid med stor tydelighet at der ikke er nogen merkbar forskjel paa dolichocephalene og mesocephalene. Blandt samtlige 662 finder jeg i alt 85 mænd som endnu sitter inde med 5 av de for denne type særegne træk. Da jeg i alt har 355 dolichomesocephaler, vil det si at ikke mindre end 24 % av disse endnu har den nordiske races eiendommelige træk.

Av affinitetsundersøkelsene fremgik videre, at der utvilsomt i vor befolkning indgaar en type hvis egenskaper er: brachycephali, mesoeuryprosopi, mesorhini, mørke øine, mørkt haar, liten legemshøide. Og disse træk findes i biologisk sikkert paaviselig tilknytning til hverandre inden den nuværende befolkning. Men samtlige træk finder jeg kun hos 10 individer. Da jeg i alt har 233 brachycephale blandt de av mig undersøkte, vil det si at kun 4,30 % av disse har bibeholdt typens oprindelige træk. 5 av typens oprindelige træk findes endnu hos 6,86 % av befolkningen. Der er i denne henseende et paafaldende misforhold tilstede mellem denne type og den dolichocephale. Hos denne sidste fandtes, som det vil erindres, 24 % som hadde bibeholdt den oprindelige types træk samlet. Dette kan ikke bare bero paa at den dolicho-mesocephale blok er litt større. Utregningen er her for begge typers vedkommende foretat i procent av hver enkelt types antal inden den nulevende befolkning. Det er da tydelig at den brachycephale blok har faat en ganske anden voldsom medfart, er blit ganske anderledes sondersplittet end den dolichocephale blok.

Det har sin naturlige og let forklarlige aarsak. Der kan vel ikke være nogen tvil om at det nordiske element inden vor befolkning fra første stund har følt sig som det herskende, det overlegne element. Ogsaa nu vil det av den „norske" befolkning ansees næsten som en nedværdigelse at indgaa egteskap med til eks. en lap.

Hvor saadanne forbindelser kommer istand, vil repræsentanten for den nordiske parts vedkommende utvilsomt være hentet fra samfundets aller dypeste lag. De høiere stillede klasser inden den nordiske race vil sikkerlig anse sig for god til saadan forbindelse. Men saa at si draapevis har det fremmede element flytt over i det nordiske. Først naar dette er skedd gjennem generationer og den fremmede indblanding er begyndt at gaa i glemmeboken, ialfald er blit mindre synlig paa grund av opblanding med det norske element, først da har det fremmede element ogsaa kunnet trænge ind i den nordiske races høiere stillede klasser.

Derfor er den alpine blok blit saa sønderlemmet. Den kunde ikke paa anden maate optages i vor befolkning. Det maatte ske derigjennem, at der gjennem aarhundreder sagte og umerkelig flot litt norsk blod over i den alpine blok. Først naar denne derved var blit passende fornorsket, kunde den vinde almindelig anerkjendelse og bli likestillet med den norske ved indgaaelse av egteskap. Derfor er det heller ikke saa rart at man blandt samtlige undersøkte finder saa meget som 15,2 % ralativt rent nordiske individer.

Endelig fremgik det ogsaa av affinitetsundersøkelsene, at der indgaar i vor befolkning en type hvis træk var hyperbrachycephali, euryprosopi, mesorhini, lyse øine, lyst haar, liten legemshøide; altsammen træk som vi gjenkjender som karakteristiske for lappene.

Paa tabel 47 findes typens vel markerte kjede som løpenr. 185. I alt fandtes 11 individer som indehavere av disse træk. Da der i alt kun fandtes 74 hyperbrachycephaler, vil det si at 15 % av hyperbrachycephalene har beholdt det for denne type karakteristiske træk.

Alle hensyn tat i betragtning vil det dog, som allerede før paapekt, være mer korrekt at si at kombinationen nr. 191 er den nu forefindende levning av lappenes urtype. Av denne type fandtes kun 5 individer, hvilket svarer til 6,8 % av samtlige hyperbrachycephaler. Hvad som her er det rigtige kan man neppe bringe paa det rene uten gjennem arvelighetsundersøkelser.

Det er jo mulig, at lappene saa længe har krydset sig med den blonde race at der nu har dannet sig en ny blond hyperbrachycephal genotype, en „Verschmelzungsgenotypus". Anderledes kan man vanskelig forklare sig den eiendommelighet, at der blandt hyperbrachycephalene er flere lyshaarede end blandt samtlige undersøkte.

Blandt hyperbrachycephalene har jeg fundet 68,8 % lyshaarede, medens jeg blandt samtlige undersøkte i Troms fylke kun fandt 58,9 %. Affinitetstallet for hyperbrachycephali og lyst haar blir da 1,17. Med de meget store tal man her har at gjøre med, viser dette en meget sterk biologisk sammenhæng mellem lyst haar og hyperbrachycephali.

Indtil videre faar man derfor nøie sig med at betegne som urlapper type nr. 191 og som nutidslapper type nr. 185. De mellemformer mellem disse som findes opført som løpenr. 186—190, blir isaafald bastardformer mellem urlapper og nutidslapper.

Det har nu interesse med éngang at se litt nærmere paa hele denne gruppe. Av de 5 urlapper, kombination nr. 191, var 1 fra Trondenes, 1 fra Lyngen, 1 fra Skjervøy og 1 fra Salangen. Disses gjennemsnitlige legemshøide var 165,4 cm. Kun to av dem regnet sig selv for lapper, to kaldte sig for finlændere, 1 sa han var rent norsk; men jeg har for ham notert „typisk lap av utseende". Hos 3 av dem (60 %) fandtes en vel utviklet mongolfold. Deres gjennemsnitlige cephalindex var 86,9. Deres ansigtsindex var 80,7. Deres næseindex 82,2. 3 (60 %) av dem hadde kulsort haar. Blandt „nutidslappene" (kombination no. 185) var 2 fra Trondenes, 1 fra Salangen, 1 fra Ibestad, 1 fra Dyrøy, 1 fra Skjervøy, 1 fra Karlsøy og 4 fra Lyngen. 6 av disse kaldte sig lapper, 5 regnet sig for norske. Deres gjennemsnitlige legemshøide var 164,3 cm. Deres cephalindex 87,3, ansigtsindex 80,3, næseindex 82,1. Mongolfold fandtes kun hos 3 av dem.

Tilbake staar kun de 13 bastarder av „anden grad". Av disse regnet kun 3 sig for lapper, de øvrige ansaa sig for helt norske. Av disse var 1 fra Lavangen, 1 fra Malangen, 2 fra Tromsøysund, 1 fra Salangen, 1 fra Ibestad, 2 fra Torsken og 2 fra Skjervøy. Deres legemshøide var 168,1, deres cephalindex 86,8. Kun hos 2 av dem fandtes mongolfold.

Gjennem alle sine karaktertræk viser saaledes disse sig virkelig at være mere „utspædd", mindre lappoide end de to førstnævnte grupper.

Naar jeg i dette avsnit med tal har forsøkt at illustrere i hvilken grad vor befolknings „urtyper" er blit sønderlemmet, saa maa jeg gjøre en reservation.

Man kan vel med en til visshet grænsende sandsynlighet si at lappene oprindelig har været hyperbrachycephale. Men det lar sig ikke gjøre nu at trække op de nøiagtige grænser for deres hyperbrachycephali. Likeledes kan man vel med temmelig stor sikkerhet gaa ut fra at den nordiske race har været dolichomesocephal. Men heller ikke her kan man trække op de nøiagtige grænser.

Naar jeg nu i dette avsnit har prøvet at illustrere i hvilken grad de oprindelige typer i tidens løp er blit sønderlemmet ved bastardering, saa maa der selvfølgelig ikke lægges for meget i disse tal. De kan kun bli *i hovedtrækkene rigtige*. Men om de altsaa end ikke kan bli helt rigtige, saa har de dog sin interesse.

Ti i det *væsentlige* er dog tallene rigtige nok. Og det væsentlige er i dette tilfælde paavisning av den alpine bloks totale sønderlemmelse og den nordiske bloks relative ubeskadigelse. Og i denne henseende er det ganske utænkelig at ikke resultatet er rigtig nok. Det kan være, at den alpine blok er blit mindre beskadiget end det efter mit regnestykke ser ut til, og det kan være at den nordiske blok er litt mere beskadiget. Men her blir der dog kun tale om en gradsforskjel.

Men ogsaa i en anden henseende tror jeg at beregningen har sin interesse, nemlig for den sammenlignende antropologi. Ti her spiller det selvfølgelig en mindre rolle *hvor* grænsene trækkes, naar de blot altid trækkes ens.

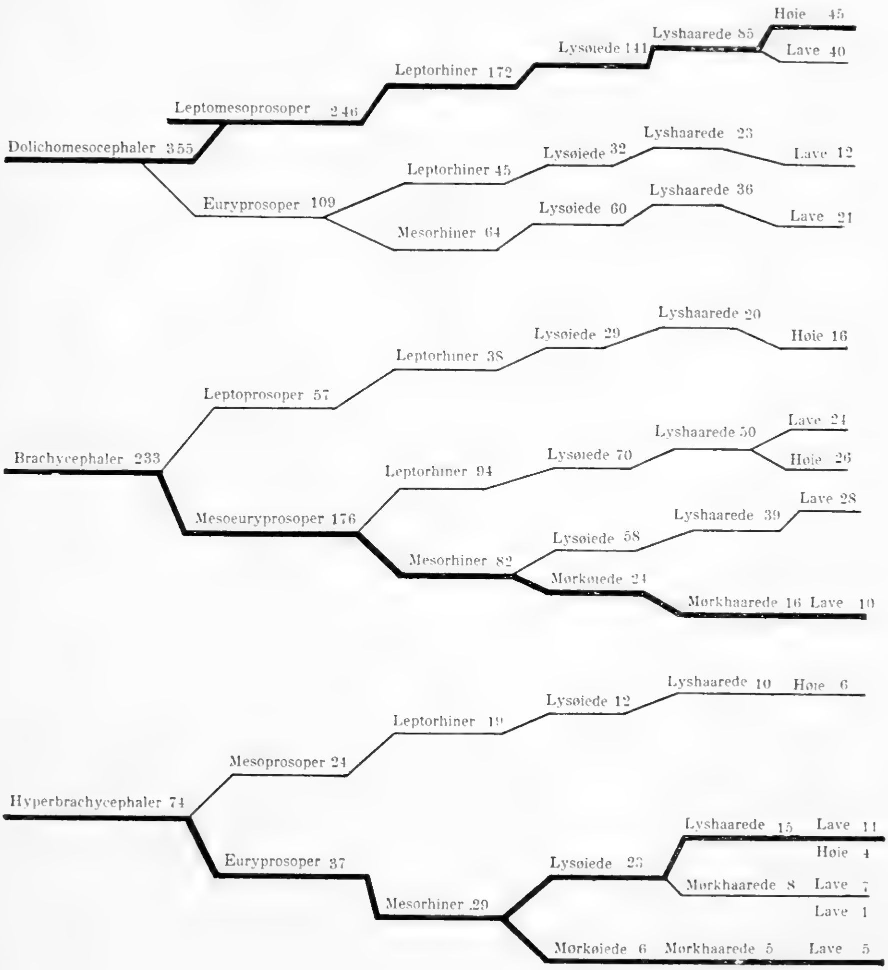
Man har ved undersøkelsen av disse 4 tabeller (44, 45, 46 og 47) faat et meget sterkt indtryk av samhørigheten av visse træk. Et fremmed træk svækker linjene merkbart.

Jeg skal først følge linjene paa tabel 44. Man ser her straks det intense biologiske sammenhæng mellem dolichocephali og leptoprosopi. Dolichocephali kan ganske vist ogsaa inden denne befolkning knyttes sammen med euryprosopi; men affinitetstallet viser at denne forbindelse har vanskelig for at komme istand. Leptorhini har sterk affinitet til leptoprosopi, men den har ogsaa meget sterk affinitet til dolichocephali.

Indskydes der et mellemled av en anden biogenetisk type, svækkes straks linjen. Indskydes 2 fremmede led, er svækkelsen endnu alvorligere. Medens linjen dolichocephali, leptoprosopi, leptorhini, lyse øine er repræsentert av henholdsvis 39, 19, 15 og 13 individer, er sidegrenen mesorhini, mørke øine repræsentert av henholdsvis 4 og 0 individer. 2 fremmede mellemled taaler altsaa ikke denne linje (se øverst paa tabel 44). Ett fremmed mellemled gjør mindre. Saaledes fortsætter den dolichocephale, leptoprosope, mesorhine linje med relativt stor kraft gjennem lyse øine til lyst haar, medens den ikke har nogen repræsentant for mørkt haar. Om man undersøker en saa talrik gruppe som brachycephalenes, saa gjentar dog det samme sig. Brachycephali har sterk tilknytning til mesoprosopi, mesorhini, mørke øine og mørkt haar.

Et *fremmed* element virker straks betydelig svækkende paa kjeden. Brachycephali, leptoprosopi, leptorhini, lyse øine viser jevnt avtagende affinitetstal. Derimot tiltar affinitetstallene igjen jevnt og sikkert om kjeden faar fortsætte sig gjennem leptoprosopi til mesorhini (0,84), mørke øine (1,73) til mørkt haar (1,86). Av stor interesse i denne henseende er de to typer 127 og 129. Phænotypisk arter jo disse sig som rene kontraster. Den ene type mørkhaaret, mørkøiet, mesorhin og mesoprosop, den anden lyshaaret, lysøiet, leptorhin og euryprosop; men allikevel har, som det vil sees, begge kjeder høie affinitetstal. Det eneste fælles tilknytningspunkt er brachycephalien. I den første kjede hører alle led genotypisk sammen. Derfor er affinitetstallene her saa høie. I den anden kjede er alle led hentet fra den hyperbrachycephale genotype (lappene). Derfor er affinitetstallene her saa høie.

Tabel 49.



Type nr. 129 har med andre ord alle træk for lappene med undtagelse av brachycephali. Men som jeg paaviste ved affinitetsundersøkelsene, hersker der intet motsætningsforhold mellem brachycephali og euryprosopi. Det blir da let forstaaelig at disse to phænotypisk saa forskjellige typer begge to kan ha høie affinitetstal. Derfor kan man ogsaa straks slutte sig til at type nr. 129 maatte være en bastard av den alpine race og lappene.

Brachycephali har derimot meget liten tilknytning til leptoprosopi. Her finder vi derfor meget svake affinitetstal for den alpine races bastarder med den nordiske race. Bastardene er der, noksaa talrike endog; men overalt viser de smaa affinitetstal at de to typers karaktertræk gaar daarlig i samme spand.

Jeg har i dette avsnit prøvet om det er mulig at finde frem hvilke typer det er som gir denne befolkning sit præg. Og jeg mener dette til en vis grad har lykkes. Jeg har nøiet mig med herunder at holde mig til 6 av de for menneskeracene mest karakteristiske træk. Men hvert av disse træk er igjen avhængig av ikke ett, men mange faktorpar. Jeg har saaledes i en anden avhandling søkt at bevise at bare for hodeformens vedkommende har vi med mindst 5 faktorpar at gjøre. For legemshøidens vedkommende sandsynligvis likesaa mange. Hvor mange faktorpar øienfarve, haarfarve, ansigtsindex og næseindex er avhængig av, derom vet vi endnu intet.

Men sikkert er det ialfald at vi blot for disse 6 træks vedkommende har med overordentlig mange faktorpar at gjøre. Naar man nu erindrer at de mulige kombinationers antal ved 10 faktorpar er 1048576, saa kan man tænke sig til hvilke svimlende tal man vil komme op i her, hvor man har med mindst det dobbelte antal faktorpar at gjøre. Man kommer op i milliarder av kombinationer. Man skulde da tro, at man vilde komme op i et saadant virvar av kombinationer at det ikke længer blir mulig at finde nogen orden i dette kaos.

Av saa meget større interesse er det at se at hovedlinjene træer ganske skarpt frem. Der er endel kombinationer som optræer med en saa stor hyppighet, og som synes at være saa fastbygget at de derigjennem præger hele populationen. Sammenhængen herved er overordentlig klart fremstillet av dr. phil. Oscar Hagem i hans bok Arvelighetsforskning, pag. 268: „Hver enkelt linnéisk art bestaar av mange forskjellige genotyper som i sin sammensætning kan være en mere eller mindre fast gruppering av artens gener. Genene følger i sine arveforhold Mendels regel, med den variation herav som mulige koblings- og frastøtningsforhold bevirker; kryssning mellem artens mange genotyper gir derfor ved spaltning og rekombination grundlag for en kaleidoskopisk variation av genotyper og fænotyper. Kryssning, spaltning og rekombination er hovedgrundlaget for alle fremmedbefrugtende arters variation og danner en rik samling av genotyper. Inden denne artens genotypsamling er det selektionen — det naturlige utvalg — har virket og fremdeles virker. En stor del av de teoretisk mulige genotyper er antagelig relativt litet levedygtige og gaar tilgrunde i kampen for tilværelsen allerede paa et tidlig tidspunkt av sit liv. Antar man f. eks. 10 faktorpar inden en art, saa vil dette muliggjøre $2^{10} = 1024$ konstante kombinationer (homozygoter). Men antallet av mulige kombinationer er 4^{10} eller 1048576, og de heterozygotiske kombinationers antal er $1048576 \div 1024 = 1047552$. Heterozygotene er altsaa teoretisk 1000 ganger saa talrike som homozygotene, og disse sidste krysses stadig med heterozygoter og gir heterozygotisk avkom. Inden fremmedbefrugtende arter er derfor en mængde av genotypene heterozygoter, og muligheten for en saadan arts variation er derfor overordentlig stor. En stor del av disse mulige genotyper er imidlertid sikkert mindre levedygtige, og i kampen for tilværelsen skjæres de bort før de har naadd fuld utvikling og forplantning. De linnéiske arters karakteristiske og ofte temmelig ensartede utseende skyldes temmelig sikkert, at meget av den variation som er mulig paa grundlag av artens gener, stadig holdes nede i kampen for tilværelsen. Disse mindre levedygtige genotyper dannes selvfølgelig for en del automatisk og nødvendig ved spaltning av bedre heterozygotiske genotyper, men naar ikke i sin utvikling saa langt at de blir med i prægningen av artens utseende. Det naturlige utvalg virker derfor kun sorterende i en variation som beror paa bestemte allerede eksisterende genotyper."

Jeg har i dette avsnit paavist hvilke kombinationer som synes at være levedygtige. Det fremgaar av undersøkelsen, at disses antal ikke er større end at de kan skrives om ikke med ensifrede tal, saa ialfald med meget lave tosifrede tal. Det vil derfor gaa an inden enhver befolkning at skaffe sig en let overskuelig oversigt over dem. Og da faar man ogsaa herigjennem et meget klart billede av angjældende befolknings sammensætning.

Av dette avsnits indhold fremgaar følgende (se tabel 49):

1. Der er ingen væsensforskjel paa dolichocephaler og mesocephaler med hensyn til disse typers forhold til ansigtstype, næsetype, øienfarve, haarfarve og legemshøide.

2. Begge disse hodetyper er sterkt knyttet til leptomesoprosopi, leptorhini, lyse øine, lyst haar og stor legemshøide.

3. Disse træk findes blandt de av mig undersøkte dolichomesocephaler samlet hos 85 = 24 %. Hos 12,8 % av samtlige undersøkte.

4. Brachycephalene har biologisk sterk tilknytning til meso-euryprosopi, mesorhini, mørke øine, mørkt haar og liten legemshøide.

5. Disse karaktertræk findes blandt de av mig undersøkte brachycephaler samlet hos 10 = 4,30 %. Hos 1,5 % av samtlige undersøkte.

6. Hyperbrachycephali synes at være sterkt knyttet til euryprosopi, mesorhini, lyse øine, lyst haar og liten legemshøide.

7. Disse træk findes blandt de av mig undersøkte hyperbrachycephaler samlet hos 11 = 15 %. Hos 1,6 % av samtlige undersøkte.

8. Hyperbrachycephalien har dog ogsaa en fast tilknytning til euryprosopi, mesorhini, mørke øine, mørkt haar og liten legemshøide. Disse træk, som antagelig er lappenes oprindelige træk, findes blandt de av mig undersøkte hyperbrachycephaler samlet hos 5 mand = 6,8 %, hvilket svarer til 0,75 % av samtlige undersøkte.

9. Ved krydsning av de her nævnte urtyper er opstaat en række bastarder, hvorav de hyppigst forekommende er følgende:

a. Dolichomesocephali, euryprosopi, leptorhini, lyse øine, lyst haar, liten legemshøide hos 12 = 1,8 %.

b. Dolichomesocephali, euryprosopi, mesorhini, lyse øine, lyst haar, liten legemshøide hos 21 = 3,2 %.

c. Brachycephali, leptoprosopi, leptorhini, lyse øine, lyst haar, stor legemshøide hos 16 = 2,4 %.

d. Brachycephali, mesoeuryprosopi, leptorhini, lyse øine, lyst haar, α. liten legemshøide hos 24 = 3,6 %. β. stor legemshøide hos 26 = 3,9 %.

e. Brachycephali, mesoeuryprosopi, mesorhini, lyse øine, lyst haar, liten legemshøide hos 28 = 4,2 %.

f. Hyperbrachycephali, mesoprosopi, leptorhini, lyse øine, lyst haar, stor legemshøide hos 6 = 0,9 %.

X. Befolkningens væsentligste og mest karakteristiske bastarder.

Det billede som jeg i det foregaaende avsnit har git av denne befolkning, kan nærmest karakteriseres som et uhyre komplicert mosaikbillede.

Ved en detaljert undersøkelse av dette mosaikbillede lyktes det dog at faa nogen klarhet over hvorledes mosaikbilledet er kommet istand. Jeg vil nu prøve at forenkle dette billede ved at utelukke alle mindre væsentlige træk og ved at slaa sammen de træk som vi nu vet er samhørige.

Men jeg tror desuten at man gjennem kun nogle faa træk kan paa en fuldt tilfredsstillende maate karakterisere en befolkning. Det er det jeg vil forsøke at gjøre i dette avsnit.

Til dette øiemed vil jeg kun bruke den del av befolkningen som regner sig for norske. Jeg vil saa til slut sammenligne dette rene norske billede med det billede som kommer istand naar jeg tar med ogsaa alle fremmede elementer, lapper og kvæner. I mit materiale har jeg i alt 559 „norske individer". De træk som jeg vil anvende for at karakterisere dem, er hodeform, ansigtsform og øienfarve.

Ogsaa de 3 urtyper som indgaar i vor nuværende befolkning, kan paa en helt tilfredsstillende maate karakteriseres gjennem disse 3 træk saaledes:

a. Det nordiske element: mesocephalt,
leptomesoprosopisk,
blaaøiet.

b. Det alpine element: brachycephalt,
meso-euryprosopisk,
brunøiet.

c, Det lappoide element: hyperbrachycephalt,
euryprosopisk,
lyst melerte øine.

I mesocephalenes gruppe vil der selvsagt indgaa et ganske betydelig antal ÷-avvikere fra den meget store brachycephale gruppe. Og da denne er saa sterkt avvikende fra mesocephalene i alle henseender, vil den ogsaa bidra ikke saa lite til at forkludre mesocephalgruppen, saa at det blir vanskelig at se hvad der er særegent for den. Dolichocephalene repræsenterer derimot ÷-avvikerne av den mesocephale gruppe, og da der ikke her er anledning til nogen væsentlig opblanding med andre grupper, kan man her vente at finde de mest typiske repræsentanter for den store mesocephale gruppe.

Jeg har paa tabel 50 i alt 48 kombinationer. Hodets form er lagt til grund for den videre inddeling.

Rækkefølgen svarer til den hyppighet hvormed de forskjellige kombinationer findes inden hver enkelt hodetype. Det er jo nemlig av liten relativ interesse ved en saadan undersøkelse at faa rede paa hvor ofte hver enkelt kombination forekommer blandt samtlige undersøkte. Det sier sig jo nemlig selv, at den kombination maa forutsættes at bli den hyppigst forekommende som repræsenterer de inden den samlede masse hyppigst forekommende enkelttræk. Da saaledes mesocephali, leptoprosopi og blaa øine er de hyppigst forekommende enkelttræk, er det ogsaa at vente at disse træk hyppigst maa forekomme kombinert.

Av betydelig større interesse er det at bemerke at dolichocephali, leptoprosopi og blaa øine er den bedst besatte kombination inden de enkelte hodetyper.

Men for den videre beregnings skyld har jeg i sidste kolonne ogsaa anført kombinationens hyppighet blandt samtlige undersøkte i pro mille.

Saa har jeg endelig i kolonne 6 anført affinitetstallet. Paa samme maate som %-tallene i kolonne 5 tar hensyn til den relative hyppighet av det ene karaktertræk — hodetypen — tar affinitetstallet hensyn til den relative hyppighet av *alle 3 karaktertræk*. Derfor er ogsaa dette tal av meget stor interesse naar det bygges paa et tilstrækkelig stort antal individer. Det er nu ikke min mening detaljert at gjennemgaa alle de 48 her anførte kombinationers forekomst. Jeg vil kun ta med hvad der forekommer mig at være av særlig interesse.

Av aller størst interesse mener jeg det er at se hvilke kombinationer det er som har det største affinitetstal. Det er da meget bemærkningsværdig, at de 3 eneste kombinationer som har høie affinitetstal, er følgende:

Nr. 17. Brachycephali, euryprosopi, brune øine 1,75.
„ 2. Hyperbrachycephali, euryprosopi, blaa øine 1,34.
„ 1. Dolichocephali, leptoprosopi, blaa øine 1,28.

De er ogsaa de 3 kombinationer som vi før har erkjendt som karakteristiske for denne befolknings urtyper. Den tredje største i antal er mesocephali, leptoprosopi og blaa øine. Jeg kom i forrige avsnit til det resultat, at ogsaa disse træk tilhører den nordiske race. Naar saa allikevel affinitetstallet er saa meget mindre end det er for den tilsvarende dolichocephale kombination, saa kan vel grunden hertil kun være den, at en stor

Tabel 50.

1 Nr.	2 Hodetype	3 Ansigts-type	4 Øientype	5 % inden hodetypen	6 Affinitets-tal	7 Antal individer med komb.	8 Pro mille blandt alle undersøkte
1	D.	L.	Bl. ø.	38,0	1,28	14	25,1
2	H. B.	E.	Bl. ø.	34,0	1,34	18	32,2
3	M.	L.	Bl. ø.	24,8	1,01	68	121,5
4	H. B.	M.	Bl. ø.	20,8	0,99	11	19,8
5	B.	M.	Bl. ø.	20,6	0,99	40	71,6
6	M.	M.	Bl. ø.	20,2	1,10	56	100,2
7	M.	E.	Bl. ø.	20,0	1,11	55	99,4
8	B.	E.	Bl. ø.	18,6	0,77	36	64,4
9	D.	M.	Bl. ø.	16,2	1,21	6	10,7
10	B.	L.	Bl. ø.	16,0	0,97	31	55,5
11	H. B.	L.	Bl. ø.	9,5	0,75	5	8,9
12	H. B.	L.	L. m. ø.	9,5	2,23	5	8,9
13	M.	L.	L. m. ø.	8,8	1,08	24	42,9
14	B.	E.	L. m. ø.	8,8	1,12	17	30,5
15	D.	M.	M. m. ø.	8,1	2,91	3	5,4
16	D.	E.	Bl. ø.	8,1	0,70	3	5,4
17	B.	E.	Br. ø.	7,8	1,75	15	26,8
18	M.	E.	L. m. ø.	7,4	1,08	18	32,2
19	H. B.	M.	L. m. ø.	7,4	0,99	4	7,2
20	B.	M.	L. m. ø.	6,7	0,99	13	23,2
21	H. B.	M.	Br. ø.	5,7	0,55	3	5,4
22	M.	M.	L. m. ø.	5,5	0,90	15	26,8
23	D.	L.	L. m. ø.	5,4	0,55	2	3,6
24	D.	E.	L. m. ø.	5,4	1,42	2	3,6
25	D.	E.	Br. ø.	5,4	2,52	2	3,6
26	M.	L.	Br. ø.	4,3	0,90	12	21,0
27	B.	E.	M. m. ø.	4,1	1,22	8	14,3
28	H. B.	M.	M. m. ø.	3,8	1,16	2	3,6
29	H. B.	E.	L. m. ø.	3,8	0,45	2	3,6
30	H. B.	E.	Br. ø.	3,8	0,81	2	3,6
31	B.	L.	L. m. ø.	3,6	0,75	7	12,5
32	B.	L.	M. m. ø.	3,6	1,74	7	12,5
33	B.	L.	Br. ø.	3,6	1,19	7	12,5
34	B.	M.	M. m. ø.	3,6	0,95	7	12,5
35	B.	M.	Br. ø.	3,1	0,82	6	10,7
36	D.	L.	Br. ø.	2,7	0,45	1	1,8
37	D.	M.	L. m. ø.	2,7	0,42	1	1,8
38	D.	M.	Br. ø.	2,7	0,74	1	1,8
39	D.	L.	M. m. ø.	2,7	0,65	1	1,8
40	M.	M.	M. m. ø.	2,5	0,64	7	12,5
41	M.	L.	M. m. ø.	2,5	0,98	7	12,5
42	H. B.	L.	Br. ø.	1,9	0,81	1	1,8
43	M.	M.	Br. ø.	1,8	0,54	5	8,9
44	M.	E.	M. m. ø.	1,8	0,70	5	8,9
45	M.	E.	Br. ø.	1,4	0,43	4	7,2
46	D.	E.	M. m. ø.	0	0	0	0,0
47	H. B.	L.	M. m. ø.	0	0	0	0,0
48	H. B.	E.	M. m. ø.	0	0	0	0,0
						559	

del av mesocephalene kun er phænotypiske mesocephaler. Genotypisk tilhører de den brachycephale gruppe.

Gruppe 4 har lappenes hodeform, den nordiske races ansigtsform og øienfarve. Denne kombination forekommer, som det vil sees, meget sjelden, kun hos 11 individer av 559, det vil si hos 1,9 % av samtlige undersøkte. Men den forekommer hos 20,8 % av samtlige hyperbrachycephaler.

Den er selvfølgelig et krydsningsprodukt av lapper med individer som tilhører den nordiske race. Det samme er tilfældet med løpenr. 11. Denne gruppe har ogsaa lappenes hodeform, den nordiske races ansigtsform og øienfarve. Av denne kategori findes i alt 5 individer, hvilket svarer til 0,89 % av samtlige undersøkte, men 9,5 % av samtlige hyperbrachycephaler. I alt er der altsaa 16 individer som har lappenes hodeform, men den nordiske races ansigtsform og øienfarve. Dette svarer til 30,3 % av alle hyperbrachycephaler.

Hos løpenr. 5 er hodeformen hentet fra den brachycephale gruppe, ansigtsformen og øienfarven fra den nordiske. Affinitetstallet tyder paa at der ikke her er noget affinitetsforhold tilstede; men der synes heller ikke at være noget motsætningsforhold tilstede. Kombinationen forekommer hos 20 % av samtlige brachycephaler, og hos 7,2 % av samtlige undersøkte.

Den næst største gruppe blandt samtlige undersøkte er mesocephali, mesoprosopi og blaa øine. Den tæller 56 individer og utgjør 100,2 ‰ av samtlige undersøkte. Den har ogsaa et høit affinitetstal, 1,10, og dette taler jo for at der kan være en biologisk sammenhæng tilstede ogsaa her. Det er der ogsaa utvilsomt. Nogen særskilt mesoprosop type findes neppe inden vor befolkning. Mesoprosopene er dels +-avvikere av leptoprosopene, dels ÷-avvikere av euryprosopene.

Den lille gruppe blaaøiede dolichocephale mesoprosoper (nr. 9) har ogsaa et saa høit affinitetstal, at man med én gang kan være sikker paa at der her har gjort sig gjældende meget sterke kræfter, at der med andre ord er biologiske forhold som er grund til den hyppig forekommende kombination av disse 3 træk.

Affinitetstallene løper ogsaa helt paralelt med den foregaaende gruppes, størst for den dolichocephale gruppe, mindst for den brachycephale. Utvilsomt har man heller ikke her med bastarder at gjøre; det er kun +- og ÷-avvikere fra den nordiske race. Disse 3 grupper tæller henholdsvis 56, 40 og 6 individer og utgjør altsaa 18,4 % av samtlige undersøkte.

Antallet av dem som har beholdt disse 3 træk fra den nordiske race samlet, forøkes derved til 33,2 %.

Den tredje største gruppe, løpenr. 7, er mesocephali, euryprosopi og blaa øine. Det er en utvilsom bastard, et krydsningsprodukt av det nordiske element med det alpine.

Løpenr. 8 er ogsaa et typisk krydsningsprodukt av det nordiske element med det alpine. Det alpine element gir sig tilkjende i hodeformen og ansigtsformen, det nordiske element i øienfarven. Man skulde vente at denne bastard var meget talrikere, da den er et krydsningsprodukt av de to hovedtyper. De repræsenterer imidlertid diametrale motsætninger baade med hensyn til hodeform, ansigtsform og øienfarve. Disse træk som her findes kombinert: brachycephali, euryprosopi og blaa øine, hører biologisk ikke sammen; affinitetstallet peker i samme retning.

Gruppe 13 svarer til gruppe 3, blot med den forskjel, at øinene er blit lyst melert. Baade hodets og ansigtets form har denne gruppe fælles

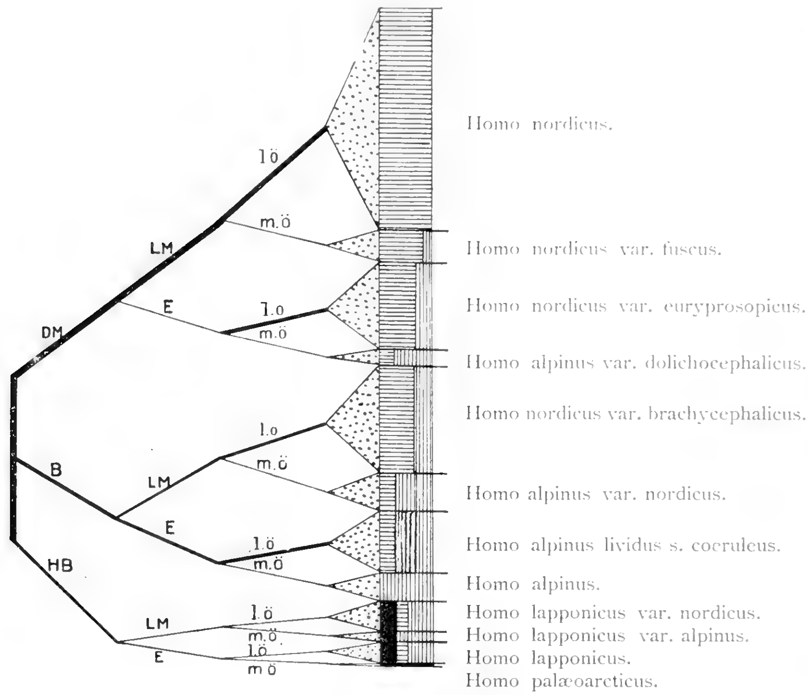


Fig. 13. Grafisk fremstilling av tabel 51.

Bastardernes forgreningsnet i henhold til tabel 51. Strekenes tykkelse illustrerer samtidig mængdeforholdet. Skraveringen har følgende betydninger:

Vandret betegner den nordiske race.
Lodret — — alpine race.
Sort - - palæoarktiske race.

med den nordiske race. De melerte øine maa den ha faat fra en av de 2 andre urtyper. Denne bastard findes overalt hvor den nordiske race findes, og dens store utbredelse overalt i Norge taler for at den hovedsagelig maa betragtes som et krydsningsprodukt av den nordiske race med den alpine race. At de melerte øine kun er en modifikation av de brune øine, er vel ganske utvilsomt. Gjennem lange tiders krydsning med den nordiske race er det brune pigment blit utspædd; men ved krydsning med blaaøiede forholder disse melerte øine sig ganske som de brune og dominerer over dem. Genetisk set blir derfor denne gruppe at slaa sammen med de tilsvarende kombinationer av mesocephale og leptoprosope med mørkt melerte øine og brune øine. Der er mellem disse grupper kun en gradsforskjel tilstede. De lyst melerte øine er resultatet av en længere fortsat krydsning end de mørkt melerte øine, og disse tyder igjen paa en længere fortsat krydsning end de lysebrune øine o. s. v.

Naar det gjælder en bastardundersøkelse, gjør man derfor rettest i at regne med disse som ensartede bastarder. Paa tabel 50 findes disse 3 grupper opført som nr. 13, 15, 22, 23, 26, 36, 37, 38, 39, 40, 41 og 43.

Fælles for alle disse grupper er det altsaa at de har tat hodeformen og ansigtsformen fra den nordiske race, medens de med hensyn til øienfarve har faat et større eller mindre stænk fra den alpine race. Tilsammen tæller disse grupper 79 individer, hvilket svarer til 14 % av samtlige undersøkte.

Tabel 51.

Rækkefølge efter størrelse	Hodetype	Ansigtstype	Øienfarve	Antal	Procent av alle undersøkte	
1	D. M.	L. M.	l. ø.	186	33,2	Dolichomesocephali 65—80
2	B.	L. M.	l. ø.	91	16,4	Brachycephali 81—85
3	D. M.	E.	l. ø.	78	14,0	Hyperbrachycephali 86—93
4	B.	E.	l. ø.	53	9,5	
5	D. M.	L. M.	m. ø.	37	6,6	Euryprosopi 70—83
6	B.	L. M.	m. ø.	27	4,8	Leptomesoprosopi 84—100
7	H. B.	L. M.	l. ø.	25	4,5	
8	B.	E.	m. ø.	23	4,0	
9	H. B.	E.	l. ø.	20	3,6	
10	D. M.	E.	m. ø.	11	2,0	
11	H. B.	L. M.	m. ø.	6	1,1	
12	H. B.	E.	m. ø.	2	0,3	
				559		

I gr. no. 18, 44 og 45 finder vi mesocephali sammen med euryprosopi og henholdsvis lyst melerte, mørkt melerte og brune øine. Disse grupper har altsaa hodeform efter den nordiske race, men ansigtsform og øienfarve efter den alpine race. Disse bastarder er saaledes sterkere alpint markert end foregaaende gruppe. Under samme kategori kommer ogsaa løpenr. 24, 25 og 46. Tilsammen har disse 6 grupper 31 individer og utgjør saaledes 4,7 % av samtlige undersøkte. Fælles for alle disse er altsaa at de har to træk fra den alpine race og ett fra den nordiske.

Bastarder mellem det lappoide og det nordiske element finder man i no. 4, 11, 12 og 19. I alt finder man 43 bastarder mellem det lappoide og det nordiske element, svarende til 6,5 % av samtlige undersøkte. Der findes ogsaa en del grupper som nærmest maa antages at ha tat et træk fra hver av urtypene. Dette er saaledes tilfældet med nr. 42.

Saa broget som dette bastardbillede av befolkningen til en begyndelse ser ut, saa kan man altsaa dog reducere det til at omfatte følgende grupper (se tabel 51).

1. En ren nordisk gruppe: dolichomesocephal, leptomesoprosopisk, lysøiet. 33,2 % av befolkningen tilhører denne gruppe, som jeg vil benævne *homo nordicus*.

2. En ren alpin gruppe: brachycephal, euryprosopisk, brunøiet. 4 % av befolkningen tilhører denne gruppe, som jeg vil benævne *homo alpinus*.

3. En ren hyperbrachycephal gruppe: hyperbrachycephal, euryprosopisk, brunøiet: kun 0,3 % av befolkningen tilhører denne gruppe, som jeg vil benævne *homo palæoarcticus*.

Ved krydsning av disse 3 typer er opstaat følgende hybride varieteter:

4. En dolichomesocephal, leptomesoprosopisk, brunøiet. Denne har altsaa to træk fra den nordiske race og ett træk som for den aller væsentligste del maa skrive sig fra den alpine race. 6,6 % av befolkningen tilhører denne varietet, som jeg benævner *homo nordicus fuscus*.

5. En dolichomesocephal, euryprosopisk, lysøiet varietet. Denne har ogsaa to træk fra den nordiske race og ett træk fra den alpine race. Den er i flere henseender en meget eiendommelig bastard. For det første er de brede ansigter i forbindelse med et avlangt hode en eiendommelig kombination. Dernæst er ogsaa de lyse øine i et bredt ansigt et meget iøinefaldende fænomen. Ikke mindre end 14 % av befolkningen tilhører denne varietet, som jeg benævner *homo nordicus var. euryprosopicus*.

6. Saa har vi en liten gruppe dolichomesocephaler som er euryprosope og har mørke øine. Den har altsaa to træk fra den alpine race, ett træk fra fra den nordiske race. Da de to mest iøinefaldende træk skriver sig fra den alpine race, vil denne varietet tilsynelatende staa den alpine race meget nær. Jeg har ogsaa benævnt den *homo alpinus var. dolichocephalicus*. Den forekommer kun hos 2 % av befolkningen.

Den har disse 3 træk tilfælles med den av mig andensteds beskrevne Tydals-type (Cro-Magnon). Men den adskiller sig fra den gjennem sin ringe legemshøide. Den har tydeligvis intet med denne at gjøre. Som jeg i næste avsnit skal paavise, maatte vi vente at støte paa en saadan type som denne. Og den forekommer ogsaa i det antal som man teoretisk kan beregne sig til bør være det rigtige.

7. Jeg kommer saa til den mest utbredte av alle hybride former, nemlig de brachycephale leptomesoprosoper med lyse øine. Av saadanne findes i alt 16,4 %. Disse har altsaa 2 træk fra den nordiske race og ett fra den alpine race. Jeg benævner derfor denne varietet *homo nordicus var. brachycephalicus*, idet det kun er dette sidste træk som adskiller den fra den nordiske race.

8. En gruppe brachycephale leptomesoprosoper med mørke øine staar den alpine race saa nær at jeg har benævnt dem *homo alpinus var. nordicus*. 4,8 % tilhører denne varietet.

9. Saa møter vi en gruppe euryprosope brachycephaler med lyse øine. Denne gruppe har altsaa sine to væsentligste træk fra den alpine race. Den har kun laant haarfarve fra den nordiske race. 9,5 % tilhører denne varietet. Jeg har benævnt den *homo alpinus lividus*.

10. Jeg kommer derefter over til de 3 varieteter som man hos os finder av den palæoarktiske race. Den største av disse er opstaat ved krydsning med den nordiske race. Den er hyperbrachycephal, men leptomesoprosopisk og har lyse øine. 4,5 % av befolkningen tilhører denne varietet, som jeg har benævnt *homo lapponicus var. nordicus*. De fleste av disse vil utvilsomt enten regne sig for lapper eller ialfald finde lapper i de nærmeste slegtled.

11. Den næste varietet er sandsynligvis opstaat ved krydsning dels av homo alpinus og homo palæoarcticus, dels av homo palæoarcticus og homo nordicus. Jeg har benævnt denne varietet *homo lapponicus var. alpinus*, idet jeg derved faar forbundet at der indgaar i denne varietet litt fra alle de nævnte urtyper. 1,1 % av befolkningen tilhører denne varietet.

12. Som sidste varietet har jeg opført de egentlige lapper, ɔ: hyperbrachycephale euryprosoper med lyse øine. 3,6 % av de undersøkte tilhører denne varietet, som jeg har benævnt *homo lapponicus*.

Jeg skal i det følgende avsnit se paa hvorledes de her opstillede hybride former, hvad antal angaar, stemmer overens med hvad man maa vente at finde, hvis krydsningen er foregaat mellem de av mig forutsatte urtyper og er skedd overensstemmende med de Mendelske arvelighetslover.

Paa den 11te almindelige antropologiske kongres i Moskva i 1892 uttalte KOLLMANN følgende: „Paa hele det store europæiske kontinent, som siden den neolitiske periode har været befolket av flere forskjellige racer, varierer indenfor de mindre gebeter stadig paany verdensdelens almindelige tema, paa grund av at disse samme 5 racer har trængt ind paa alle omraader, og det allerede for Kurganernes tid. Den allikevel overalt merkbare forskjel mellem de ulike folkeslag beror ikke paa optræden av nye racer, ti disse er overalt de samme, men paa det relative antal av hver races repræsentanter; ti disse veksler indenfor hver folkegruppe og betinger det ulike fysiognomi."

De 5 racer som KOLLMANN mente hadde bebodd Europa siden den neolitiske tid, var følgende:

1. Dolichocephale leptoprosoper.
2. Dolichocephale chamæprosoper.
3. Brachycephale leptoprosoper.
4. Brachycephale chamæprosoper.
5. Mesocephale chamæprosoper.

Hvad det altsaa gjælder om, mener KOLLMANN, er at bringe paa det rene hvor mange repræsentanter hver av ovenstaaende 5 racer har inden et visst omraade. Har man det paa det rene, saa er dermed ogsaa distriktets antropologiske fysiognomi tegnet.

Jeg har i denne avhandling paavist at disse 5 „racer" ogsaa findes i Troms fylke, og jeg har paavist hvor mange repræsentanter hver enkelt av disse 5 „racer" har inden fylket. Jeg har endvidere fremholdt betydningen av at man ogsaa medtar øienfarven.

Da KOLLMANN formulerte sin opfatning, var arvelighetslæren endnu i sin barndom. Man hadde paa den tid ingen idé om, hvorledes det gik naar to uensartede racer krydsedes med hinanden. Med vort nuværende kjendskap til disse ting vet vi ogsaa at ved krydsning av *to* racer: en brachycephal euryprosop med en dolichomesocephal leptoprosop, saa vil inden avkommet i F_2-generationen samtlige KOLLMANNS 5 racer være repræsentert. Hvis de to „urracer" findes i samme mængde alle steder, vil ogsaa de 5 „racer" bli like talrikt repræsentert overalt. Naar dette ikke er tilfældet, beror det paa at snart den ene, snart den anden av urracene fra første stund av har været tilstede i større antal end den anden.

Her i Troms fylke er forholdene blit yderligere komplicert ved at der ogsaa er kommet til en hyperbrachycephal type. Denne hyperbrachycephale type har imidlertid ikke været medtat av KOLLMANN, fordi den slet ikke forekom i de deler av Europa hvorfra han hadde hentet sit materiale.

Jeg tror ikke længer, der kan være tvil om at den av mig her givne forklaring paa raceblandingen i Troms fylke er den rigtige. Jeg tror heller ikke, der kan være tvil om at krydsningen av de to racer for en meget væsentlig del maa være foregaat inden selve fylket. Dette forutsætter, at fylket har været bebodd av en brachycephal type før den nordiske race kom hit. Det kan vel være sandsynlig, at heller ingen av disse to racer har været helt rene da krydsningen foregik. Fremfor alt maa man vel gaa ut fra at det sidst indflyttede raceelement, den nordiske race, har været opblandet endel med alpine raceelementer tidligere. Det kunde neppe naa saa langt nord i Skandinavien uten at det vilde ske. Men det behøver dog ikke at ha været sterkere opblandet end tilfældet har været med de i de senere aar indflyttede østerdølinger. Og vi ser nu, hvorledes raceblandingen er blit i de bygder hvortil disse østerdølinger og gudbrandsdølinger er flyttet. Disse bygder (Bardu, Maalselv o. fl.) har et helt avvikende præg. Disse bygder har da indflytningen foregik, omtrent ikke været bebodd. Dette er store indlandsbygder, som har virket særlig dragende paa de nordiske raceelementer. Enkelte lappefamilier har vistnok holdt til i disse indlandsbygder; men det alpine raceelement har ikke følt sig tiltrukket av denne natur. Det er i kyst- og fjorddistriktene det alpine raceelement har holdt sig. Derfor har ogsaa saa mange av kystdistriktene og fjorddistriktene et eiendommelig præg. Ikke alle. Der er ogsaa en forskjel paa disse. Men netop dette gjør, at man nødes til at gaa ut fra at krydsningen er foregaat paa stedet. Hvis nemlig ikke det var tilfældet, hvis krydsningen hadde foregaat til eks. i Sydnorge, blev det aldeles umulig at forklare sig hvorledes distriktene nu kan ha et i raceantropologisk henseende saa forskjelligartet præg. Det maatte da kun bli i høiden nuanceringsforskjelligheter. Men som det fremgaar av denne avhandling, er dette ikke tilfældet.

At dette fremmede element ikke skyldes tidligere indflyttede lapper, tør ogsaa være sikkert nok. Det er tydelig nok et brachycephalt, ikke et hyperbrachycephalt element. Det fremmede elements utbredningsomraade netop i kystdistriktene taler ogsaa herimot. Det fremmede element har helt igjennem det samme præg som i Søndmør og som paa Jæderen. Og det samme, for den nordiske race fremmede element er jo ogsaa paavist i Sverige, hvor det ogsaa overalt holder sig til kystdistriktene. Professor C. M. Fürst er ogsaa av den overbevisning, at „vi i Sverige i stenalderen ikke bare har to forskjellige folkestammer eller kaster, men mindst *2 forskjellige racer*. Den ene race har den nordiske langskalleform og tilhører særskilt de store stengraver, den anden race — eller muligens den ene av de andre — *er kortskallet og sikkert ogsaa den ældre i landet*“.

Just saaledes maa vi ogsaa tænke os forholdene her i landet. Og vi skal nu se litt nærmere paa til hvilket resultat krydsningen av de 2 forskjellige racer har ført.

XI. Nogen spørsmaal vedrørende arvelighetsforholdene specielt angaaende hvilke karaktertræk som er eller har været dominerende.

Jeg har i de foregaaende avsnit gjort rede for utbredelsen av de væsentligste antropologiske karaktertræk inden den nulevende befolkning i Troms fylke.

Den senere tids arvelighetsundersøkelser har bragt paa det rene at flere av disse karaktertræk er overmaade stabile. De nedarves uforandret fra generation til generation. De kan derunder indgaa nye forbindelser, men de blir ellers uforanderlige. Dette gjælder i særlig grad index cephalicus, index facialis morphologicus og index nasalis. Relativt uforanderlig nedarves ogsaa øienfarven.

Nogen undersøkelser synes at tale for at de her nævnte træk herunder følger de Mendelske lover, saaledes at enkelte træk er dominerende, andre recessive. Meget sparsomme er imidlertid de undersøkelser som foreligger over disse spørsmaal for menneskenes vedkommende.

Av de av professor Eugen Fischer angaaende disse spørsmaal foretagne undersøkelser blandt „die Rehobother Bastards“ fremgaar, at ialfald index cephalicus med stor sandsynlighet nedarves overensstemmende med Mendels lover, og saaledes, at den høiere index dominerer over den lavere. Hvorvidt dette altid er tilfældet, er et andet spørsmaal.

Ved de av mig foretagne undersøkelser i Tydalen og Selbu fandt ogsaa jeg at brachycephali synes ubetinget at dominere over mesocephali. I Tydalen kunde jeg imidlertid paavise en dolichocephal type som i alle henseender mindet sterkt om Cro-Magnon-typen.

Denne dolichocephale type synes at eie dominans over den mesocephale type. Rigtignok er dette materiale sparsomt, men det er dog stort nok til at man kan si at sandsynligheten taler for denne dolichocephale types dominans over den mesocephale.

For ansigtsindeks's vedkommende mener FISCHER at kunne fastslaa at ogsaa denne nedarves alternativt, ikke intermediært.

For øienfarvens vedkommende foreligger en række undersøkelser, som alle gaar i den retning, at øienfarven nedarves Mendelsk, og at brune øine dominerer over blaa øine. De fleste forskere er ogsaa av den mening, at melerte øine dominerer over blaa. Men paa hele dette omraade er undersøkelsene meget sparsomme.

Det vilde være altfor dristig allerede nu at fastslaa som en almindelig regel at brachycephali i alle tilfælder dominerer over mesocephali, eller at brune øine altid dominerer over blaa øine o. s. v. Der kan vel her spille faktorer med som vi endnu kun har litet kjendskap til. Vort kjendskap til de faktorer som fremkalder de her omhandlede karaktertræk, er jo endnu lik nul. Det er i den senere tid av flere forskere fremholdt, at de her omhandlede træk, sp. index cephalicus er beroende paa flere faktorer. I en undersøkelse som den her foreliggende vil det imidlertid være mest praktisk at betragte index cephalicus som en enhet. For denne undersøkelse vil nemlig resultatet bli det samme, og materialet blir derved mere oversigtlig og haandterlig.

Ved den taksinometriske undersøkelse av denne befolkning er jeg i de foregaaende avsnit kommet til det resultat, at befolkningen er av en meget heterogen beskaffenhet.

Hovedmassen av den tilhører den nordiske race. Jeg kom til det resultat at denne blok maa utgjøre omtrent 66 % av befolkningen. En anden, ogsaa ganske stor blok tilhører den alpine race. Jeg kom til det resultat, at denne blok har utgjort omtrent 30 % av befolkningen.

Endelig indgaar der ogsaa i befolkningen en ganske liten blok av lappoid herkomst. Jeg har gaat ut fra at denne blok neppe utgjør mere end 4 % av befolkningen.

Disse tal kan naturligvis ikke gjøre krav paa nogen matematisk nøiagtighet. Det kan saaledes være at den sidstnævnte blok er noget større, skjønt sandsynligheten herfor er meget liten. Det kan ogsaa være at den er mindre end 4 %. Likeledes kan det være at den alpine blok er nogen procent mindre eller større end av mig beregnet. Hvad der i hvert fald er sikkert, er at den nordiske blok maa ha været mindst dobbelt saa stor som den alpine, og den igjen mange ganger større end den lappoide. Og sikkert er det ogsaa, at naar man anvender alle de hjælpemidler som for tiden staar til vor raadighet, saa kommer man til det resultat, at inden den nulevende befolkning indgaar de nævnte blokker paa det aller nærmeste i det forhold som ovenfor er anført. Og jeg vil indtil videre gaa ut fra at dette er rigtig.

Nu er det ganske vist saa, at man ikke kan være viss paa at dette forhold altid har været det samme. Heller ikke har man visshet for, at de anførte „urracer" var rene dengang de støtte sammen i Norge. For lappenes vedkommende kan man jo endog med sikkerhet gaa ut fra at det motsatte har været tilfældet. Men for det første er denne blok meget liten. Dertil kommer at affinitetsundersøkelsene peker paa, at hvis de har været opblandet før de kom hertil, saa har dette hovedsagelig været med elementer tilhørende der nordiske „race". Dette spiller derfor ved den undersøkelse som her skal foretages, en mindre rolle.

Det samme kan siges om de to andre blokker. Det kan være, at den alpine race har været litt opblandet før den kom til Troms fylke. Men isaafald har det hovedsagelig været med de samme to elementer hvormed den senere er blit krydset i Troms fylke.

Jeg vil ved slutten av dette avsnit komme nærmere tilbake til hvilken vegt man bør tillægge de momenter, som svækker rigtigheten av de forutsætninger hvorpaa hele denne undersøkelse hviler.

Jeg vil her gaa ut fra, at disse 3 blokker har været rene dengang krydsningen foregik. Om krydsningen muligens for en del er foregaat et andet sted end i Troms fylke, spiller jo i denne forbindelse ingensomhelst rolle.

De tre træk som jeg her vil ta med, er index cephalicus, index facialis morphologicus og øienfarven.

Jeg har i et foregaaende avsnit nøiagtig gjort rede for bastardenes fordeling med hensyn til disse 3 træk i Troms fylke. Hvorledes svarer nu denne fordeling til det man vil faa, om urtypene har krydset sig i det mængdeforhold som jeg ovenfor har forutsat.

Resultatet av denne krydsning vil naturligvis helt avhænge av hvilke træk som er dominerende og hvilke recessive.

Om jeg tænker mig at 2 „rene" racer krydses, saa vil selvfølgelig i F_1-generationen de recessive karaktertræk helt forsvinde, saafremt de to blokker som krydses, har nøiagtig samme størrelse. I F_2-generationen vil de igjen komme frem, men i mindre antal end før krydsningen, medens de dominerende træk har øket i tilsvarende grad. Ved den fortsatte panmiksi vil de procentforhold som fandtes i F_2-generationen, forbli uforandret. Og om den ene blok fra første stund av har været meget større end den anden, saa vil selvfølgelig ogsaa dette medføre at dennes karaktertræk forekommer i et større procenttal i F_2-generationen. Men ogsaa i dette tilfælde vil det samme procenttal som findes i F_2-generationen, fortsætte uforandret i de senere generationer[1].

I sin bok: Anthropologische Untersuchungen über die Eingeborenen des Russischen Altai fremholder ogsaa KAARLO HILDÉN den store betydning herav for raceantropologien. I den nævnte boks side 106 siger han saaledes: „Es sei hinzugefügt, daß genau die gleichen Gesetze gelten auch wenn wir Rassen kreuzen, die sich in mehreren Merkmalen unterscheiden, wenn wir also Polyhybriden haben. Wir können demnach generell sagen: eine Bastardpopulation, die sich panmiktisch fortpflanzt, behält ihre nach der ersten Bastardierung erworbene Zusammensetzung durch sämtliche folgende Generationen bei.“

Vi har jo ingen grund til at tro at ikke ogsaa den samme lov gjelder for en menneskelig bastardpopulation. Og hvis denne regel gjælder et menneskesamfund, saa har vi derigjennem et udmerket middel til at utdype vor forstaaelse av dette menneskesamfunds raceologiske oprindelse. Jeg vil i dette avsnit bringe denne regel i anvendelse paa det her foreliggende materiale.

Jeg vil til at begynde med gaa ut fra at hyperbrachycephali dominerer baade over brachycephali og dolichomesocephali, og at brachycephali dominerer over dolichomesocephali; fremdeles at euryprosopi dominerer over leptoprosopi og brune øine over blaa øine. Kan man nu gjøre sig op nogen mening om, hvorledes det vil gaa naar 2 saadanne typer krydses? Hvor mange synlig forskjellige grupper vil der komme istand, og hvor stort antal kombinationer vil der være?

Jeg tar altsaa her kun hensyn til disse 3 karaktertræk.

Jeg tar først for mig forholdet ved krydsning av den nordiske race med den alpine race. Jeg vil i det følgende gaa ut fra, at brachycephali fremkaldes ved en faktor som jeg benævner *B*. Mesocephali kommer istand hvor denne faktor mangler, og denne manglende faktor betegner jeg med *b*. Paa samme maate fremkaldes euryprosopi ved en faktor som jeg benævner *E*, og leptoprosopi ved manglen av denne faktor *e*. Brune øine fremkaldes av en faktor *P*, og blaa øine ved manglen av denne faktor *p*. F_1-generationens formel blir da *Bb. Ee. Pp*. Denne vil danne 8 slags kjønsceller: *BEP, BEp, BeP, bEP, Bep, bEp, beP* og *bep*.

Man vil da ved krydsning av disse 2 typer faa 64 kombinationsmuligheter og i alt 8 synlig forskjellige grupper, som vil fordele sig saaledes:

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1 NILS VON HOFSTEN: Ärftlighetslära, Upsala 1919.

1	med 3	dominerende	faktorer	*B E P*	=	27
2	— 2	—	—	*B E p*	=	9
3	— 2	—	—	*B e P*	=	9
4	— 2	—	—	*b E P*	=	9
5	— 1	—	—	*B e p*	=	3
6	— 1	—	—	*b E p*	=	3
7	— 1	—	—	*b e P*	=	3
8	— ingen	—	—	*b e p*	=	1
				Tilsammen		64

Saaledes vil fordelingen bli hvis begge typer fra første stund av har været tilstede i samme mængde, og under forutsætning av at der fra første stund av har hersket panmiksi.

Hvis dermot den ene type er tilstede i dobbelt saa stort antal som den anden, vil forholdet selvfølgelig bli et andet. Om jeg forutsætter at den dolichomesocephale type fra første stund av har været dobbelt saa talrik som den brachycephale, saa vil altsaa halvparten av den dolichomesocephale blok komme til at krydses indbyrdes.

Dette avkom har formelen *b e p*, og man faar altsaa da i tillæg til ovenstaaende 32 *b e p*. Nu vet vi, som allerede nævnt, at en bastardpopulation som forplanter sig panmiktisk, gjennem samtlige senere generationer beholder den sammensætning som den fik efter første bastardering.

For disse 2 typers vedkommende skulde altsaa typegrupperingen bli som paa tabel 52 anført, med den forandring, at 1 *b e p* blir forandret til 33 *b e p*.

Tabel 52.

Brachycephali	euryprosopi	brune øine	14 × 27 =	378
Brachycephali	euryprosopi	blaa —	14 × 9 =	126
Brachycephali	leptoprosopi	brune —	14 × 9 =	126
Dolichocephali	euryprosopi	brune —	14 × 9 =	126
Brachycephali	leptoprosopi	blaa —	14 × 3 =	42
Dolichocephali	euryprosopi	blaa —	14 × 3 =	42
Dolichocephali	leptoprosopi	brune —	14 × 3 =	42
Dolichocephali	leptoprosopi	blaa —	14 × 1 =	14

Jeg sætter nu at der ogsaa kommer til en anden type: hyperbrachycephal, euryprosopisk og brunøiet. Jeg vil først se, hvorledes det gaar naar denne type krydses med den dolichomesocephale type.

Den har en faktor for hyperbrachycephali som jeg vil benævne *H*, og manglen av denne faktor *h* (= dolichomesocephali). Den har en faktor for euryprosopi som jeg benævner *E*, og manglen av denne faktor *e* (= leptoprosopi). Dens formel blir altsaa *H E P*. F_1-generationens formel blir *H h E e P p*, og denne vil igjen danne følgende kjønsceller: *H E P*, *H E p*, *h E P*, *H e P*, *H e p*, *h E p*, *h e P*, *h e p*. Ved krydsning av disse to typer vil man derfor faa 64 kombinationsmuligheter og i alt 8 synlig forskjellige grupper:

Med 3 dominerende faktorer	*H E P*	=	27
2 — —	*H E p*	=	9
2 — —	*H e P*	=	9
2 — —	*h E P*	=	9
1 — —	*h E p*	=	3
1 — —	*h e P*	=	3
1 — —	*H e p*	=	3
ingen	*h e p*	=	1

Tabel 53.

Hyperbrachycephali	euryprosopi	brune øine =	27
Hyperbrachycephali	euryprosopi	blaa — =	9
Hyperbrachycephali	leptoprosopi	brune — =	9
Dolichocephali	euryprosopi	brune — =	9
Dolichocephali	euryprosopi	blaa — =	3
Dolichocephali	leptoprosopi	brune — =	3
Hyperbrachycephali	leptoprosopi	blaa — =	3
Dolichocephali	leptoprosopi	blaa — =	1

Ved krydsning av den hyperbrachycephale type med den brachycephale vil utfaldet bli anderledes. Den brachycephale type hadde, som det vil erindres, formlen *B E P*. Den hyperbrachycephale type hadde formlen *H E P*.

FISCHERS undersøkelser tyder paa at hyperbrachycephali dominerer over brachycephali, og jeg vil i det følgende gaa ut fra at saa er tilfældet. F_1-generationens formel blir da *H B E E P P*. Denne vil danne følgende slags kjønsceller: *H E P* og *B E P*.

Vi faar altsaa 4 mulige kombinationer, som imidlertid vil fordele sig paa følgende 2 grupper:

Tabel 54.

H E P	Hyperbrachycephali	euryprosopi	brunøiet	48
B E P	Brachycephali	euryprosopi	brunøiet	16

Ved den ovenfor av mig forutsatte størrelse av de forskjellige grupper vil der under forutsætning av panmiksi bli tilbake 36 dolichomesocephale som ikke blir krydset med nogen av de øvrige. Disse 36 krydses indbyrdes, og deres avkom faar formelen *b e p*.

Den ved krydsning frembragte population skulde isaafald faa følgende sammensætning:

a. Bastarder av hyperbrachycephaler og brachycephaler .... 4 %
b. Bastarder av hyperbrachycephaler og dolichomesocephaler ..... 4 %
c. Bastarder av brachycephaler og dolichomesocephaler .... 56 %
d. Ukrydsede dolichomesocephaler .... 36 %

Tilsammen 100 %

Anbringer jeg nu de her fundne tal paa de for for hver kombination fundne gruppetal, finder jeg følgende (se tabel 55) som slutresultat for krydsningen.

Tabel 55.

1	2	3	4	5	6	7	8	9	10	11
	Hode-type	An-sigts-type	Øien-type	Ved krydsning av nedenstaaende typer i det anførte mængdeforhold skulde F_2-generationen faa nedenanførte sammensætning						Av mig er i Troms fylke fundet:
				H. B. × B. 2 : 2	H. B. × D. 2 : 2	B. × D. 28 : 28	D. : D. 18 : 18	Sum	%	
a.	H. B.	E.	m. o.	48	27	-	-	75	4,7	0,3
b.	H. B.	E.	l. o.	-	9	-	-	9	0,50	3,0
c.	B.	E	m. o.	10	-	378	-	394	24,60	4,0
d.	B.	E.	l. o.	-	-	126	-	126	7,9	9,5
e.	H. B.	L.	l. o.	-	3	-	-	3	0,19	4,5
f.	D.	E.	l. o.	-	3	42	-	45	2,9	14,0
g.	B.	L.	m. o.	-	-	126	-	126	7,9	4,8
h.	D.	E.	m. o.	-	9	126	-	135	8,5	2,0
i.	B.	L.	l. o.	-	-	42	-	42	2,8	16,4
k.	D.	L.	m. o.	-	3	42	-	45	2,9	6,0
l.	D.	L.	l. o.	-	1	14	-	591	37,0	33,2
m.	H. B.	L.	m. o.	-	9	-	570	9	0,56	1,1
				64	64	896	570	1000		

H. B. betyr Hyperbrachycephali.
B. — Brachycephali.
D. — Dolichocephali.
E. — Euryprosopi.
L. — Leptoprosopi.
l. o. — lyse øine.

m. o. betyr mørke øine.
H. B. dominerer over B. og D.
B. — — D.
E. — — L.
m. o. — — l. o.

Flere end disse 12 bastarder kan heller ikke forekomme i de senere generationer, saafremt der ikke paa en eller anden maate sker et utvalg, naturlig eller kunstig.

I kolonne 5 har jeg utregnet resultatet av krydsningen for brachycephalenes og hyperbrachycephalenes vedkommende. I kolonne 6 findes utregnet resultatet for hyperbrachycephalene og dolichocephalene, og i kolonne 8 er anført det tilsvarende resultat av de resterende dolichocephalers indbyrdes krydsning.

I kolonne 9 og 10 er opsummert antal og procent av hver bastardtype. Endelig har jeg i kolonne 11 anført i hvilket antal hver av de samme bastardtyper av mig er fundet inden denne befolkning, naar typegrænsene er de i denne avhandling anvendte. Det er da med engang iøinefaldende, at der hersker en gjennemgaaende uoverensstemmelse mellem det teoretisk beregnede resultat og det av mig fundne. Ved det teoretisk beregnede er der saaledes 24,6 % mørkøiede euryprosope brachycephaler, mens der i virkeligheten kun findes 4,0 % av dem. Omvendt finder jeg ved den teoretiske beregning kun 2,90 % lysøiede euryprosope dolichocephaler, mens virkeligheten fortæller os at der er 14 % saadanne. Og av lysøiede leptoprosope brachycephaler har jeg fundet 16,4 % inden den nulevende befolkning, mens jeg ved den teoretiske beregning finder at der kun burde været 2,9 %.

Er det teorien som er feil, eller er det mit fund som er feilagtig?

I dette sidste kan der vel være feil av flere grunde. Mine observationer fortæller mig jo kun antallet av fænotypiske brachycephaler, dolichocephaler, leptoprosoper o. s. v. Og det er jo klart at endel av de fænotypiske brachycephaler i virkeligheten er +-avvikere av de genotypiske dolichomesocephaler. Dette kan imidlertid ikke volde nogen nævneværdig forstyrrelse. Ti paa tilsvarende maate vil jo omtrent like mange av de fænotypiske dolichomesocephaler i virkeligheten være ÷-avvikere av den brachycephale type. Da imidlertid denne sidste gruppe er litt mindre end den første, vil der ogsaa blandt de fænotypiske dolichomesocephaler være litt færre genotypiske brachycephaler end omvendt. Men dette har jeg ogsaa tat hensyn til ved beregning av de genotypiske gruppers gjensidige størrelse, saa den herved fremkaldte feil maa bli ganske minimal.

Vanskeligere er det unegtelig at trække grænsene rigtig mellem brunøiede og blaaøiede inden den nulevende befolkning. Jeg har ved den teoretiske beregning gaat ut fra at disse to øientyper ved krydsning bibeholdes uforandret. Undersøkelsene viser at dette ikke holder stik. Øienfarvene er ikke saa stabile og uforanderlige som hodeformen. Det synes som de brune øine har mistet adskillig av sit pigment og har fordelt dette paa et relativt stort antal blaaøiede.

Det tør ogsaa være at F_1-generationen ved krydsning av en brunøiet og blaaøiet type ikke faar utelukkende brunøiede og blaaøiede, men at den ogsaa faar endel med melerte øine. Herom vet vi endnu saare lite. Jeg har av den grund fordelt de melerte øine saaledes, at jeg har henført de lyst melerte øine til den lyseste øiengruppe og de mørkt melerte øine til den mørkøiede øientype. Her er altsaa plads for mindre feil. Men da antallet av melerte øine i det hele tat ikke er stort, blir det heller ikke paa dette omraade tale om at en forandret beregning kan gi noget synderlig andet resultat ved beregningen av den relative størrelse av de i kolonne 11 opførte bastardtyper.

Jeg kommer saaledes til det resultat, at uoverensstemmelsene mellem de to resultater maa bero paa at den teoretiske beregning hviler paa feilagtige forutsætninger. Jeg gik, som det vil erindres, ved den teoretiske beregning ut fra at euryprosopi dominerer over leptoprosopi. Der foreligger selvfølgelig ingen grund til at gaa ut fra at dette er rigtig. Der kan derfor være al grund til at se hvorledes resultatet vil bli, om jeg forutsætter at leptoprosopi dominerer over euryprosopi.

Likesaa har jeg forutsat som givet at brune øine dominerer over blaa øine. Dette har jeg jo hat god grund til, al den stund der foreligger en række undersøkelser som peker hen paa at saa er tilfældet inden den nulevende befolkning paa flere steder baade i Amerika og i Norge. Men derfor behøver selvfølgelig ikke dette at være saa altid og alle steder.

Tabel 56.

	Hode-type	Ansigts-type	Øien-type	H. B. × B. 2 : 2	H. B. × D. 2 : 2	B. × D. 28 : 28	D. : D. 18 : 18	Sum	%	Av mig fundet
a.	H. B.	E.	m. ø.	48	0	-	-	57	3,5	0,2
b.	H. B.	E.	l. ø.	-	3	-	-	3	0,19	2,1
c.	B.	E.	m. ø.	16	-	126	-	142	8,8	3,1
d.	B.	E.	l. ø.	-	-	42	-	42	2,6	3,8
e.	H. B.	L.	l. ø.	-	9	-	-	9	0,6	5,9
f.	D.	E.	l. ø.	-	1	14	-	15	0,9	5,7
g.	B.	L.	m. ø.	-	-	378	-	378	23,6	6,1
h.	D.	E.	m. ø.	-	3	42	-	45	2,8	0,5
i.	B.	L.	l. ø.	-	-	126	-	126	7,9	22,8
k.	D.	L.	m. ø.	-	9	126	-	135	8,5	8,0
l.	D.	L.	l. ø.	-	3	42	576	621	38,7	41,6
m.	H. B.	L.	m. ø.	-	27	-	-	27	1,7	1,2
				64	64	896	576	1600		

Sammendrag:

	Teoretisk beregnet	Av mig fundet
Dolichocephaler	51,3	55,8
Brachycephaler	43,0	34,7
Hyperbrachycephaler	5,7	0,5
Leptoprosoper	88,9	66,5
Euryprosoper.	19,1	33,5
Lyse øine	54,9	81,2
Mørke øine	45,1	18,8

H. B. dominerer over B. og D.
B. — D.
L. — E.
m. ø. — l. ø.

Tabel 57.

1	2	3	4	5	6	7	8	9	10	11
	Hode-type	An-sigts-type	Øien-type	Ved krydsning av nedenstaaende typer i det av mig anførte mængdeforhold skulde F_2-generationen faa nedenstaaende sammensætning						Av mig er i Troms fylke fundet
				H. B. × B. 2 : 2	H. B. × D 2 : 2	B. D. 28 : 28	D. : D. 18 : 18	Sum	%	
a.	H. B.	E.	m. ø.	48	3	-	-	51	3,2	0,3
b.	H. B.	E.	l. ø.	-	9	-	-	9	0,5	3,0
c.	B.	E.	m. ø.	16	-	42	-	58	3,6	4,0
d.	B.	E.	l. ø.	-	-	120	-	120	7,9	9,5
e.	H. B.	L.	l. ø.	-	27	-	-	27	1,7	4,5
f.	D.	E.	l. ø.	-	3	42	-	45	2,8	14,0
g.	B.	L.	m. ø.	-	-	120	-	120	7,9	4,8
h.	D.	E.	m. ø.	-	1	14		15	0,9	2,0
i.	B.	L.	l. ø.	-	-	378	-	378	23,6	16,4
k.	D.	L.	m. ø.	-	3	42	-	45	2,8	6,6
l.	D.	L.	l. ø.	-	9	126	570	711	44,5	33,1
m.	H. B.	L.	m. ø.	-	9	-	-	9	0,5	1,1
				64	64	896	576	1600		100

B. forutsættes at dominere over D.
H. B. - - — — B. og D.
L. — - — — E.
l. ø. — - m. ø.

H. B. betyr Hyperbrachycephali.
B. — Brachycephali.
D. - Dolichomesocephali.
E. — Euryprosopi.
L. betyr Leptoprosopi.
l. ø. lyse øine.
m. ø. — mørke øine.

Paa tabel 56 har jeg utregnet, hvorledes forholdet skulde været om leptoprosopi dominerer over euryprosopi. Som man vil se, er overensstemmelsen mellem teori og virkelighet her betydelig større. Men der mangler dog endnu meget paa at der er fuld overensstemmelse.

Under disse omstændigheter fandt jeg, at der kunde være al grund til at undersøke hvorledes forholdet vilde arte sig, om jeg ogsaa gik ut fra at lyse øine dominerer over mørke øine. Dette er gjort paa tabel 57. Og som man vil se, er resultatet helt forbløffende. Den eneste nævneværdige uoverensstemmelse mellem teori og virkelighet er her den, at de euryprosope grupper er uforholdsmæssig smaa og de leptoprosope for store.

Ved den av mig foretagne gruppeinddeling har jeg anvendt de vanlige grænser for ansigtstypene: euryprosopi 70—83, mesoprosopi 84—87, leptoprosopi 88—100. Nogen rationel grund for denne inddeling eksisterer neppe. Den genotypisk rigtige inddeling kjender vi desværre endnu lite til. Euryprosopenes gruppe blir paa denne maate meget stor. Da jeg hadde grund til at tro at dette kunde være aarsaken til den ovenfor nævnte uoverensstemmelse mellem teori og virkelighet, tok jeg mig for at omarbeide mit materiale saaledes, at grænsen mellem mesoprosopi og euryprosopi flyttedes nedover.

Paa tabel 58 er dette gjort i 2 alternativer.

Tabel 58.

1	2	3	4	5	6	7
1	D. M.	L. M.	l. o.	232	41,6	39,2
2	B.	L. M.	l. o.	123	22,8	19,2
3	D. M.	E.	l. o.	32	5,7	7,9
4	B.	E.	l. o.	24	3,8	6,0
5	D. M.	L. M.	m. o.	45	8,0	7,4
6	B.	L. M.	m. o.	34	6,1	5,5
7	H. B.	L. M.	l. o.	33	5,9	4,8
8	B.	E.	m. o.	10	3,1	3,6
9	H. B.	E.	l. o.	12	2,1	3,2
10	D. M.	E.	m. o.	3	0,5	1,2
11	H. B.	L. M.	m. o.	7	1,2	1,1
12	H. B.	E.	m. o.	1	0,2	0,3
				559		

I kolonne 6 er anført resultatet hvis jeg regner som euryprosoper alle med index 70—81, og i kolonne 7 er anført resultatet hvis jeg regner som euryprosoper alle med index 70—82.

Som man vil se, blir overensstemmelsen mellem teori og virkelighet nu saa stor som man overhodet kunde vente at finde den under et saa heterogent materiale som denne befolkning er.

Paa tabel 59 har jeg sammenstillet de teoretisk beregnede tal med de av mig fundne tal, naar jeg regner som euryprosoper alle med index 70—81.

Det er vel hoist sandsynlig at man ved at flytte litt paa grænsene mellem mesocephali og brachycephali vil kunne opnaa en endnu større overensstemmelse mellem teori og virkelighet. Dette er efter min mening helt overflodig.

Enhver som har arbeidet med antropologi, vil indromme at ovenstaaende talrække er overensstemmende nok allikevel. At der paa index 79 og 80 for cephalindexens vedkommende vil være individer baade fra den brachycephale og fra den mesocephale genotype, er jo ingen tvil om.

Det er ogsaa hoist sandsynlig at der ikke inden Troms fylke hersker en komplet panmiksi. Saaledes er der endnu kun et faatal av lappene som krydses med den norske befolkning.

De to første bastardgrupper paa tabel 59 vil dermed bli større end av mig beregnet. Og dette vil igjen føre til at gruppe 10, 6 og 5 blir endel mindre.

Tabel 59.

1	2	3	4	5	6	7	8
Bastard no.	Hodetype	Ansigts-type	Øientype	I henhold til den teoretiske beregning		Av mig er fundet	
				Antal	Procent	Antal	Procent
1	D. M.	L.	l. o.	714	44,5	232	41,6
2	D. M.	L.	m. o.	42	2,8	45	8,0
3	D. M.	E.	l. o.	46	2,8	32	5,7
4	D. M.	E.	m. o.	14	0,9	3	0,5
5	B.	L.	l. o.	378	23,6	123	22,0
6	B.	L.	m. o.	126	7,9	34	6,1
7	B.	E.	l. o.	138	7,9	24	4,3
8	B.	E.	m. o.	46	3,6	16	2,9
9	H. B.	L.	l. o.	36	1,7	30	5,4
10	H. B.	L.	m. o.	-	0,5	7	1,2
11	H. B.	E.	l. o.	48	0,5	12	2,1
12	H. B.	E.	m. o.	12	3,2	1	0,2
				1600		559	

Endvidere maa man ta i betragtning at den av mig beregnede størrelse av de forskjellige genotypiske grupper selvfølgelig ikke kan gjøre krav paa matematisk nøiagtighet. Jeg har, som det vil erindres, regnet med at den hyperbrachycephale gruppe utgjorde 4 %, den brachycephale 30 % og den dolichomesocephale gruppe 66 % inden den nulevende befolkning. Det tør hænde at det hadde været rigtigere at beregne med henholdsvis 6, 32 og 62 %. Men dette betragter jeg her som finesser av underordnet interesse.

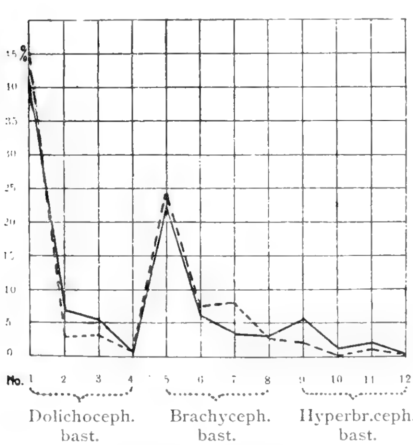

Fig. 14. Grafisk fremstilling av tabel 59.

—— Bastardenes antal i henhold til mine undersøkelser.

.... Bastardenes antal i henhold til den teoretiske beregning.

Naar overensstemmelsen mellem det teoretisk beregnede forhold mellem bastardtypene og det i virkeligheten fundne er saa uttalt som den i dette tilfælde er, saa kan man herav slutte sig til, at den i Troms fylke nu eksisterende befolkning i alt væsentlig er kommet istand paa den maate som den teoretiske beregning er basert paa.

Man maa ha lov til at si, at der er en aldeles forbløffende overensstemmelse ialfald mellem en flerhet av de tal som findes i kolonne 6 og 8 paa tabel 59. Saaledes er det meget bemerkningsværdig at hos 41,6 %

av de undersøkte findes kombinert den nordiske races 3 vigtige træk: dolichocephali, leptoprosopi, blaa øine, medens man efter den teoretiske beregning skulde vente at finde 44,5 %. Dette taler i høi grad for at disse 3 træk ved krydsning har forholdt sig overensstemmende med de Mendelske lover.

Der kan ikke her bli tale om intermediær arv. Den paafaldende overensstemmelse i talrækkene taler endvidere for, at de forutsætninger hvorpaa den teoretiske beregning hviler, i alt væsentlig maa være rigtig. Ialfald maa beregningens forutsætning angaaende hvilke træk som er dominante, og hvilke som er recessive, være rigtig. At brachycephali dominerer over dolichocephali, er jo ikke noget nyt. At leptoprosopi dominerer over euryprosopi, fremgaar tydelig nok ved at sammenligne de av mig fundne procenttal med de teoretisk beregnede paa tabel 59.

Med hensyn til øienfarven var jeg paa forhaand overbevist om at de brune øine dominerer over de blaa. Dette fremgaar av DAVENPORTS og HUNTS undersøkelser, og jeg har ogsaa selv paavist fra en anden norsk befolkning (Selbu og Tydalen) at dette ogsaa forholder sig saa her i Norge. Ved alle de teoretiske beregninger som jeg først foretok, gik jeg derfor ut fra som selvsagt, at jeg maatte regne med at de mørke øine dominerer over de lyse. Men som det vil sees av alle disse tabeller (56 til 58), blir der i alle disse tilfælder en paafaldende og aldeles uforklarlig uoverensstemmelse mellem teori og virkelighet.

Først da jeg tok mig for at beregne, hvorledes typeforholdene vilde arte sig under forutsætning av at lyse øine dominerte over mørke øine, fik jeg overensstemmelse mellem teori og virkelighet. Og overensstemmelsen var saa stor, at jeg ikke kunde være i tvil om at jeg her var inde paa den rigtige vei. Men hvorledes skulde jeg saa kunne forklare mig dette resultat?

Brune øine kan ikke være dominerende i Selbu og Tydalen, men recessive i Tromsø. Kan det være tænkelig at baade DAVENPORTS, HUNTS og mine egne slutninger om de brune øines dominans er feilagtig? Har den nyere tids arvelighetsforskning eksempel paa noget lignende paa andre omraader? Er muligens læren om en egenskaps dominans ikke saa absolut sikker?

I sin bok „Einführung in die experimentelle Vererbungslehre" sier professor E. BAUER herom følgende paa side 70:

„Man hat dieser Dominanserscheinung, die durchaus keine allgemeine Regel ist, vielfach übertrieben große Bedeutung zugeschrieben, von einer „Dominansregel" gesprochen. Das ist ganz verkehrt. Eine irgendwie allgemein gültige Dominansregel gibt es nicht, und sehr häufig ist eine Dominanz nur scheinbar. Es kann, darauf hat zuerst CORRENS hingewiesen, für unser Auge ein Bastard völlige Dominanz, etwa in der Blütenfarbe eines Elters zeigen, aber wenn wir die Farbe des Bastards kolorimetrisch untersuchen, dann sehen wir, daß er, im Grunde genommen, sich so verhält wie der

Bastard zwischen dem roten und dem elfenbeinfärbigen Antirrhinum, d. h. daß die Färbung des Heterozygoten viel schwächer ist als die der Homozygoten, daß also die völlige Dominanz nur eine scheinbare ist.

Ob überhaupt völlige Dominanz häufig vorkommt, ist mir fraglich. Scheinbar völlige Dominanz beruht eben wohl oft nur auf unserem *mangelhaften Unterscheidungsvermögen.*

Hat man durch langes Arbeiten mit einem bestimmten Versuchstier oder eine Versuchspflanze seinen Blick geschärft, dann wird man wohl meistens Unterschiede zwischen den Homozygoten und den Heterozygoten erkennen."

Heterozygotene er i virkeligheten altid litt mindre pigmentert end den brunøiede av forældrene. Har til eks. den brunøiede av forældrene brune øine som svarer til Martins no. 1, vil den homozygotiske part av avkommet ogsaa ha like brune øine, medens den heterozygote del av avkommet har øine som svarer til Martin 2 og 3 til eks. For undersøkeren vil det da fortone sig som baade homozygoter og heterozygoter er like brunøiet, og man vil drage den slutning, at brune øine dominerer over blaa.

Hos en mindre brunøiet race (som til eks. den norske), hvor den brunøiede av forældrene har en øienfarve som svarer til Martin no. 6, vil ogsaa den homozygotiske del av avkommet faa denne øienfarve, medens heterozygotenes øienfarve svarer til Martin 7, 8 og 9. Ogsaa i dette tilfælde ligger det heterozygote avkoms øienfarve saa nær op til det homozygotes, at man vil si at ogsaa denne type av brune øine dominerer over de blaa. Der er altsaa blot en tilsynelatende dominans tilstede.

I virkeligheten er forholdet det, at øienfarven ikke nedarves efter „Pisumtypen" men efter „Zeatypen".

Men forskjellen paa de heterozygotiske og de homozygotiske brunøiede er saa liten at den kun kan erkjendes gjennem lang øvelse eller en meget detaljert undersøkelse.

Naar en saadan sondring mellem mere og mindre sterkt pigmenterte øine ikke gjøres, vil nødvendigvis resultatet bli, at man tillægger de brune øine en dominans som de i virkeligheten ikke eier. Ti det maa jo fastholdes, at virkelig dominans kun foreligger hvor heterozygotene har *nøiagtig* samme utseende som den ene av forældrene (Bauer pag 70).

Brune øine i egentlig forstand (Martins tavle 1—4) findes praktisk talt ikke inden denne befolkning. Man finder i høiden hos 1 av hundrede brune øine som svarer til Martins tavle 4 à 5. Hos de fleste brunøiede svarer farven omtrent til Martins tavle no. 6—8. Det blir altsaa nærmest at regne for mørkt melerte øine. Naar jeg i denne undersøkelse har delt efter øienfarven i 2 grupper: lyse og mørke øine, saa vil den første gruppe omfatte alle blaa, graa og lyst melerte øine (Martins 8—16). Den anden gruppe, de mørke øine, vil hovedsagelig komme til at omfatte alle de mørkt melerte øine samt desuten de meget sparsomt forekommende rent brune øine.

Hovedmassen av heterozygotene vil da selvfølgelig komme med i den første gruppe. Den for den nordiske race genotypiske øienfarve er utvilsomt *blaa*.

I distrikter hvor den nordiske race findes særlig ren, der er ogsaa de *blaaøiedes* antal meget stort. Alle graa, grønne og lyst melerte øine er resultater av krydsning.

Men hvis denne min forutsætning er rigtig: at øienfarven nedarves Mendelsk efter Zeatypen og heterozygotene inden vor befolkning svarer til de graa, grønne og lyst melerte øine, da blir alt forstaaelig. Ti da vil jo tallene bli de samme som om blaa øine eide dominans over brune, 1 : 2 : 1 = blaaøiede homozygoter (1), lyst melerte heterozygoter (2), mørkt melerte homozygoter (1), idet vi, som jeg allerede har nævnt, ikke har virkelig brunøiede inden vor befolkning. Her vil forholdet mellem lyse øine og mørke øine bli som 3 : 1, eller de lyse øine eier en falsk, en tilsynelatende dominans over de brune øine.

I virkeligheten blir der heller ikke nogen uoverensstemmelse mellem det resultat som de foran refererte arvelighetsundersøkelser har git, og det resultat som denne bastardundersøkelse har git. Men den absolute dominans for de brune øine maa opgives. Ialfald mener jeg at man av denne undersøkelse kan dra den slutning, at:

1. Øienfarven nedarves Mendelsk.

2. Heterozygotenes øine er svakere pigmentert end den brunøiede av forældrene. Hvis man deler vor befolkning i en lysøiet og en mørkøiet befolkning, vil heterozygotene for en væsentlig del være at finde inden den lysøiede gruppe.

Før jeg avslutter disse betragtninger, maa jeg endnu engang komme tilbake til de forutsætninger som ligger til grund for denne bastardundersøkelse. Disse er følgende:

1. Den av mig undersøkte befolkning er opstaat ved krydsning av 3 forskjellige typer: en dolichomesocephal, en brachycephal og en hyperbrachycephal, i forholdet 66 : 30 : 4.

2. Krydsningen er foregaat i alt væsentlig overensstemmende med de Mendelske lover og saaledes, at hyperbrachycephali dominerer over brachycephali og dolichomesocephali, brachycephali dominerer over dolichomesocephali, leptoprosopi dominerer over euryprosopi. De brune og mørkt melerte øine eier ikke fuld dominans over blaa øine, idet heterozygotene har mellemfarvede øine. Hvis alt dette forholder sig saaledes, vil resultatet bli som fremstillet paa fig. 15 a. Nu er resultatet av min undersøkelse saaledes som fremstillet paa fig. 15 b. Uoverensstemmelsene er, som man vil se, ganske smaa og uvæsentlige og er hovedsagelig begrænset til den hyperbrachycephale gruppe.

Jeg maa herav kunne dra den slutning, at mine forutsætninger *i alt væsentlig er rigtige.*

Uoverensstemmelsene kan ha flere aarsaker:

1. Den relative størrelse av de 3 urtyper kan være noget anderledes end av mig forutsat. Resultatet tyder dog paa at min forutsætning i denne henseende ikke kan ligge saa særdeles langt fra det rigtige forhold.

2. Mine forutsætninger kan være feilagtige med hensyn til hvilke træk som er dominante og hvilke recessive.

Jeg har, som det vil erindres, i denne avhandling gaat ut fra at index cephalicus er en enkel arvelig eiendommelighet. Om den beror paa et enkelt faktorpar eller flere faktorpar, om disse er likeværdige eller ikke, er spørsmaal som jeg her har sat ut av betragtning av den simple grund, at den her fremlagte undersøkelse ikke i ringeste maate kan bidra til løsningen av dette vanskelige spørsmaal.

Det kan ogsaa i denne forbindelse være likegyldig om man har med ett eller flere faktorpar at gjøre.

Det som er uomstøtelig sikkert er, at index cephalicus er en overmaade arvefast eiendommelighet.

Hvad jeg gjennem denne undersøkelse har villet forsøke at bringe paa det rene er, hvorledes dette arvefaste træk forholder sig ved krydsning. Og da mener jeg, at denne undersøkelse tyder paa at hvis man her har med flere faktorpar at gjøre, saa forholder dog disse sig ganske saaledes som om der var en enkelt faktor for brachycephali med dominans over en tilsvarende faktor for dolichomesocephali.

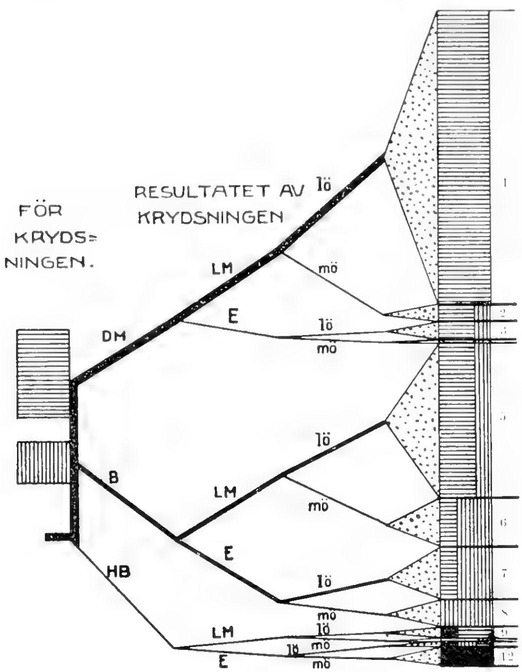

Fig. 15 a.
Bastardenes fordeling efter den teoretiske beregning.

Om hvorledes hyperbrachycephali forholder sig ved krydsning, foreligger der for tiden ingen undersøkelse, og derom kan man heller ikke av denne undersøkelse drage nogen slutninger.

Hvis det skal være tillatt av denne undersøkelse at dra nogen slutning, saa maatte det for hyperbrachycephalenes vedkommende først og fremst være den, at den hyperbrachycephale gruppe muligens oprindelig har været litt større end av mig forutsat. (Den maa efter al sandsynlighet ha utgjort ca. 6 % av urtypene.) En anden uoverensstemmelse angaar ogsaa den hyperbrachycephale gruppe. Min opfatning var at den oprindelig har været brunøiet. Som man vil se av fig. 15 a og b, kan dette ikke holde stik. Den tredje forutsætning var at den oprindelig har været euryprosopisk. Antallet av lysøiede, leptoprosope hyperbrachycephaler inden den nulevende befolkning er imidlertid saa stort, at man saa at si nødes til at gaa ut fra at den hyperbrachycephale type maa være indgaat i vor befolkning som delvis lysøiede leptoprosoper. I motsat fald skulde hyperbrachycephalenes bastarder ha været som paa fig. 15 a. De er altsaa som paa fig. 15 b. Den logiske slutning herav maa da bli den, at den hyperbrachycephale blok som indgaar i vor befolkning, ikke har været ublandet euryprosopisk; den har ogsaa omfattet lepto- og mesoprosoper. Heller ikke kan den ha været rent brunøiet; den har ogsaa hat individer med lysere øine, blaa og melerte, saaledes som tilfældet er nu. Dette kan vel igjen forklares saaledes, at *hyperbrachycephalien* ved krydsning med andre racer har en større evne til at holde sig end ansigtsformen og øienfarven.

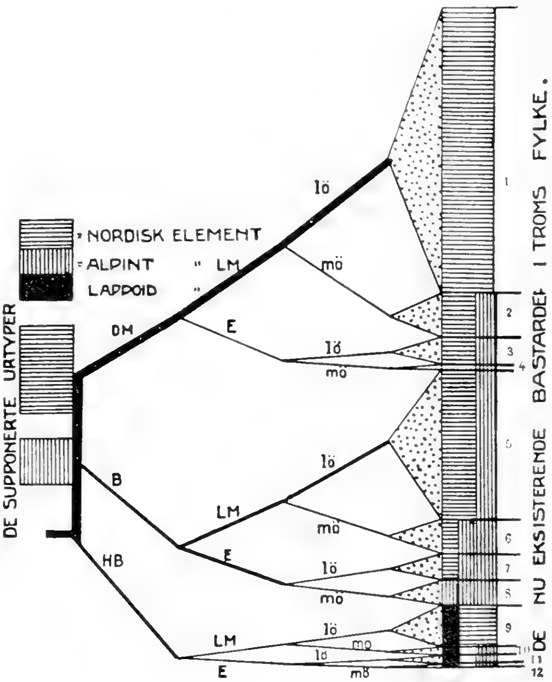

Fig. 15 b.
Bastardenes fordeling som de er fundet av mig.

Jeg kommer da til at maatte gjøre den forandring i min forutsætning, at den hyperbrachycephale blok sandsynligvis har været noget over 4 $^0/_0$, samt at denne blok ikke har været euryprosopisk og brunøiet, men hat repræsentanter for alle 3 ansigtstyper og for alle nuancer av øienfarve. Dette medfører atter endel yderligere forandringer paa fig. 15 a. Gruppe H. B. har i henhold til hvad jeg her har fremholdt, ikke været helt brunøiet og euryprosop. Den kan altsaa ikke ved krydsningen ha tilført den brachycephale og den dolichocephale gruppe saa mange brunøiede euryprosope individer som beregnet paa fig. 15 a. De leptoprosope og lysøiede grupper vil altsaa bli litt større end beregnet, og uoverensstemmelsene mellem fig. 15 a og b vil bli endnu mindre end de er.

Men de reservationer som jeg her har maattet ta med hensyn til mine forutsætningers rigtighet, er dog ganske smaa og uvæsentlige. I det hele og store tat mener jeg, at denne undersøkelse av de nu eksisterende bastarder taler for at mine forutsætninger er rigtige, og at bastardene ogsaa er kommet i stand i alt væsentlig saaledes som av mig forutsat.

Resumé.

Av det i dette avsnit meddelte fremgaar følgende:

1. Den i Troms fylke nu boende befolkning er sandsynligvis kommet i stand ved en krydsning av 3 genotypisk forskjellige folketyper:
   a. en dolichomesocephal, leptomesoprosopisk, blaaøiet blok,
   b. en brachycephal, euryprosopisk, brunøiet blok,
   c. en hyperbrachycephal blok med meget stor variationsvidde for ansigtsindex og øienfarve.

2. Den relative størrelse av disse 3 blokker har ialfald tilnærmelsesvis været som 66 : 30 : 4. Muligens har de to første været litt mindre end anført og den sidste litt større.

3. Ved krydsning nedarves de 3 her nævnte karaktertræk overensstemmende med de Mendelske lover, saaledes at:
   a. hyperbrachycephali dominerer tilsyneladende over brachycephali og dolichocephali,
   b. brachycephali dominerer tilsyneladende over dolichomesocephali,
   c. leptoprosopi dominerer tilsyneladende over euryprosopi,
   d. øienfarven nedarves overensstemmende med Zeatypen og saaledes, at heterozygotene har noget lysere øine end den brunøiede av forældrene.

XII. De fremmede elementer.

Jeg har i de foregaaende avsnit saavidt mulig søkt at holde den norske fastboende befolkning ut fra de mere tilfældige fremmede elementer.

Der er nemlig ikke saa ganske liten bevægelse i befolkningen i Troms fylke. De fremmede elementer utgjøres hovedsagelig av lapper og kvæner.

Saafremt den undersøkte mand har kunnet meddele at han var av lappoid eller kvænsk eller av anden fremmed avstamning, har jeg selvfølgelig notert dette paa hans individualseddel.

For 559 mænds vedkommende kunde ingen oplysning erholdes om fremmed herkomst. Jeg har allikevel i de foregaaende avsnit kunnet paavise at der ogsaa i denne befolkning indgaar omtrent 34 % fremmede elementer; men herom vet de undersøkte altsaa intet selv.

103 av de undersøkte var selv vidende om at de ikke var rent norske. Jeg skal i dette avsnit gi en ganske kort fremstilling av de væsentligste antropologiske eiendommeligheter hos disse.

1. Lapper.

Det er ikke min mening her at gi nogen uttømmende skildring av lappenes antropologi. Dertil er mit materiale altfor litet. Jeg vil her kun omtale de træk hos lappene som jeg foran har skildret hos den norske befolkning.

Det er umulig av det her foreliggende materiale at gjøre sig nogen mening om de norske lappers legemshøide. Alle de mindste lapper blir jo ved utskrivningen kassert som udygtige til militærtjeneste. Ved at gjennemgaa utskrivningslistene viste det sig at ikke mindre end 23 mænd med en høide under 155 cm. var kassert ved utskrivningen. Hvor mange av disse som var lapper, fremgaar ikke av utskrivningslistene. Men at ialfald størsteparten av disse var av lappisk herkomst, derom kan der neppe være tvil.

Blandt de av mig undersøkte lapper var gjennemsnitshøiden 164,1 cm.; regner jeg med at alle de ved utskrivningen kasserte var lapper, vil middelhøiden bli 158,1 cm.

Blandt de av mig undersøkte var 18 meget smaa (under 164,1 cm.), 5 var 166—168 cm., 6 var 169—170 cm., og 1 var 171 cm. At ogsaa disse lappers forfædre gjennem generationer har krydset sig med nordmænd, svensker, finner og andre høivoksne folkeslag, er jo hævet over enhver tvil. Det maa da forbause at ikke en eneste av disse er høiere end 171 cm. Den nordiske races gjennemsnitshøide ligger adskillig over 171 cm. Ved krydsningen skulde man jo vente at endel av lappene skulde ha faat den nordiske races legemshøide, likesaavel som de har faat den nordiske races haarfarve og øienfarve. Den almindelige opfatning er jo ogsaa den, at stor legemshøide dominerer over liten legemshøide.

Ved krydsning mellem en lap og et individ av ren nordisk herkomst skulde da alt avkom faa den nordiske races legemshøide.

Nu er det vel saa, at der ikke saa særdeles ofte indgaaes egteskap mellem rene lapper og rene norske. For lappenes vedkommende er vel forholdet det, at av og til en lappepike har faat et uegte barn med en norsk, svensk eller en anden person av nordisk race. Dette barn har saa fulgt sin mor og er blit lap. Men denne lappebastard vil efter al sandsynlighet komme til at gifte sig med en lap.

Hvis det nu er saa, at stor legemshøide dominerer over liten legemshøide, saa skulde dog halvparten av de barn som resulterer av dette egteskap, faa den nordiske races høide. Og dette skulde vedblivende fortsætte gjennem de følgende generationer.

Man burde derfor, hvis forutsætningen om den store legemshøides dominans er rigtig, vente at finde ialfald endel lapper med stor legemshøide, likesom man finder endel lapper med blaa øine. Naar man nu ikke gjør det, saa synes det mig at den logiske slutning maa bli enten den,

Tabel 61.

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Antal	Legems-høide	Hodets største bredde	Hodets største længde	Ansigtshøide n-gn	Ansigtsbredde zy-zy	Index cephalicus	Index facialis	Næsens bredde	Næsens høide	Index nasalis	Mindste pandebredde	Transvers. fronto-parietal index	Jugo-frontal index	Indre øien-vinkelbredde	Haarfarve-index	Øienfarve-index
Lapper	30	164,1	15,6	18,5	11,67	14,1	84,32	82,08	3,40	4,63	73,91	11,14	71,15	78,73	3,340	3,33	2,23
Finner	17	166,2	15,4	18,75	11,82	14,0	82,00	84,20	3,35	4,92	67,35	11,10	72,08	70,20	3,204	3,20	2,23
Lapper × Finner	8	165,4	15,4	18,8	11,61	14,1	81,91	82,27	3,56	4,78	72,91	11,03	71,42	78,01	3,337	3,02	2,0
— × Norske	22	166,8	15,4	19,0	11,04	14,3	81,05	83,22	3,35	4,89	68,35	11,3	73,38	70,02	3,254	3,27	2,8
Finner × Norske	26	168,7	15,4	19,1	11,06	14,1	80,63	84,40	3,41	4,93	69,39	11,2	72,73	70,43	3,300	3,34	2,0
Norske	559	172,8	15,2	19,4	12,4	13,9	79,3	88,0	3,4	5,0	68,0	11,0	71,7	70,2	3,4	2,01	1,38

	Øientype					Haartype					Lyst haar	Mørkt haar	Blaa øine	Melerte øine	Brune øine	Lyse øine	Mørke øine	Pigment-index
	1	2	3	4	5	1	2	3	4	5	1 + 2 + 3	4 + 5	1	2 + 3	4 + 5	1 + 2	3 + 4 + 5	(18 + 19) / 2
Lapper	9	12	3	5	1	4		11	12	3	15	15	9	15	6	21	6	2,80
Finner	7	4	2	3	1	3	1	5	4	4	9	8	7	6	4	11	6	2,70
Lapper × Finner	4	2	1		1			4	3	1	4	4	4	3	1	6	2	2,81
— × Norske	8	3	1	6	4	5		4	10	3	9	13	8	1	10	11	11	3,03
Finner × Norske	16	2	3	3	3	5		6	11	4	11	15	16	5	5	18	8	2,07
103	11	23	10	16	10													1,00

Blaa og graa øine = 1, lyst mel. øine 2, mørkt melerte 3, lysebrune 4, mørkebrune 5.

1) at stor legemshøide *ikke* dominerer over liten legemshøide ved krydsning av lapper og norske, eller den 2) at heterozygotene har en intermediær høide.

De høieste blandt disse lapper naar kun op til at bli ÷-avvikere av den nordiske races legemshøide. Nu foregaar jo, som allerede nævnt, krydsningen av lapper og norske saagodtsom udelukkende mellem kvindelige lapper og norske mænd. Det kan jo være at dette spiller nogen rolle, at med andre ord den kvindelige part har en meget væsentlig indflydelse paa avkommets legemshøide. Herom foreligger der mig bekjendt ingen arvelighetsundersøkelse. Men det her paapekte forhold peker ialfald i den retning.

Hodets bredde er hos disse lapper meget stor (15,63 cm.) og *hodets længde* meget liten (18,54 cm.). Bredden svarer altsaa til 9,50 % av legemshøiden og længden til 11,82 %.

Hos nordmænd av samme høide er hodets bredde og længde henholdsvis 15,22 og 19,20 cm. Hos nordmænd er hodets bredde gjennemsnitlig 8,91 % og hodets længde 11,17 % av legemshøiden. Hodets proportioner er saaledes helt forrykket hos lappene.

Hodets ørehøide er hos lappene gjennemsnitlig 12,56 cm., hos nordmænd 13,11 cm. Beregnet ad modum Welcker blir da lappekraniets kapacitet 1 444 $cm.^3$, mens nordmændenes blir 1 468 $cm.^3$. Noget materiale til sammenligning med andre folk har desværre ikke staat til min raadighet. Skal sammenligningen kunne foretages, maa jo beregningen være utført paa ensartet maate. Og der foreligger desværre kun sparsomme beregninger efter denne metode.

Den gjennemsnitlige størrelse av index cephalicus var 84,29. Serien for index cephalicus ser saaledes ut:

	76.	77.	78.	79.	80.	81.	82.	83.	84.	85.	86.	87.	88.	80.	00.	91.	
Lapper	1.		2.	2.	3.	1.	2.	3.	1.	3.	4.	3.	3.	1.		1.	30.
Hyperbrach......								1.	1.	2.	3.	3.	3.	1.		1.	15.
Brachyceph......					1.	1.	2.	2.		1.	1.						8.
Mesoceph.	1.		2.	2.	2.												7.

At de laveste indexer her ikke er ÷-avvikere av den genotypiske hyperbrachycephale type, er vel sikkert nok. De markerer disse lapper som utprægede bastarder. Der er blandt disse lapper bastarder baade med den brachycephale type og med den nordiske.

Det er vel ikke usandsynlig at serien er sammensat saaledes som anført paa tabellens nederste linjer, ɔ: 15 genotypiske hyperbrachycephaler, 8 brachycephaler og 7 mesocephaler.

Jeg kommer nedenfor nærmere tilbake hertil. Fænotypisk er 8 av lappene mesocephaler, 10 er brachycephaler, 11 hyperbrachycephaler, og 1 er ultrabrachycephal. Fænotypiske dolichocephaler findes ikke blandt lappene. Man skulde dog ha ventet at der blandt lappene ogsaa kunde findes dolichocephaler. Ti blandt norske forældre har der vel været baade fænotypiske dolichocephaler og mesocephaler. Men det er vel høist sandsynlig at den sterke hyperbrachycephali hos den ene av forældrene vil ha nogen virkning ogsaa paa den del av avkommet som blir avspaltet. At hyperbrachycephalien hos den ene av forældrene med andre ord vil gjøre at det dolicho-mesocephale avkom væsentlig vil bli mesocephalt.

Jeg har heller aldrig hos andre undersøkere fundet dolichocephale lapper, men nok av mesocephale. Nogen anden plausibel forklaring herpaa end den anførte kan jeg vanskelig tænke mig. Som allerede nævnt var jo dette samme forhold mindst like saa uttalt for legemshøidens vedkommende. Aldrig finder man rigtig høie lapper. Det kan ikke være livskaarene som gjør at lappebastardene aldrig faar den nordiske races legemshøide og hodeform.

For legemshøidens vedkommende har man jo altid ogsaa gaat ut fra at stor legemshøide dominerer over liten legemshøide. Dette skulde jo føre til at der blev relativt mange høie lappebastarder. Og hvorfor skulde der ikke ogsaa blandt lappene like saa vel bli +-avvikere som ÷-avvikere av den nordiske races gjennemsnitshøide. Jeg kan kun forklare mig dette saaledes, at det spiller en væsentlig rolle at den kvindelige part av forældreparret er en lap.

Det er kvindens evne til at holde fast ved det genotypiske som har gjort sig gjældende. Avkommet faar ganske vist fra den mandlige part av forældrene en faktor for stor legemshøide eller liten cephalindex. Men morens indflydelse gjør sig saa sterkt gjældende i motsat retning, virker *saa sterkt svækkende paa den fra faren mottagne faktor at avkommet baade for legemshøidens og hodeindexens vedkommende blir avvikere av den anden type, og avvikelsen gaar i alle tilfælder i mortypens favør.*

Hvis nogen vil si at den her meddelte serie for cephalindex ikke viser tegn paa avspaltning av en anden genotype, vil jeg henvise til den av Mantegazza meddelte serie for index cephalicus. Den har følgende utseende:

82.	83.	84.	85.	86.	87.	88.	89.	90.	91.	92.	93.	94.	95.
2.	1.	2.	7.	7.	5.	15.	4.	5.	3.	1.	3.	1.	1.

I denne serie findes ikke en eneste fænotypisk mesocephal. Disse lapper var dog aabenbart adskillig opblandet med den nordiske race. Det fremgaar av haarfarven og øienfarven hos de av ham undersøkte lapper. Der var vistnok ikke mange blondhaarede og blaaøiede. Men et ganske stort antal hadde mellemfarve baade med hensyn til øine og haar.

Hvis det forholder sig saaledes som jeg har gaat ut fra i et foregaaende avsnit, at der ikke eksisterer nogen absolut dominans for brune øine og mørkt haar, men at heterozygotene kun utpræger sig med lysere haar og øine end den mørke forældrepart har, saa kan jo dette fuldt forklare MANTEGAZZAS fund. Isaafald kan man hos F_1-generationen kun vente at finde mellemfarver. Og da der vel ogsaa blandt nordmænd og svenske kun er et faatal homozygotisk blonde, er det jo let forstaaelig, at der vil gaa en rum tid hen og kræves adskillige krydsninger før man faar virkelig blonde lapper.

Men MANTEGAZZAS serie for cephalindex synes at tyde paa at der for denne karakters vedkommende eksisterer en absolut dominans for hyperbrachycephali. Der maa mange generationers krydsninger til før man kan vente at finde dolicho-mesocephale lapper; ti ogsaa her foregaar krydsningen med folk som selv for en meget væsentlig del er heterozygoter.

I den av mig optagne serie indgaar derfor utvilsomt et ganske betydelig nordisk element. I hans store serie har ingen lap en index under 82, og kun 9 % har index under 85. Lægger jeg denne maalestok paa den av mig leverte serie, saa maa mindst 25 % være homozygoter av den dolicho-mesocephale type, 25 % maa tilhøre den alpine race, og i høiden 50 % er dels homo- dels heterozygoter av den hyperbrachycephale genotype.

Jeg kommer saaledes til det resultat, at selv disse lapper, som dog regnet sig selv for rene lapper, kun har omtrent 50 % lappeblod i sine aarer.

Men da man paa dette omraade endnu ikke har anledning til at regne med matematisk sikre tal, vil jeg nøie mig med at si at de *er meget sterkt opblandet med fremmede elementer.*

Ansigtsindex var hos de av mig undersøkte lapper 82,98. Hos de av MANTEGAZZA undersøkte lapper var den 82,34. I denne henseende har altsaa lappene undergaat endnu mindre forandring. Blandt de av mig undersøkte var der 4 (13,5 %) leptoprosoper, 7 (23 %) mesoprosoper og 19 (63,5 %) euryprosoper.

Med hensyn til ansigtsindex adskiller altsaa ikke lappene sig fra den vestlandske brachycephale type. Ogsaa hos dem er ansigtsindex 83. Hos de 4 leptoprosope var leptoprosopien kun litet uttalt (fra 88,2—92,8). Underansigtet (n—gn) er overordentlig kort hos lappene, 11,67 cm., mens det er 12,4 cm. hos nordmænd. Der er betydelig mindre forskjel paa ansigtsbredden hos lappene og norske, henholdsvis 14,1 cm. og 13,9 cm.

Index nasalis var 73,91. 30 % var leptorhiner, 63,4 % mesorhiner og 6,6 % chamærhiner.

MANTEGAZZA har desværre intet herom. Heller ikke har jeg fundet lappens næseindex angit hos andre forskere.

Den størrelse av næseindex som jeg har fundet hos disse lapper, svarer til hvad der er angit for ostjaker og kalmücker. 21 av disse hadde en retbygget næse, og 9 hadde konkav næse eller rettere sagt tupnæse. Øienfarven var hos 9 (30 %) blaagraa, hos 15 (50 %) melert og hos 6 (20 %) brun.

Mantegazza fandt hos 20 (30 %) blaagraa, hos 19 (29 %) melerte og hos 27 (41 %) brune øine. De helt brune øine har altsaa avtat ganske betydelig i antal. For haarets vedkommende fandt jeg følgende:

Tabel 62.

	Antal	%	Mantegazza	
			Antal	%
Sort haar	3	6,7	2	0,9
Morkebrunt haar	14	47,5	0	31,0
Lysebrunt haar	9	20,1	14	47,0
Rodt haar				
Blondt haar	4	13,7	6	20,1

Begge tabeller viser at de nulevende lapper er relativt lyshaarede.

At Mantegazza har saa mange blonde og lyshaarede, beror paa to ting. For det første at alle de av mig undersøkte er 21 og 22 aar gamle, mens Mantegazzas er av alle aldersklasser.

Dernæst har Mantegazza som italiener været langt snarere end jeg til at betegne et haar som lyst og langt strengere end jeg i sine fordringer til sort haar. Det som her i landet kaldes sort haar, er Martins tavle no. 4, mens Mantegazza med sort haar utvilsomt mener Martins tavle no. 27. Derfor gaar det ikke an at dra nogen sammenligning her.

Derimot kan jeg nok sammenligne mit eget fund med hvad jeg har fundet andre steder i Norge. Og det er da vel værd at lægge merke til at disse lapper har *lysere haar end mænd av samme alder i Søndre Søndmør: Ulstein, Herø og Sandø.*

Mongolfold (plica marginalis og epicantus) fandtes hos 13 (44 %) av dem. Jeg har før beskrevet deres utseende og paavist at mongolfold er genotypisk for lappene. Naar den findes hos den nordiske befolkning, beviser dette kun en tidligere foregaat krydsning med lappene.

Pandebredden maa nærmest karakteriseres som stor hos lappene, 11,14 cm. Men den er *meget* liten i forhold til lappenes store hodebredde og store ansigtsbredde. Pandebredden utgjør hos lappene 6,81 % av legemshøiden, hos nordmænd derimot kun 6,35 %.

Hvilke breddedimensioner man end tar for sig hos lappene, saa faar man det indtryk, at deres legeme har været under pres ovenfra nedad. Sidetrykket er derved øket og breddedimensionene har tiltat, men i forskjellig grad.

Baade pandebredde, ansigtsbredde og hodebredde er relativt store hos lappene. Men av disse 3 har dog pandebredden tiltat mindst i forhold til legemshøiden.

Lappene har derfor ogsaa en meget liten transversal fronto-parietal-index, 71,15. De er stenometope.

Blandt samtlige av mig undersøkte var der 14,0 % stenometope, 37,5 % metriometope og 49,5 % eurymetope.

Blandt lappene derimot er forholdet følgende: 50 % stenometope, 20 % metriometope og 30 % eurymetope.

Dette er med andre ord et for lappene meget karakteristisk træk.

Sammenholder man derimot pandebredden med ansigtsbredden, saa viser det sig at disse to dimensioner løper mere paralelt sammen. Til en større pandebredde svarer ogsaa en relativt større kindbredde. Forholdet mellem pandebredden og kindbredden er derfor omtrent ens hos nordmænd og lapper, en liten grand mindre (78,7) hos lappene end hos nordmændene (79,2).

	Nordmænd	Lapper
Liten jugo-frontal index (70—77)	34,1	30,0
Middels —„— (78—80)	43,1	43,5
Stor —„— (81—93)	22,8	16,5

Indenfor vor befolkning har derfor den transversale fronto-parietale index betydelig større interesse end jugo-frontal-indexen.

Man kan gjennem den første tydelig utskille 3 antropologisk forskjellige typer inden vor befolkning.

1. Den dolicho-mesocephale med høi transversal parieto-frontal index, eurymetopisk, affinitetstal 1,94.

2. Den brachycephale, ogsaa med høi transversal parieto-frontal index, metriometopisk, affinitetstal 1,16.

3. Den hyperbrachycephale med liten transversal parieto-frontal index, stenometopisk, affinitetstal 1,61.

2. Kvænene.

De finlændere som bor i Troms fylke, er utvilsomt fra flere forskjellige finske län. Men selv kalder de sig i almindelighet kvæner, og denne benævnelse brukes ogsaa i almindelighet av den norske befolkning paa alle finlændere. Derfor benytter jeg ogsaa i det følgende denne benævnelse paa alle finlændere.

Blandt de 662 mænd som jeg undersøkte, var der kun 17 som mente at de var av ren finsk herkomst. Men jeg hadde ikke mindre end 26 som var av blandet norsk og finsk herkomst, og 8 som var av blandet finsk og lappisk herkomst.

Jeg vil foreløbig holde mig til de 17 som mente at de var av ren finsk herkomst. Legemshøiden hos disse var 166,2 cm. WESTERLUND opgir for de naturlige finske folkegrupper følgende legemshøider:

Vestfinner	168,6
Tavaster	167,8
Kareler	165,4
Kvæner	164,4

Index cephalicus' gjennemsnitlige størrelse var 82,06. Middeltallet for hodets største længde var 18,75. Bredden var gjennemsnitlig 15,4 cm. Hodet er altsaa samtidig litt kortere og litt bredere end nordmændenes. 1 var dolichocephal, 6 mesocephale og 1 hyperbrachycephal.

Middeltallet for hodets ørehøide var 13,06 cm., en liten grand mindre end hos nordmændene altsaa. Hjernekraniets kubikindhold beregnet ad modum WELCKER blir da 1432 cm.^{3}, litt mindre altsaa end baade hos lapper og hos nordmænd. Ansigtsmaalene var for bredden 14,00 cm. og for høiden 11,82 cm. Ansigt-index blir saaledes 84,29.

Pandebredden er 11,10 cm., litt mindre end hos lappene, litt større end hos nordmændene.

Den transversale fronto-parietal-index er 72,08 og jugo-frontal-index 79,29. I begge disse henseender staar de den norske befolkning meget nær.

Indre øienvinkel-bredde 3,26 cm., litt mindre end hos lappene, litt større end hos nordmændene.

Mongolfold fandtes hos 4 (23,5 %), altsaa meget sjeldnere end hos lappene.

Ansigtet er relativt firkantet at se til, idet kjævebredden er meget stor. Næsens høide er 4,92 cm. og bredden 3,35 cm. Index nasalis altsaa 67,35. De er mere leptorhine end nordmændene.

De er meget lyse baade av haar og øine, men de naar dog i denne henseende paa langt nær op mot den indfødte norske befolkning.

Med hensyn til øienfarve fandt jeg følgende:

Blaa og graa øine	41,4 %	lyse øine 64,9 %
Lyst melerte øine	23,5 „	
Mørkt melerte øine	11,7 „	mørke øine 35,1 %
Lysebrune øine	17,5 „	
Mørkebrune øine (MARTIN 4)	5,9 „	
Blondt og rødt haar	23,4 „	lyst haar 53,0 %
Lysebrunt haar	29,6 „	
Mørkebrunt haar	23,5 „	mørkt haar 47,0 %
Brunsort og sort haar.....	23,5 „	

De 17 „rene" kvæner skrev sig fra følgende herreder:

6 fra Lyngen.
6 fra Kvænangen.
2 fra Karlsøy.
1 fra Skjervøy.
1 fra Tromsøysund.
1 fra Tromsø.

Paa 2 undtagelser nær skriver de sig altsaa alle sammen fra fylkets aller nordligste herreder.

I sin beskrivelse av de finske folkestammer har dr. F. W. WESTERLUND kun delvis anvendt de samme karaktertræk som jeg har benyttet. Han har saaledes brukt andre ansigtsmaal end jeg. Han har ogsaa en helt anden gruppe-inddeling end jeg. Det viser sig derfor her, som saa ofte ellers i antropologien, meget vanskelig at dra sammenligninger. I enkelte henseender lar det sig dog gjøre.

Han deler finlænderne i 4 naturlige folkegrupper, og jeg skal her anføre de for hver av disse grupper eiendommelige træk.

Tabel 63.

	Vestfinner	Tavaster	Kareler	Kvæner	Norske kvæner
Legemshøide	168,6	167,8	165,4	164,4	166,2
Index cephalicus.....	79,4	80,9	82,2	82,6	82,06
Lyse øine	83,0	80,0	73,0	71,7	64,9 %
Mørke øine	17,0	20,0	27,0	28,3	35,1 %
Lyst haar	65,0	58,0	50,6	54,3	53,0 %
Mørkt haar	35,0	42,0	49,4	45,7	47,0 %

Jeg kan nøie mig med at anføre disse 4 karaktertræk.

Som det vil sees av denne tabel, staar de norske kvæner med hensyn til legemshøide og cephalindex nærmest karelene, mens de med hensyn til haarfarve og øienfarve har mest tilfælles med de finske kvæner.

De finske kvæner repræsenterer det mørke element i den finske befolkning; de repræsenterer endvidere det brachycephale og lavvoksne element. De repræsenterer altsaa i alle disse henseender de samme eiendommeligheter som den vestlandske brachycephale type gjør i Norge.

Det er i WESTERLUNDS beskrivelse av dem vanskelig at se nogensomhelst forskjel paa dem og den vestlandske brachycephal.

Og likesom den alpine urtype i Nord-Norge har krydset sig med lappene, saa har ogsaa de finske kvæner krydset sig med de finske lapper.

„Den relativt mörkare typen i norra Österbotten, Kvänerna, som i manga antropologiska hänseenden intager en själfständig plats, skild från karelarne, har väl af dessa trängts mot väster och norr, och därunder mottagit intryck från de af dem själfa undanträngda lapparne, såsom vi redan tidigare, med anledning af kvänernas betydande brakycefali, framhållit", sier WESTERLUND[1].

Men som allerede før nævnt, de norske kvæner repræsenterer ikke nogen bestemt finsk type. De er for det første absolut ikke i antropologisk henseende analoge med de finske kvæner.

En hel masse av vore norske kvæner har helt igjennem træk som svarer til tavastenes.

Og de finske kareler svarer jo stort set til den type som vi her i Norge kalder Vestlandstypen. Der er i somatisk henseende neppe nogen forskjel paa disse to typer. Begge to er vel ætlinger av den alpine race.

3. Bastardene.

a. Norske × lapper.

22 mænd opgav at den ene av forældrene var norsk, den anden lap.

18 av disse hadde norsk far og lappisk mor. 4 meddelte at faren var lap og moren norsk.

Jeg har ikke fundet nogen grund til at skille denne sidste gruppe fra den første. I alle de tilfælder hvor faren var lap, var han av de fastboende sjølapper i Lyngen eller Kvænangen. Jeg kunde ikke hos de 4 opdage noget som skilte dem fra de andre 18. Fælles for alle disse 22 var at de hadde et utpræget mongolsk utseende. Gjennemgaaende var de mindre av vekst end den norske befolkning. Dette sammen med det brede ansigt, de fremstaaende kindben, den ringe avstand mellem øienlokene, de ofte skjæve øienspalter og den spinkle underkjæve gav dem et fremmedartet utseende. En nøiere undersøkelse bragte dog for dagen at disse bastarder var mere

[1] Fennia, 21,5 pag. 40.

nordiske end de saakaldte rene lapper. Dette fremgaar allerede av gjennemsnitstallene paa tabel 61.

Deres middelhøide var saaledes 166,8 cm., deres cephalindex 81,05, deres ansigtsindex 83,2, deres index nasalis 68,35, altsammen tal som ligger betydelig nærmere den norske befolknings middeltal end lappenes.

Tabel 64.

a. Serie for legemshøiden.

	Blandt alle undersøkte		Blandt lapper		Blandt lapper × norske	
	Antal	%	Antal	%	Antal	%
151—155	1	0,15				
156—160	30	3,5	6	20,0	1	4,5
161—165	112	17,0	12	30,0	9	41,0
166—170	211	31,8	11	36,6	5	22,7
171—175	185	27,8	1	3,4	5	22,7
176—180	96	14,6			2	9,0
181—185	23	3,4				
186—190	4	0,0				
	662		30		22	

b. Serie for index cephalicus.

	Blandt alle undersøkte		Blandt lapper		Blandt lapper × norske	
	Antal	%	Antal	%	Antal	%
71—75	36	5,4			1	4,55
76—80	315	47,4	8	26,6	7	31,50
81—85	257	38,9	10	33,4	12	55,00
86—90	51	7,7	11	3,7	2	9,00
91—95	3	0,6	1	3,3		
	662		30		22	

For legemshøidens vedkommende vil jeg, idet jeg henviser til tabel 64, særlig bemerke følgende:

Av de 22 var der kun én som var under 160 cm. høi. Og der var kun 2 som var over 175 cm. Der er altsaa blandt disse bastarder langt færre smaa end blandt lappene og langt færre høie end blandt den norske befolkning. Mellemklassen var derimot godt besat, og særlig godt besat var høidegruppen 161—165.

Dette støtter ialfald den opfatning, at heterozygotene har en intermediær høide. Ganske likedan er forholdet med index cephalicus. Av de

22 var der kun 2 som hadde en index 86 eller derover, og der var kun 1 som hadde en index under 76.

55 % hadde derimot en index mellem 81—85; blandt lappene talte denne gruppe kun 33,4 % og blandt nordmændene 38,9 %. Det ser herav ut som index cephalicus blir mer og mer intermediær jo hyppigere krydsningen gjentages.

Gaar jeg derefter over til ansigtsindex, gjentar ogsaa her det samme forhold sig.

Blandt samtlige undersøkte fandt jeg 36,8 % euryprosope, 32,6 % mesoprosope og 30,6 % leptoprosope. Blandt lappene var tallene henholdsvis 63,5, 23,0 og 13,5.

Blandt disse bastarder var tallene 50,0, 27 og 23. De ligger altsaa saa præcist midt mellem forholdstallene hos de „rene" lapper og de „rene" norske som det vel er mulig. Ansigtsindex synes derfor ogsaa at bli intermediær ved hyppig gjentat krydsning.

Anderledes med næseindex.

Av den norske befolkning er 57 % leptorhiner og 43 % mesochamærhiner.

Blandt lappene fandtes 30 % leptorhiner og 70 % mesochamærhiner.

Av de 22 bastarder var 14 (63 %) leptorhine og 8 (37 %) mesochamærhine.

Dette synes mig at tale for at leptorhini fuldstændig dominerer over mesochamærhini.

Med hensyn til bastardenes øienfarve og haarfarve er intet av interesse at meddele. De staar baade med hensyn til haarfarve og øienfarve nærmere til lappene end til de norske. Hos 5 (23 %) av disse bastarder fandtes en meget tydelig mongolfold.

Gjennemgaaende maa man være berettiget til at si, at disse bastarder mellem norske og lapper i somatisk henseende indtar et mellemstandpunkt mellem de to typer hvortil forældrene hører.

b. Norske × kvæner.

Av saadanne bastarder har jeg i alt 26. Av tabel 61 fremgaar, at deres middeltal for legemshøide og cephalindex ligger midt imellem hvad jeg har fundet hos norske og hos kvæner. Bastardenes ansigtsindex svarer derimot nøiagtig til hvad den er hos den mest bredansigtede av forældrene, nemlig 84,4.

Av bastardene var 1 dolichocephal, 17 mesocephale, 5 brachycephale og 2 hyperbrachycephale.

Der er altsaa blandt bastardene et betydelig større antal mesocephale end blandt dem som regnet sig for rene kvæner.

En nærmere undersøkelse av disse bastarder frembyr litet av interesse av den grund, at forældreparrene utvilsomt selv for en meget stor del har været meget litet racerene.

Tabel 65. Middeltal fra samtlige herreder.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Herredets navn	Antal undersøkte	Gjennemsnitlig legemshøide	Gjennemsnitlig hodebredde	Gjennemsnitlig hodelængde	Gjennemsnitlig ansigtshøide n—gn	Gjennemsnitlig ansigtsbredde	Gjennemsnitlig index cephalicus	Gjennemsnitlig index facial. morph.	Gjennemsnitlig næsebredde	Gjennemsnitlig næsehøide	Gjennemsnitlig nasal index	Gjennemsnitlig pandebredde	Gjennemsnitlig transversal fronto-parietal index	Gjennemsnitlig jugo-frontal index	Gjennemsnitlig indre øienvinkel-avstand	Gjennemsnitlig haarfarve-index	Gjennemsnitlig øienfarve-index	Antal individer med plica marginalis
1	Kvæfjord	15	171,1	15,7	19,3	12,0	14,3	81,2	83,6	3,4	5,0	68,1	11,5	73,3	80,0	3,4	3,13	1,80	2
2	Trondenes (Harstad)	58	171,1	15,5	19,2	12,1	14,1	80,7	86,3	3,4	4,8	68,0	11,1	71,8	78,8	3,2	2,96	1,67	3
3	Bjarkøy	8	167,8	15,5	19,2	11,7	14,1	80,9	83,5	3,3	4,8	69,2	11,0	71,0	78,4	8,2	2,75	1,50	-
4	Salangen	26	170,4	15,4	18,8	12,0	14,0	82,4	85,7	3,5	4,9	73,1	11,1	71,7	78,9	3,3	3,15	1,80	8
5	Bardu	13	172,8	15,4	19,4	12,4	13,9	79,3	88,9	3,4	5,0	68,6	11,0	71,7	79,2	3,1	2,61	1,38	2
6	Lavangen	17	170,4	15,2	18,5	11,9	13,7	82,1	87,1	3,4	4,9	69,9	10,8	71,3	79,3	3,1	2,82	1,76	4
7	Ibestad	41	170,9	15,7	19,1	12,2	14,1	79,3	86,7	3,5	4,9	70,8	11,3	72,0	79,8	3,1	2,95	1,82	7
8	Tranøy	41	173,3	15,4	19,1	12,2	14,1	80,2	86,8	3,4	5,1	68,0	10,9	71,3	77,8	3,1	2,63	1,40	4
9	Sørreisa	2	167,5	15,1	18,8	12,0	13,0	80,0	86,7	3,4	5,0	68,3	10,6	70,9	76,2	3,5	4,00	3,00	-
10	Dyrøy	23	171,9	15,1	18,9	12,0	13,9	80,2	86,5	3,4	5,0	67,9	11,1	72,9	79,4	3,3	2,86	1,60	2
11	Berg	8	170,6	15,6	19,2	12,4	14,2	81,4	87,3	3,4	5,3	63,5	11,1	71,4	78,4	3,2	3,75	2,37	2
12	Torsken	9	166,8	15,4	18,8	11,8	13,0	81,9	84,7	3,4	4,8	71,8	10,9	71,4	78,1	3,2	3,44	2,11	-
		261	171,2	15,4	19,4	12,1	14,0	80,6	86,4	3,4	4,9	69,4	11,1	72,1	79,3	3,2	3,08	1,77	-
13	Lenvik	33	170,8	15,4	19,3	12,2	14,1	79,5	86,4	3,4	4,9	69,3	11,1	72,4	79,3	3,2	3,24	1,78	-
14	Hillesøy	5	167,6	15,3	19,1	11,0	13,9	80,0	80,2	3,4	5,0	68,1	10,7	70,3	77,5	3,3	3,20	2,00	-
15	Maalselv	23	171,3	15,4	19,4	12,3	13,9	79,1	88,7	3,4	5,0	69,0	11,0	71,4	78,8	3,3	2,86	1,52	1
16	Balsfjord	34	172,6	15,4	19,2	12,4	14,4	80,2	87,6	3,4	5,1	68,3	11,1	71,7	78,3	3,3	2,91	1,58	3
17	Malangen	28	170,9	15,4	19,1	12,0	14,0	80,9	86,3	3,4	4,9	69,4	10,9	70,7	78,0	3,3	2,78	1,32	4
18	Tromsøysund	46	170,0	15,3	18,9	11,9	14,0	81,0	84,9	3,4	5,0	68,3	11,1	72,4	78,5	3,2	3,02	1,73	6
19	Tromsø	30	169,4	15,4	19,2	11,9	13,9	79,9	85,6	3,4	5,0	67,6	11,1	72,6	79,6	3,2	3,00	1,96	2
20	Sørfjord	14	168,3	15,5	19,0	11,8	14,1	81,7	83,7	3,5	5,0	69,5	11,1	71,6	78,5	3,3	3,28	1,92	8
21	Lyngen	72	167,6	15,6	19,1	11,9	14,1	81,9	84,7	3,4	4,9	69,0	11,2	71,7	79,2	3,3	3,18	2,31	13
22	Karlsøy	30	167,7	15,4	19,6	11,9	14,1	81,4	84,7	3,4	4,9	69,6	11,2	72,4	79,4	3,4	3,10	2,03	4
23	Helgøy	12	168,7	15,3	19,1	11,7	14,2	81,1	82,7	3,5	4,8	72,5	11,2	73,0	78,5	3,3	2,33	2,16	2
24	Skjervøy	55	169,0	15,3	19,0	12,1	14,6	80,5	85,6	3,4	5,0	68,3	11,2	73,2	79,1	3,2	3,00	1,70	2
25	Nordreisa	2	166,5	15,0	18,7	11,2	13,7	80,3	81,4	3,6	5,2	68,8	11,0	73,0	80,1	2,9	4,00	1,00	-
26	Kvænangen	17	169,1	15,5	19,1	12,1	14,2	81,3	85,1	3,3	5,1	65,1	11,2	72,4	78,9	3,2	3,05	2,05	3
		401	169,5	15,4	19,1	12,0	14,2	80,8	84,5	3,4	5,0	68,0	11,1	72,1	78,8	3,3	3,07	1,78	85

XIII. De enkelte herreders antropologi.

1. Gruppekarakteristik.

Naar jeg nu til slutning skal gi en fremstilling av de enkelte herreders antropologi, kan jeg fatte mig i stor korthet.

Det falder da naturlig at samle flere eller færre herreder hvor forholdene i antropologisk henseende er ensartet, i større grupper.

Den første av disse vil jeg kalde Bardu-gruppen. Den bestaar av følgende herreder: Bardu, Maalselv, Balsfjord, Malangen, Dyrøy, Lenvik, Sorreisa og Hillesøy. Fra de to sidstnævnte distrikter er mit materiale vistnok meget sparsomt. Jeg kan derfor intet *sikkert* si om disse to herreders antropologi. Men jeg tror dog nærmest at de hører hjemme under denne gruppe.

Hele denne gruppe har faat sit antropologiske præg derigjennem, at dens befolkning for en meget væsentlig del nedstammer fra de indflyttede Østerdøler og tildels Gudbrandsdøler. Likesom Østerdølene er ogsaa befolkningen i disse bygder meget høivoksen (omkring 172 cm.), lysøiet og lyshaaret, har en relativ lav cephalindex (mellem 79 og 80) samt en høi ansigtsindex (omkring 88). Næsen er som regel meget smal og retbygget, og avstanden mellem de indre øienvinkler er mindre end i de øvrige herreder. Paa tabel 66 har jeg anført størrelsen av de forskjellige karakteristiske typer. Ved beregningen av disses størrelse har jeg benyttet de i denne avhandlings specialavsnit optrukne typegrænser. Det er den samme inddeling som blev anvendt paa tabel 51 (fig. 13).

Det fremgaar av tabel 66 at den rent nordiske type er overordentlig utbredt i disse herreder. Den utgjør 38,4 % av samtlige undersøkte. Til sammenligning henvises til gruppe 5, hvor den nordiske type kun utgjør 22,0 %. Tilsammen utgjør de 5 første typer, som jo i det hele tat har et sterkt nordisk præg, 85 % i disse herreder. Bemerkningsværdig er det ogsaa, at de bastardtyper som jeg har benævnt homo alpinus, er yderst sjeldne i disse herreder (1,8 %). Bastardtype 9 og 12 (homo palæoarcticus) mangler helt.

Den anden gruppe omfatter en række øer og fjorddistrikter: Kvæfjord, Trondenes, Bjarkøy, Ibestad, Tranøy, Lavangen og Salangen.

I disse herreder er befolkningen litt lavere av vekst, ca. 171 cm., litt mere brachycephal, litt mørkere av haar og øine end i foregaaende gruppe. Den rent nordiske type utgjør ogsaa her ca. 34 % av samtlige undersøkte.

Til den tredje gruppe hører Tromsø, Tromsøysund, Berg og Torsken. Her er befolkningen endnu lavere av vekst, 169 à 170 cm., endnu mere brachycephal, samt mørkere av haar og øine end i de foregaaende grupper. Den rent nordiske type utgjør kun 26 %. Den 4de gruppe omfatter Skjervøy, Helgøy og Karlsøy med en meget lavvoksen befolkning, ca. 168 cm., meget mørkhaaret og mørkøiet. Den nordiske type er mindsket til 25,3 %.

Tabel 66. Viser den hyppighet hvormed de forskjellige bastarder optræer inden de forskjellige distrikter:

Gruppe 1: Bardu, Maalselv, Balsfjord, Malangen, Sorreisa, Lenvik, Dyrøy, Hillesøy.
Gruppe 2: Kvæfjord, Trondenes, Bjarkøy, Ibestad, Tranøy, Lavangen, Salangen.
Gruppe 3: Tromsø, Tromsøysund, Berg, Torsken.
Gruppe 4: Skjervøy, Helgøy, Karlsøy.
Gruppe 5: Kvænangen, Nordreisa, Lyngen, Sorfjord.

Kombination nr.	Hodetype	Ansigtstype	Øientype	Gruppe 1 Fig. 16	Gruppe 2 Fig. 17	Gruppe 3 Fig. 18	Gruppe 4 Fig. 19	Gruppe 5 Fig. 20	Bastardkombinationens benævnelse i denne avhandling.
1	Dolichomesocephali	Leptomesoprosopi	Lyse øine	38,4	33,6	26,0	25,3	22,0	Homo nordicus.
2	— „ —	— „ —	Mørke øine	6,8	5,3	7,5	6,2	6,5	Homo nordicus v. fuscus.
3	— „ —	Euryprosopi	Lyse øine	16,2	9,2	20,2	14,2	12,5	Homo nordicus v. euryprosopicus.
4	— „ —	— „ —	Mørke øine	0,6	2,9	2,2	5,2	4,0	Homo alpinus v. dolichocephalicus.
5	Brachycephali	Leptomesoprosopi	Lyse øine	23,0	20,0	11,0	16,2	9,5	Homo nordicus v. brachycephalicus.
6	— „ —	— „ —	Mørke øine	3,2	3,9	3,2	7,2	10,5	Homo alpino-nordicus.
7	— „ —	Euryprosopi	Lyse øine	7,5	9,6	15,0	11,2	16,5	Homo alpinus v. pallidus.
8	— „ —	— „	Mørke øine	1,8	4,8	6,4	5,2	7,5	Homo alpinus.
9	Hyperbrachycephali	Leptomesoprosopi	Lyse øine	-	5,3	4,3	3,1	1,0	Homo lapponicus v. nordicus.
10	— „	— „ —	Mørke øine	1,2	-	1,1	-	4,0	Homo lapponicus v. alpinus.
11	— „ —	Euryprosopi	Lyse øine	1,2	3,4	2,2	5,2	5,0	Homo lapponicus.
12	— „ —	— „ —	Mørke øine	-	1,4	1,1	1,0	1,0	Homo palæoarcticus.

Den 5te og sidste distriktsgruppe omfatter Kvænangen, Nordreisa, Lyngen og Sørfjord.

Her finder man den laveste befolkning og samtidig den sterkest brachycephale befolkning i hele Troms fylke. Paa fig. 16—20 har jeg illustrert disse distrikters antropologi.

Meget tydelig fremgaar det av disse figurer hvorledes type 1, 3 og 5 mindsker jevnt og sikkert i størrelse fra gruppe 1 til gruppe 5. Type 4,

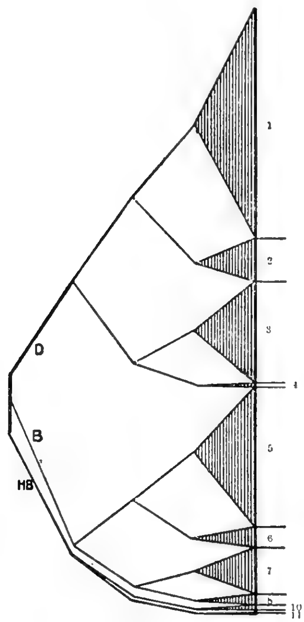

Fig. 16. Bastarder i distriktsgruppe 1. (Tabel 66.)

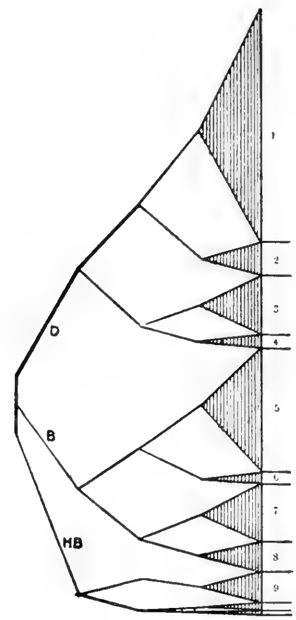

Fig. 17. Bastarder i distriktsgruppe 2. (Tabel 66.)

som næsten ikke findes i „Bardu"-bygdene, er blit ganske stor i sidste distriktsgruppe.

Men det fremgaar ogsaa av disse figurer og tabellen, at bastarderingen er ikke mere broget end at linjene er ganske klare naar man blot har saapas som 100 mand til behandling. Man ser hvorledes hver enkelt bastardtype enten økes eller mindskes, alt eftersom man gaar den ene eller den anden vei. Linjene er overalt klare. Disse figurer gir os et helt klart billede av folketypene i disse distrikter.

2. Individualtabeller.

Det værdifuldeste antropologiske billede av de enkelte herreders antropologi har man dog i individualtabellene. Derfor medtar jeg her disse. Fra Norge er der hittil kun offentliggjort meget litet av saadanne. Det er væsentlig forfatternes bearbeidelse av individualtabellene som er offentliggjort. Og hver forfatter og hver tidsperiode har sin egen metode, som snart gaar i glemmeboken. Meget av det arbeide som er nedlagt paa det antropologiske omraade, blir derfor efter kortere eller længere tid noksaa værdiløst. Men for efterslegten vil det utvilsomt være av stor interesse at ha de enkelte individers nøiagtige maal til sammenligning.

Disse tabeller behøver kun i et par henseender litt nærmere forklaring. Alle enkelte maal er tat helt overensstemmende med nu gjældende

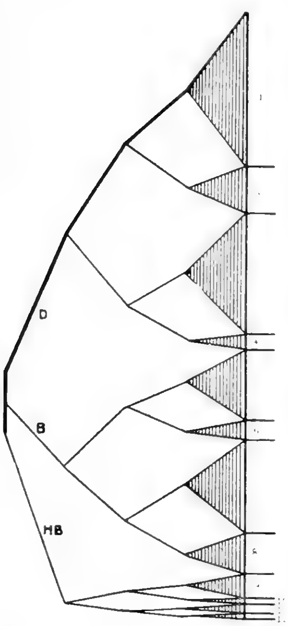

Fig. 18. Bastarder i distriktsgruppe 3. (Tabel 66).

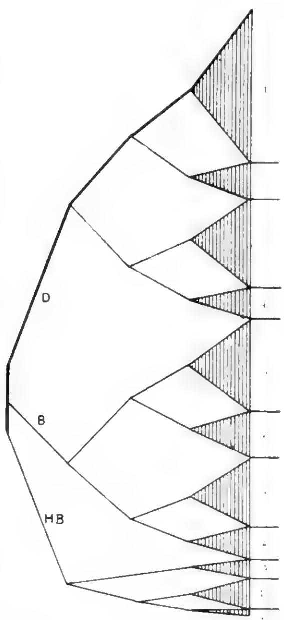

Fig. 19. Bastarder i distriktsgruppe 4. (Tabel 66).

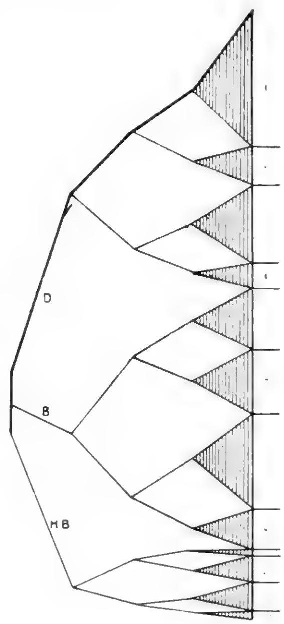

Fig. 20. Bastarder i distriktsgruppe 5. (Tabel 66).

regler, og saaledes som det nærmere findes beskrevet i professor Rudolf Martins store haandbok.

Betydningen av de tal som er anført under rubrikkene øienfarve og haarfarve, findes angit ved indledningen av hvert av disse avsnit. Længst tilhøire findes en rubrik som har til oversigt „formel". Bokstavene eller tabellene her angir til hvilken type individet hører med hensyn til de 6 vigtigste træk: 1) legemshøide, 2) index cephalicus, 3) index facialis morphologicus, 4) index nasalis, 5) øienfarve, 6) haarfarve. Legemshøiden betegnes med tal, saaledes at

1 betyr meget smaa	145—165 cm.
2 betyr smaa	166—168 —
3 betyr middels	169—170 —
4 betyr høie	171—200

Derefter kommer et bokstav som angir hodetypen saaledes:

D betyr index cephalicus	67—75.
M betyr index cephalicus	76—80.
B betyr index cephalicus	81—85.
H B betyr index cephalicus	86—93.

Saa kommer et bokstav som angir ansigtstypen saaledes:

E betyr index facialis morpholog.	70— 83.
M betyr index facialis morpholog.	84—87.
L betyr index facialis morpholog.	88—110.

Derefter kommer et bokstav som angir til hvilken næsetype individet hører, saaledes:

L betyr index nasalis	45— 69.
Ch betyr index nasalis	70—120.

Derefter kommer et litet bokstav som angir pigmenteringsgraden saaledes:

l betyr at baade øine og haar er lysfarvet,

m betyr at baade øine og haar er mørke,

x betyr at der er motsætningsforhold tilstede med hensyn til øinenes og haarets farve. Hvis øinene er lyse, er haaret mørkt, og omvendt.

Tabel 67.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øienvinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Formel				
																		Høide	Hode	Ansigt	Næse	Pigment
Kvæfjord, 15 mænd.																						
1	N.	161	16,0	18,2	11,3	13,7	3,3	4,6	10,9	2,9	1	3	87,9	68,1	82,5	71,7	79,6	1	B	E	Ch	l
2	N.	175	15,4	19,4	11,9	14,5	3,3	5,0	11,0	3,3	4	1	79,4	71,4	82,6	66,0	76,4	4	M	E	L	x
3	N.	182	15,1	18,7	11,5	14,3	3,2	4,8	11,8	3,6	4	3	80,8	78,2	80,4	66,7	82,5	4	M	E	L	x
4	N.	167	15,2	19,0	11,3	14,6	3,4	4,6	11,7	3,8	1	4	80,0	77,0	77,4	73,9	80,1	2	M	E	Ch	x
5	N.	166	14,7	18,3	11,6	13,6	3,2	5,0	10,9	3,2	1	4	80,3	74,2	85,3	64,0	80,2	2	M	M	L	x
6	N.	175	15,6	19,4	12,6	14,8	3,4	5,0	12,1	3,7	1	4	80,4	77,0	85,1	68,0	81,8	4	M	M	L	x
7	N.	177	15,8	19,7	12,4	13,7	3,5	4,8	11,5	3,2	1	1	80,2	72,8	90,5	72,9	83,9	4	M	L	Ch	l
8	N.	166	15,4	19,8	12,5	14,0	3,4	5,8	10,8	3,0	1	4	77,8	70,1	89,3	58,6	77,1	2	M	L	L	x
9	N.	163	15,9	18,4	13,0	14,4	3,4	5,0	11,8	3,8	2	3	86,4	74,2	90,3	68,0	81,9	1	B	L	L	l
10	N.	180	15,8	19,0	11,6	14,2	3,2	5,0	11,3	3,2	1	4	83,2	71,5	81,7	64,0	79,6	4	B	E	L	x
11	N.	168	15,6	18,6	11,8	14,5	3,4	4,3	11,3	3,4	1	1	83,9	72,4	81,4	79,1	77,9	2	B	E	Ch	l
12	N.	170	15,9	19,7	12,1	14,0	3,4	5,2	11,2	3,1	1	4	80,7	70,4	86,4	65,4	80,0	3	M	M	L	x
13	N.	168	16,7	20,6	12,2	15,1	3,6	5,4	11,2	3,4	2	3	81,1	67,1	80,8	66,7	74,2	2	B	E	L	l
14	N.	162	15,5	19,1	11,2	14,2	3,3	4,5	11,6	3,4	5	4	81,2	74,8	78,9	73,3	81,7	1	B	E	Ch	m
15	N.	173	16,0	19,9	11,8	14,8	3,6	5,3	12,0	3,6	1	3	80,4	75,0	79,7	67,9	81,1	4	M	E	L	l
Trondenes og Harstad, 58 mænd.																						
16	N.	170	15,1	19,7	11,8	13,5	2,8	5,2	11,0	3,0	1	1	76,7	72,9	87,4	53,9	81,5	3	M	M	L	l
17	N.	173	15,6	19,5	11,8	14,2	3,5	5,3	11,2	3,2	2	1	80,0	71,8	83,1	66,0	78,9	4	M	E	L	l
18	N.	165	15,1	19,8	12,6	13,7	3,0	5,0	11,3	3,4	1	3	76,3	74,8	92,0	60,0	82,5	1	M	L	L	l
19	N.	174	15,6	19,0	11,4	14,2	3,4	4,6	10,8	3,4	1	3	82,1	69,2	80,3	73,9	76,1	4	B	E	Ch	l
20	N.	165	15,6	19,0	12,2	14,0	3,3	4,7	10,8	3,6	4	4	82,1	69,2	87,1	70,2	77,1	1	B	M	Ch	m
21	N.	171	15,4	20,3	10,6	14,1	3,4	5,0	11,3	3,0	4	4	75,9	73,4	75,2	68,0	80,1	4	D	E	L	m
22	N.	169	15,6	20,1	11,8	14,2	3,2	4,7	11,2	3,9	1	4	77,6	71,8	83,1	68,1	78,9	3	M	E	L	x
23	N.	169	15,4	20,0	13,4	13,4	3,4	5,3	10,9	3,3	1	1	77,0	70,8	100,0	64,2	81,3	3	M	L	L	l
24	N.	169	15,8	18,7	12,2	13,9	3,4	5,5	10,4	3,0	1	3	84,5	65,8	87,8	61,8	74,8	3	B	M	L	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Høide	Hode	Ansigt	Næse	Pigment
25	N.	170	16,7	19,8	12,2	15,0	3,4	4,5	12,0	3,7	3	3	84,3	71,9	81,3	75,6	80,0	3	B	E	Ch	x
26	N.	168	15,7	20,4	12,5	14,4	3,5	5,0	11,0	3,9	2	4	77,0	70,1	86,8	79,0	76,4	2	M	M	Ch	x
27	N.	171	15,9	19,6	13,2	14,4	3,0	5,6	11,4	3,1	4	4	81,1	71,7	91,7	53,6	79,2	4	B	L	L	m
28	N.	170	15,0	18,6	12,3	13,7	3,1	5,5	11,0	2,9	1	1	80,7	73,3	89,3	56,4	80,3	3	M	L	L	l
29	N.	168	14,8	19,7	11,2	13,3	3,6	4,6	10,7	3,0	1	4	75,1	72,3	84,2	78,3	80,5	2	D	M	Ch	x
30	N.	170	15,4	19,1	11,2	14,2	3,4	4,7	11,2	3,2	1	1	80,6	72,7	78,9	72,3	78,0	3	M	E	Ch	l
31	N.	172	15,6	19,2	11,7	14,6	3,5	5,3	11,1	2,9	1	3	81,3	71,2	80,1	66,0	76,0	4	B	E	L	l
32	N.	169	15,9	19,1	11,9	14,6	3,7	4,7	11,4	3,7	3	3	83,3	71,7	81,5	78,7	78,1	3	B	E	Ch	x
33	L.	168	16,4	18,5	11,9	14,4	3,8	4,7	10,8	3,8	2	4	88,7	65,9	82,6	80,9	75,0	2	B	E	Ch	x
34	N.	171	15,4	19,0	12,1	13,9	3,4	5,2	11,0	3,4	1	4	81,1	71,4	87,1	65,4	79,1	4	B	M	L	x
35	N.	172	16,8	18,9	13,0	15,2	3,0	4,8	11,0	3,3	1	4	88,9	65,5	85,5	62,5	72,4	4	B	M	L	x
36	N.	168	14,8	18,2	11,5	13,8	3,5	4,8	11,0	3,4	1	3	81,3	74,3	83,3	72,9	79,7	2	B	E	Ch	l
37	N.	170	15,2	19,0	12,0	14,0	3,4	5,0	11,0	3,3	1	3	80,0	72,4	85,7	68,0	78,6	3	M	M	L	l
38	N. × S.	168	14,7	19,0	12,2	13,7	3,5	5,8	10,9	3,0	5	5	77,4	74,2	89,1	60,3	79,0	2	M	L	L	m
39	N.	171	15,3	17,5	12,1	14,0	2,8	4,7	11,4	2,9	1	3	87,4	74,5	86,4	59,6	81,4	4	B	M	L	l
40	N.	161	16,0	18,2	11,3	13,7	3,3	4,6	10,9	2,9	1	3	87,9	68,1	82,5	71,7	79,6	1	B	E	Ch	l
41	N.	167	15,8	17,6	11,8	14,4	3,2	5,0	11,4	3,3	4	4	89,8	72,2	81,9	64,0	79,2	2	B	E	L	m
42	L.	163	15,9	18,4	11,8	14,5	3,3	4,9	14,2	3,2	4	5	86,4	70,4	81,4	75,0	77,2	1	B	E	Ch	m
43	L.	157	15,8	17,2	11,0	14,2	3,3	4,7	11,7	3,3	1	3	91,9	74,1	77,5	70,2	82,4	1	B	E	Ch	l
44	N.	178	15,6	17,5	12,9	14,3	3,4	5,3	10,4	2,9	1	4	89,1	66,7	90,2	64,2	72,7	4	B	L	L	x
45	N.	175	16,2	18,6	12,6	14,1	3,4	4,7	11,2	3,4	2	1	87,1	69,1	89,4	72,3	79,4	4	B	L	Ch	l
46	N.	173	15,5	17,5	12,2	14,2	3,4	5,0	10,8	3,4	1	1	88,6	69,7	85,9	68,0	76,1	4	B	M	L	l
47	N.	178	15,6	19,2	12,3	14,8	3,5	5,2	11,8	3,4	1	1	81,3	75,6	83,1	67,3	79,7	4	B	E	L	l
48	N.	177	14,8	19,0	12,0	14,0	3,0	4,9	10,4	2,8	1	4	77,9	70,3	85,7	61,2	74,3	4	M	M	L	x
49	N.	161	15,0	19,0	12,6	13,4	3,6	5,2	11,0	3,1	2	3	79,0	73,3	94,0	69,2	82,1	1	M	L	L	l
50	N.	177	16,2	20,6	12,4	14,4	3,4	4,8	11,6	3,7	1	3	78,6	71,6	86,1	70,8	80,0	4	M	M	Ch	l
51	N.	173	15,0	19,0	12,2	14,0	3,6	4,8	11,2	3,2	1	3	79,0	74,7	87,1	75,0	80,0	4	M	M	Ch	l

52	N.	167	15,4	20,1	12,0	14,0	4,8	5,2	10,4	3,3	2	3	76,6	67,5	85,7	92,3	74,3	2	M	M	Ch	l
53	N.	174	15,2	19,0	12,4	14,4	4,0	5,3	12,2	3,7	1	4	80,0	79,7	86,1	75,5	84,7	4	M	M	Ch	x
54	N.	179	14,8	19,2	12,1	13,4	3,5	4,8	10,7	2,8	1	4	77,1	72,3	90,3	72,9	79,9	4	M	L	Ch	x
55	N.	181	15,6	19,9	13,0	14,1	3,6	5,5	11,0	3,1	1	3	78,4	70,5	92,2	65,5	78,0	4	M	L	L	l
56	N.	173	15,3	20,4	13,1	14,8	3,8	5,2	11,5	3,3	1	1	75,0	75,2	88,5	73,1	77,7	4	D	L	Ch	l
57	N.	167	16,2	19,1	12,5	14,0	3,6	5,0	11,6	3,7	2	2 (3)	84,9	71,6	89,3	72,0	82,9	2	B	L	Ch	l
58	N.	179	16,1	20,6	12,6	15,2	3,4	5,7	12,4	3,8	3	4	78,2	77,0	82,9	59,7	81,6	4	M	E	L	x
59	N.	173	15,8	19,2	12,2	13,8	3,2	5,2	11,2	2,9	1	3	82,3	70,9	88,4	61,5	81,2	4	B	L	L	l
60	N.	182	15,4	18,8	12,5	13,7	3,3	5,0	10,2	2,8	1	1	81,9	66,2	91,2	66,0	74,5	4	B	L	L	l
61	N.	160	15,1	19,0	11,8	14,1	3,3	5,1	10,6	3,2	2	3	79,5	70,2	83,7	64,7	75,2	1	M	E	L	l
62	N.	181	15,4	20,0	11,6	14,1	3,4	5,1	10,8	3,3	1	1	77,0	70,1	82,3	66,7	76,0	4	M	E	L	l
63	N.	179	15,6	19,5	11,6	14,2	3,6	4,5	11,2	3,0	1	4	80,0	71,8	81,7	80,0	78,9	4	M	E	Ch	x
64	N.	178	15,0	19,0	11,7	14,0	3,1	5,0	11,0	2,7	1	1	79,0	73,3	83,6	62,0	78,6	4	M	L	E	l
65	N.	164	15,0	18,9	12,3	13,0	3,8	5,5	10,4	2,8	3	5	79,4	69,3	94,6	69,1	80,0	1	M	L	L	x
66	N.	164	14,9	19,6	11,6	13,6	3,2	4,8	11,2	2,8	3	4	76,0	75,2	85,3	66,7	82,4	1	M	M	L	x
67	N.	177	14,7	19,4	12,3	14,0	3,0	4,6	11,2	3,1	3	4	75,8	76,2	87,9	65,2	80,0	4	D	M	L	x
68	N.	178	14,9	20,0	11,6	12,9	3,2	5,0	10,2	2,7	1	1	74,5	68,5	89,9	64,0	79,1	4	D	L	L	l
69	N.	179	16,2	20,9	12,3	14,4	3,8	5,3	11,5	3,6	1	3	77,5	71,6	85,4	71,7	79,9	1	M	M	Ch	l
70	N.	162	14,4	19,1	12,0	12,9	2,8	4,8	10,4	3,3	1	4	75,4	72,2	93,0	58,3	80,6	1	D	L	L	x
71	N.	178	15,6	19,6	13,3	15,2	3,2	5,4	11,0	3,4	1	3	79,6	70,5	87,5	59,3	72,4	4	M	M	L	l
72	N.	175	15,2	19,1	12,2	13,1	3,5	5,0	10,5	3,0	1	3	79,6	69,1	93,1	70,0	80,2	4	M	L	Ch	l
73	N.	162	15,2	19,6	12,5	14,1	3,7	5,0	11,5	3,4	1	3	77,6	75,7	88,7	74,0	81,6	1	M	L	Ch	l

Bjarkøy, 8 mænd.

74	N.	176	15,6	19,2	12,4	14,6	3,2	5,2	11,3	3,5	1	1	81,3	72,4	84,9	61,5	77,4	4	B	M	L	l
75	N.	159	15,9	19,7	11,4	13,9	3,3	4,7	11,2	3,2	1	4	80,7	70,4	82,0	70,2	80,6	1	M	E	Ch	x
76	N.	158	16,0	20,0	11,8	14,2	3,3	4,6	11,2	3,3	1	1	80,0	70,0	83,1	71,7	78,9	1	M	E	Ch	l
77	N.	173	15,2	18,1	10,6	13,6	3,4	4,4	10,8	3,3	3	4	84,0	71,1	77,9	77,3	79,4	4	B	E	Ch	x
78	N.	168	15,3	18,2	12,2	13,9	3,3	4,9	11,2	3,2	1	4	84,1	73,2	87,7	67,4	80,6	2	B	M	L	x
79	N.	170	15,0	19,3	11,1	13,8	3,0	4,4	10,4	3,3	1	4	77,7	69,3	80,4	68,2	75,4	3	M	E	L	x
80	N.	168	15,6	19,5	11,8	14,4	3,8	5,5	11,5	3,0	3	3	80,0	73,7	81,9	69,1	79,9	2	M	E	L	x
81	N.	170	15,4	19,5	12,6	14,0	3,4	5,0	10,5	3,0	1	1	79,0	68,2	90,0	68,0	75,0	3	M	L	L	l

Salangen, 26 mænd.

82	N.	167	15,3	18,4	12,6	14,7	3,7	5,0	11,0	3,3	1	3	83,2	71,9	85,7	74,0	74,8	2	B	M	Ch	l
83	N. × T.	175	15,8	18,7	12,2	13,6	3,6	5,0	11,2	3,0	2	4	84,5	70,9	89,7	72,0	82,4	4	B	L	Ch	x
84	N.	158	15,2	18,7	17,7	13,4	3,4	4,8	10,4	3,1	1	3	81,3	68,4	87,3	70,8	77,6	1	B	M	Ch	l
85	N.	176	15,7	18,7	12,2	14,1	3,6	5,1	11,5	3,6	1	1	84,0	73,3	86,5	70,6	81,6	4	B	M	Ch	l
86	N.	173	15,3	18,6	12,4	14,0	3,6	5,2	10,8	3,0	1	3	82,3	70,6	88,6	69,2	77,1	4	B	L	L	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Høide	Hode	Ansigt	Næse	Pigment
87	N.	167	14,8	18,4	11,0	13,5	3,7	4,8	11,2	3,8	5	4	80,4	75,7	81,5	77,1	83,0	2	M	I	Ch	m
88	N.	187	16,2	20,2	12,6	14,8	3,6	5,2	11,9	3,7	1	3	80,2	73,5	85,1	69,2	80,4	4	M	M	I	l
89	N.	176	14,3	19,0	12,2	13,2	3,5	5,4	10,8	3,1	1	3	75,3	75,5	92,4	64,8	81,8	4	D	I	I	l
Løpe-no. 90 tilhører Kvænangen og findes opført der.																						
91	N.	180	15,0	18,6	11,4	13,4	3,6	4,3	10,5	3,0	1	1	80,7	70,0	85,1	83,7	78,4	4	M	M	Ch	l
92	N.	177	15,1	19,1	11,8	13,8	3,5	4,5	10,8	3,0	1	4	79,1	71,5	85,5	77,8	78,3	4	M	M	Ch	x
93	N.	181	15,8	20,0	12,5	14,2	3,6	5,0	11,2	3,4	1	4	79,0	70,9	88,0	72,0	78,0	4	M	I	Ch	x
94	N.	175	15,4	19,4	12,0	14,0	3,6	5,4	11,4	3,4	1	4	79,4	74,0	86,4	66,7	81,4	4	M	M	I	x
95	N.	159	14,5	18,6	12,2	13,7	3,0	4,8	10,8	3,1	1	4	78,0	74,5	89,1	62,5	78,8	1	M	I	I	x
96	N.	173	15,6	19,4	12,7	14,0	3,3	5,1	10,8	3,5	1	1	80,4	69,2	90,7	64,7	77,1	3	M	I	L	l
97	L.	159	16,1	18,6	11,6	14,0	4,7	4,0	11,6	3,4	3	4	80,6	72,1	82,9	117,5	82,9		B	E	Ch	x
98	L.	165	16,0	18,1	11,6	14,0	3,9	4,5	11,2	3,4	1	3	88,4	70,0	82,9	86,7	80,0	2	B	E	Ch	l
99	N.	165	16,0	17,7	12,2	14,1	3,2	5,0	10,4	2,9	1	3	90,4	65,0	86,5	64,0	73,8	2	B	M	L	l
100	N.	175	15,4	18,4	12,1	14,7	3,9	5,0	11,2	3,4	3	4	83,7	72,7	82,3	78,0	76,2	4	B	E	Ch	x
101	N. × F.	174	16,0	19,2	12,2	14,6	3,7	4,4	12,2	4,0	3	3	83,3	76,3	83,6	84,1	83,0	4	B	E	Ch	x
102	N. × S.	166	15,6	18,4	11,5	14,9	3,8	5,3	11,5	3,2	4	4	84,8	73,7	77,2	71,7	77,2	2	B	I	Ch	m
103	N.	167	15,6	18,3	11,0	13,6	3,4	4,7	10,5	3,2	4	5	85,3	67,3	80,9	72,3	77,2	2	B	I	Ch	m
104	N.	166	15,8	18,4	11,4	14,0	3,5	4,7	11,1	3,0	1	4	85,0	70,3	81,4	74,5	79,3	2	B	E	Ch	x
105	F. × N.	162	15,3	18,6	12,0	14,0	3,0	4,8	11,0	3,4	5	5	82,3	71,0	85,7	62,5	78,6	1	B	M	I	m
106	N.	169	14,8	18,6	11,7	13,2	3,2	5,0	10,0	2,6	1	1	79,6	67,6	88,6	64,0	75,8	3	M	I	I	[illegible]
107	N.	170	15,2	18,2	12,2	14,0	3,4	5,2	11,0	3,5	1	3	83,5	72,4	87,1	65,4	78,6	3	B	M	I	l
108	N.	169	15,3	19,2	12,8	14,6	3,2	4,9	11,4	3,7	1	4	79,7	74,5	87,7	65,3	78,1	3	M	M	I	x
Bardu, 13 mænd.																						
109	N.	174	15,7	19,2	11,8	14,4	3,0	5,0	11,3	3,4	2	4	81,8	72,0	81,9	60,0	78,5	4	B	I	I	x
110	N.	173	15,6	19,1	12,6	14,3	3,6	4,6	11,8	3,4	3	3	81,7	75,0	88,1	78,3	82,5	4	B	I	Ch	x
111	N.	177	16,0	19,0	13,3	14,0	2,8	5,5	10,8	3,0	1	1	84,2	67,5	95,0	50,9	77,1	4	B	I	I	l

112	G. × S.	170	15,0	19,3	11,8	13,2	3,6	4,8	10,4	3,0	1	2	77,7	69,3	89,4	75,0	78,8	3	B	L	Ch	l
113	S. × G.	170	15,1	19,7	13,2	13,4	3,2	5,4	10,9	3,4	1	1	76,7	72,2	98,5	59,3	81,3	3	M	L	L	l
114	N.	171	15,4	19,0	12,2	14,0	3,4	5,0	11,0	2,6	1	3	81,1	71,4	87,1	68,0	78,6	4	B	M	L	l
115	N. Ø. d.	164	15,2	19,2	11,4	14,1	3,7	4,7	10,7	3,2	2	3	79,2	70,4	80,9	78,7	75,9	1	M	E	Ch	l
116	N.	175	15,8	20,0	12,6	14,6	3,9	5,0	11,4	3,2	1	4	79,0	72,2	86,3	78,0	78,1	4	M	M	Ch	x
117	N.	178	15,0	19,5	12,2	13,6	3,2	5,2	11,0	3,0	1	3	76,9	73,3	89,7	61,5	80,9	4	M	M	L	l
118	N.	173	15,6	19,6	13,4	13,9	3,2	5,2	10,6	3,1	2	4	79,6	68,0	99,4	61,5	79,3	4	M	L	L	x
119	N.	173	15,1	18,7	12,2	13,8	3,6	5,3	11,0	3,2	1	1	80,8	72,9	88,4	67,9	79,7	4	M	L	L	l
120	Ø. × G.	173	14,8	19,4	11,6	13,4	3,6	4,6	10,6	2,7	1	2	76,3	71,6	86,6	78,3	79,1	4	M	M	Ch	l
121	N.	175	15,4	20,5	12,4	14,2	3,7	5,0	11,7	3,4	1	3	75,1	76,0	87,3	74,0	82,4	4	D	M	Ch	l
Lavangen, 17 mænd.																						
122	F. × N.	175	15,4	19,6	13,6	14,0	3,9	5,5	11,1	3,0	2	4	78,6	72,1	97,1	79,9	79,3	4	M	L	Ch	x
123	N.	178	15,0	18,2	12,2	13,0	3,6	5,0	11,2	3,0	1	4	82,1	74,7	93,9	72,0	80,2	4	B	L	Ch	x
124	N.	173	15,2	18,7	12,0	14,2	3,3	4,8	10,4	2,9	2	1	81,3	68,4	84,5	68,8	73,2	4	B	M	L	l
125	S. × N.	167	14,6	18,1	11,7	13,7	3,5	4,7	10,1	3,1	1	1	80,7	69,2	85,4	74,5	73,7	2	M	M	Ch	l
126	N.	173	14,9	19,4	12,2	13,8	3,2	5,0	11,0	3,0	1	4	76,8	73,8	88,4	64,0	79,7	4	M	L	L	x
127	N.	167	15,1	19,2	11,3	11,6	3,6	5,4	10,8	3,0	1	3	78,7	71,5	97,4	66,7	93,1	2	M	L	L	l
128	N.	166	14,4	19,2	11,7	13,1	3,4	5,1	10,4	3,1	1	4	75,0	72,2	89,3	66,7	79,4	2	D	L	L	x
129	N.	167	15,0	17,9	11,5	14,4	3,4	4,6	11,4	3,6	1	4	83,8	71,7	79,9	73,9	79,2	2	B	E	Ch	x
130	N.	168	15,2	18,0	11,9	13,6	3,2	5,2	10,2	2,8	5	4	84,4	67,1	87,5	61,5	75,0	2	B	M	L	m
131	L.	169	15,3	18,0	11,5	13,4	3,6	5,3	11,2	3,2	1	3	85,0	73,2	85,8	67,9	83,6	3	B	M	L	l
132	N.	172	14,6	17,0	9,8	12,7	3,9	4,2	10,2	3,5	1	3	85,9	69,9	77,2	62,9	80,3	4	B	E	Ch	l
133	N.	169	15,2	18,8	11,6	13,9	3,1	4,6	11,2	3,5	1	1	80,9	73,7	83,5	67,4	80,6	3	M	E	L	l
134	S. × N.	171	14,8	18,6	11,6	13,8	3,0	4,8	10,8	2,9	3	3	79,6	73,0	84,1	62,5	78,3	4	M	M	L	x
135	N.	172	15,3	18,6	12,4	14,0	3,4	5,0	10,8	3,0	5	1	82,3	70,6	88,6	68,0	77,1	4	B	L	L	x
136	N.	169	15,0	18,8	12,2	14,2	3,3	4,9	10,7	2,8	2	4	79,8	71,3	85,9	67,4	75,4	3	M	M	L	x
137	N.	169	15,1	18,2	11,9	14,0	3,5	5,2	10,8	3,1	1	3	84,6	70,1	85,0	67,3	77,1	3	B	M	L	l
138	N.	172	16,4	18,8	13,0	14,8	3,6	4,7	11,4	3,3	1	1	87,2	69,5	87,8	76,0	77,0	4	B	M	Ch	l
Ibestad, 41 mænd.																						
139	L.	160	16,6	18,9	11,8	14,6	3,6	4,7	11,0	3,7	2	4	87,8	66,3	89,8	76,6	75,3	1	B	E	Ch	x
140	L.	165	16,3	18,6	11,0	13,5	3,5	4,8	11,2	3,5	2	4	87,6	68,7	88,2	72,9	83,0	1	B	L	Ch	x
141	N.	174	15,9	17,8	12,4	14,6	3,3	4,9	10,7	3,3	1	3	89,3	67,3	88,6	67,4	79,4	4	B	L	L	l
142	N.	178	16,0	18,6	12,0	13,9	3,6	4,6	11,8	3,2	1	1	86,0	73,8	86,3	78,3	84,9	4	B	M	Ch	l
143	N.	177	15,6	18,6	12,4	14,6	3,5	5,4	10,9	3,4	3	5	83,9	69,9	84,9	64,8	74,7	4	B	M	L	m
144	N.	180	16,8	20,0	12,6	14,6	3,5	5,2	11,5	3,4	1	1	84,0	68,5	86,3	67,3	78,8	4	B	M	L	l
145	N.	167	15,6	18,7	12,8	13,8	3,3	5,0	10,6	3,0	2	3	83,4	68,0	92,8	66,0	76,8	2	B	L	L	l
146	N.	173	16,1	19,0	12,2	14,4	3,5	4,8	11,2	3,4	1	1	84,7	69,6	84,7	72,9	77,8	4	B	M	Ch	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Høide	Hode	Ansigt	Næse	Pigment
147	N.	163	16,1	19,7	11,7	13,9	3,5	4,9	10,7	3,0	1	1	81,7	66,5	84,2	71,4	77,0	1	B	M	Ch	l
148	N.	174	15,5	19,0	11,7	13,8	3,6	5,2	11,0	3,2	1	4	81,6	71,0	84,8	66,2	79,7	4	B	M	L	x
149	N.	174	15,7	18,9	12,9	13,9	3,4	5,3	10,9	3,3	1	1	83,1	69,4	92,8	64,2	78,4	4	B	L	L	l
150	N.	171	14,9	19,1	11,5	14,4	3,7	4,4	11,4	3,0	1	3	78,0	76,5	79,9	84,1	79,2	4	M	E	Ch	l
151	N.	173	15,4	19,2	12,2	14,6	3,5	4,0	11,8	3,2	1	1	80,2	76,6	83,6	71,4	80,8	4	M	E	Ch	l
152	L. × N.	166	15,0	19,2	13,1	14,0	3,2	5,0	11,2	3,0	5	4	79,0	74,7	93,6	64,0	80,0	2	M	L	L	m
153	N.	178	14,8	18,8	11,9	13,5	3,7	4,7	11,0	3,0	3	4	78,7	74,3	88,2	78,7	81,5	4	M	L	Ch	m
154	N.	165	15,4	19,4	13,0	14,2	3,4	5,2	11,2	3,4	2	1	79,4	72,7	91,6	65,4	78,0	1	M	L	L	l
155	N.	166	15,0	19,0	12,0	14,2	3,6	4,4	11,7	3,2	1	1	79,0	78,0	84,5	81,8	82,4	2	M	M	Ch	l
156	N.	179	14,6	18,7	12,2	13,6	3,5	5,0	11,2	3,0	1	4	78,1	76,7	89,7	70,0	82,4	4	M	L	Ch	x
157	N.	173	15,4	19,9	13,1	14,3	3,7	5,4	11,5	3,7	1	4	77,4	74,7	91,6	68,5	80,4	4	M	L	L	x
158	N.	186	16,2	20,6	12,6	14,3	3,2	5,0	11,5	3,5	1	1	78,6	71,0	88,1	64,0	80,4	4	M	L	L	l
159	N.	165	14,8	19,4	12,0	13,7	3,6	5,2	11,2	2,8	2	4	76,3	75,7	87,0	66,2	81,8	1	M	M	L	x
160	N.	182	15,9	20,3	12,5	14,4	3,4	5,0	11,4	3,4	1	4	78,3	71,7	86,8	68,0	79,2	4	M	M	L	x
161	L.	167	15,5	17,3	11,0	14,1	3,7	4,7	11,0	3,7	1	3	89,6	71,0	78,0	78,7	78,0	2	B	E	Ch	l
162	L.	164	15,3	18,4	11,6	14,6	3,6	4,8	11,0	3,4	5	5	83,2	71,9	79,5	75,0	75,3	1	B	E	Ch	m
163	N.	164	15,7	18,7	11,4	14,2	3,4	4,0	11,1	3,4	5	5	84,0	72,6	80,3	73,0	80,3	1	B	E	Ch	m
164	N.	166	15,9	19,0	11,3	14,4	3,3	4,8	11,1	3,5	1	3	83,7	71,7	78,5	68,8	79,2	2	B	E	L	l
165	N.	174	16,5	19,6	12,1	14,5	3,6	5,2	11,0	3,7	2	3	84,2	70,3	83,5	66,2	80,0	4	B	E	L	l
166	N.	167	16,2	19,4	11,7	14,2	3,7	4,9	12,0	4,0	1	1	83,5	74,1	82,4	75,5	84,5	2	B	E	Ch	l
167	N.	170	15,0	18,3	11,8	14,0	3,5	4,7	11,2	3,5	2	4	82,0	74,7	84,3	74,5	80,0	3	B	M	Ch	x
168	N.	172	14,6	18,4	12,2	13,0	3,4	5,4	10,5	2,7	1	4	79,4	71,9	93,0	63,0	80,8	4	M	L	L	x
169	N.	169	15,2	19,0	12,6	14,2	3,2	4,9	11,0	3,0	5	5	80,0	70,3	88,7	65,3	81,7	3	M	L	L	m
170	N.	172	15,7	19,2	12,5	14,0	3,4	5,0	11,4	3,2	1	1	81,8	72,6	89,3	68,0	81,4	4	B	L	L	l
171	N.	169	15,5	19,2	13,5	13,8	3,7	5,0	10,8	3,0	1	3	80,7	69,7	97,8	74,0	78,3	3	M	L	Ch	l
172	N.	169	15,7	19,2	12,0	13,6	3,6	4,4	11,3	3,2	1	3	81,8	72,0	88,2	81,8	83,1	3	B	L	Ch	x
173	N.	172	15,4	19,2	12,0	14,6	3,5	5,7	11,2	3,4	1	4	80,2	72,7	82,2	61,4	79,7	4	M	E	L	x

174	N.	168	15,8	20,6	13,2	13,9	3,0	5,4	11,2	3,0	1	3	76,7	70,9	95,0	55,6	80,6	2	M	L	L	l
175	F. × N.	169	15,6	19,3	12,4	14,0	3,6	5,0	11,0	3,5	1	1	80,8	70,5	88,6	72,0	78,6	3	M	L	Ch	l
176	N.	172	16,4	19,5	12,8	14,3	3,6	5,0	11,2	3,9	1	4	84,1	68,3	89,5	72,0	78,3	4	B	L	Ch	x
177	N.	171	15,7	19,3	12,4	15,0	3,7	5,3	12,0	3,6	1	4	81,4	76,4	82,7	69,8	80,0	4	B	E	L	x
178	N.	171	16,5	20,0	12,4	14,7	3,8	4,8	12,0	3,5	5	2	82,5	72,7	84,4	79,2	81,6	4	B	M	Ch	x
179	N.	168	16,4	19,4	12,5	14,2	3,2	4,5	11,7	3,6	1	4	84,5	71,3	88,0	71,1	82,4	2	B	L	Ch	x
Tranøy, 41 mænd.																						
180	N.	181	15,1	19,7	12,4	14,7	3,2	5,2	10,9	3,4	1	3	67,7	72,2	84,4	61,5	74,2	4	D	M	L	l
181	N.	174	15,9	19,4	13,1	14,1	3,3	4,9	10,2	3,0	1	3	82,0	64,2	92,9	67,4	72,3	4	B	L	L	l
182	N.	174	16,4	19,1	12,9	14,9	3,4	5,0	11,5	3,3	1	1	85,9	70,1	86,6	68,0	77,2	4	B	M	L	l
183	N.	165	15,2	19,3	12,0	14,4	3,2	5,0	10,8	3,3	2	1	78,8	71,1	83,3	64,0	75,0	2	M	E	L	l
184	N.	181	15,2	18,9	11,5	14,1	3,4	4,7	10,5	3,0	1	1	80,4	69,1	81,6	72,3	74,5	4	M	E	Ch	l
185	N.	182	15,8	20,1	12,6	14,6	3,7	5,4	11,0	3,2	1	3	78,6	69,6	86,6	68,5	75,3	4	M	M	L	l
186	N.	163	14,8	18,2	11,6	13,8	3,8	4,9	10,6	3,2	1	3	81,3	71,6	84,1	77,6	76,8	1	B	M	Ch	l
187	N.	179	16,0	19,4	12,6	14,7	3,5	5,2	11,0	3,7	2	3	82,5	68,8	85,7	67,3	74,8	4	B	M	L	l
188	N.	177	16,2	19,4	12,6	14,7	3,1	5,2	11,1	3,0	1	4	83,5	68,5	85,7	59,6	75,5	4	B	M	L	x
189	N.	177	15,0	18,5	12,2	14,1	3,2	5,2	10,7	2,9	1	3	81,1	71,3	86,5	61,5	75,9	4	B	M	L	l
190	N.	174	16,4	19,7	12,7	14,5	3,1	5,4	11,4	3,4	1	1	83,3	69,5	87,6	57,4	78,6	4	B	M	L	l
191	N.	164	15,3	18,8	12,2	13,8	3,5	4,9	10,6	3,2	1	1	81,4	69,3	88,4	71,4	76,8	1	B	L	Ch	l
192	N.	166	14,9	17,9	11,7	13,9	3,8	5,0	11,3	3,3	2	4	83,2	75,8	84,2	76,0	81,3	2	B	M	Ch	x
193	N.	176	15,8	19,2	13,2	14,2	3,2	5,4	11,0	3,8	1	4	82,3	69,6	86,6	59,3	77,5	4	B	M	L	x
194	N.	181	15,6	20,0	11,6	14,3	3,7	5,3	12,3	3,6	2	1	78,0	78,9	81,1	69,8	86,0	4	M	E	L	l
195	N.	180	15,4	20,1	12,2	14,4	3,3	5,0	10,8	3,2	1	4	76,6	70,1	84,7	66,0	75,0	4	M	M	L	x
196	N.	180	14,9	19,0	12,0	14,2	3,7	5,0	10,9	2,8	5	3	78,4	73,2	84,5	74,0	76,8	4	M	M	Ch	x
197	N.	167	14,4	18,5	12,1	13,4	3,4	5,0	11,1	2,9	2	3	77,8	77,1	90,3	68,0	82,8	2	M	L	L	l
198	S. × N.	166	15,4	19,6	12,9	13,3	2,8	5,4	10,9	3,3	1	4	78,6	70,8	97,0	51,9	82,0	2	M	L	L	x
199	N.	177	15,0	18,8	12,4	13,1	3,6	5,4	11,0	3,2	1	4	79,8	73,3	94,7	66,7	84,0	4	M	L	L	x
200	N.	162	14,7	19,8	12,1	13,3	3,4	5,0	10,3	3,2	1	3	74,2	70,1	91,0	68,0	77,4	1	D	L	L	l
201	N.	178	15,2	20,0	12,6	13,7	3,5	5,4	11,6	3,0	1	3	76,0	76,3	92,0	64,8	84,7	4	M	L	L	l
202	N.	174	15,5	19,2	11,9	13,6	3,4	5,1	10,6	3,2	2	3	80,7	68,4	87,5	66,7	77,9	4	M	M	L	l
203	N.	175	16,1	20,0	12,3	14,4	3,4	5,1	11,2	2,8	1	3	80,5	69,6	85,4	66,7	77,8	4	M	M	L	l
204	N.	182	15,3	19,1	12,6	14,0	4,0	5,6	11,2	3,2	1	1	80,1	73,2	90,0	71,4	80,0	4	M	L	Ch	l
205	N.	182	15,0	19,4	13,2	14,5	3,9	4,8	11,2	3,3	1	1	77,3	74,7	91,0	79,6	77,2	4	M	L	Ch	l
206	N.	173	15,0	18,5	11,7	14,1	3,3	5,2	10,6	3,2	1	3	81,1	70,7	83,0	63,5	75,5	4	B	E	L	l
207	N.	178	15,6	18,2	11,8	14,9	3,4	4,9	11,8	3,2	1	1	85,7	75,6	79,2	69,4	79,2	4	B	E	L	l
208	N.	166	15,0	17,8	11,6	14,0	3,4	5,1	10,6	3,2	2	4	84,3	70,7	82,9	66,7	75,7	2	B	E	L	x
209	N.	183	16,2	19,5	12,7	15,3	3,7	5,0	11,6	3,7	1	1	83,1	71,6	83,0	74,0	75,8	4	B	E	Ch	l
210	N.	167	15,1	18,6	11,7	14,0	3,4	4,7	10,8	3,6	1	1	81,2	71,5	83,6	72,3	77,1	2	B	E	Ch	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Formel				
																		Høide	Hode	Ansigt	Næse	Pigment
211	N.	175	15,3	18,1	11,1	14,5	3,3	4,5	11,8	3,4	1	3	84,5	77,1	76,6	71,7	81,4	4	B	E	Ch	l
212	N.	171	15,5	19,2	12,4	14,0	3,5	5,4	10,6	3,0	2	3	80,7	68,4	88,6	64,8	75,7	4	M	L	I	l
213	N.	168	15,3	17,9	11,3	14,2	3,3	5,0	10,5	3,2	1	3	85,5	68,6	79,6	66,0	73,9	2	B	E	I	l
214	N.	170	16,1	19,6	12,1	14,0	3,8	5,2	10,5	2,8	2	4	82,1	65,2	86,4	73,1	75,0	3	B	M	Ch	x
215	N.	169	14,3	18,8	12,5	12,5	3,0	4,7	10,3	3,0	4	4	76,1	72,0	100,0	63,8	82,4	3	M	I	L	m
216	N.	171	15,0	18,1	12,0	13,5	3,4	5,0	10,6	2,7	1	1	82,9	70,7	88,9	68,0	78,5	4	B	I	I	l
217	N.	168	15,2	19,2	12,6	13,9	3,5	5,0	10,7	2,9	1	3	79,2	70,4	90,7	70,0	77,0	2	M	L	Ch	l
218	N.	169	15,2	19,6	11,5	13,4	4,1	4,7	10,6	3,4	1	3	77,6	69,7	85,8	87,2	79,1	3	M	M	Ch	l
219	N.	168	15,2	19,8	12,6	13,9	3,2	5,0	11,1	2,9	4	3	76,8	73,0	90,7	64,0	79,9	2	M	I	L	x
220	N.	172	15,6	20,4	12,8	14,5	3,5	5,2	11,1	2,9	1	3	76,5	71,2	88,3	67,3	76,6	4	M	L	I	l
Sørreisa, 2 mænd.																						
221	N.	163	15,2	18,3	11,7	13,7	3,6	4,8	10,4	3,4	1	4	83,1	68,4	85,4	75,0	75,9	1	B	M	Ch	x
222	?	172	15,0	19,2	12,3	14,0	3,2	5,2	10,7	3,6	5	4	78,1	71,3	87,9	61,5	76,4	4	M	M	L	m
Dyrøy, 23 mænd.																						
223	N.	171	16,0	18,7	11,7	14,5	3,5	5,0	11,0	3,7	2	3	85,6	68,8	80,7	70,0	75,9	4	B	F	Ch	l
224	N.	174	14,8	17,5	12,4	14,0	3,3	5,4	10,5	3,1	2	4	84,6	71,0	88,6	61,1	75,0	4	B	I	I	x
225	S. × N.	160	14,5	19,0	10,5	12,7	3,3	4,3	10,9	3,6	2	1	76,3	75,2	82,7	76,7	85,8	1	M	F	Ch	l
226	N.	163	14,7	18,2	11,0	13,2	2,7	4,7	10,5	3,0	1	1	80,8	71,4	83,3	57,5	79,6	1	M	F	I	l
227	N.	176	15,3	18,9	11,5	13,7	3,5	5,0	11,4	3,5	1	4	80,9	74,5	83,9	70,0	83,2	4	M	F	Ch	x
228	N.	179	15,2	19,2	11,1	14,1	3,0	4,8	11,2	3,0	1	3	80,0	73,7	78,7	62,5	79,4	4	M	F	I	l
229	N.	176	15,9	19,7	12,0	15,2	3,7	4,7	11,2	3,4	1	4	80,7	70,4	78,9	78,7	73,7	4	M	F	Ch	x
230	N.	178	15,6	19,8	12,2	14,2	3,4	5,2	11,0	3,3	4	4	78,8	70,5	85,9	65,4	77,5	4	M	M	I	m
231	N.	175	14,7	18,8	13,2	13,8	3,2	5,3	11,2	3,0	2	5	78,2	76,2	95,6	60,4	81,2	4	M	I	I	x
232	N.	173	15,7	20,2	12,9	14,6	3,5	5,4	11,6	3,6	1	4	77,7	73,9	88,4	64,8	79,5	4	M	L	L	x
233	N.	178	14,4	18,5	12,0	14,0	3,8	4,8	10,6	3,5	1	1	77,8	73,6	85,7	79,2	75,7	4	M	M	Ch	l

234	N.	177	15,0	19,0	12,6	14,2	3,6	5,4	11,4	3,7	1	4	79,0	76,0	88,7	66,7	80,3	4	M	L	L x
235	N.	175	15,4	20,0	13,2	13,4	3,3	5,5	10,8	3,3	1	1	77,0	70,1	98,5	60,0	80,6	4	M	L	L l
236	N.	175	15,9	18,4	12,2	14,8	3,5	5,6	12,2	3,3	1	3	86,4	76,2	82,4	62,5	82,4	4	B	E	L l
237	N.	166	15,5	18,3	11,2	13,8	3,3	4,8	11,4	3,4	1	1	84,7	73,6	81,2	68,8	82,6	2	B	E	L l
238	N.	161	15,7	18,3	12,1	14,8	3,6	4,8	11,6	3,6	1	3	85,8	73,9	81,8	75,0	78,5	1	B	E	Ch l
239	N.	175	15,9	19,5	13,0	14,4	3,4	5,2	11,4	3,4	5	4	81,5	71,7	90,3	65,4	79,2	4	B	L	L m
240	N.	172	14,4	19,2	11,9	13,1	3,4	5,4	10,7	2,8	1	1	75,0	74,3	90,8	63,0	81,7	4	D	L	L l
241	N.	169	14,9	18,2	11,6	13,5	3,2	4,6	11,0	3,4	1	3	81,9	73,8	85,9	69,6	81,5	3	B	M	L l
242	N.	170	14,7	18,2	11,8	13,5	4,0	4,5	10,7	3,2	1	1	80,8	72,8	87,4	88,9	79,3	3	M	M	Ch l
243	N.	170	14,5	18,5	12,1	13,2	3,3	5,0	10,4	3,0	2	4	78,4	71,7	90,9	66,0	78,8	3	M	L	L x
244	N.	170	14,8	19,6	11,9	13,6	3,0	5,0	11,0	3,0	3	3	75,5	74,3	87,5	60,0	80,9	3	D	M	L l
245	N.	171	15,0	19,4	12,8	13,9	3,5	5,0	10,5	3,0	1	4	77,3	70,0	92,1	70,0	75,5	4	M	L	Ch x
Berg, 8 mænd.																					
246	N.	175	16,1	19,5	11,7	14,4	3,3	5,0	11,2	3,2	4	5	82,6	69,6	81,3	66,0	77,8	4	B	E	L m
247	N.	177	16,4	18,8	13,6	14,6	3,3	5,5	11,1	3,4	1	3	87,2	67,7	93,2	60,0	76,0	4	B	L	L l
248	N.	164	15,6	19,6	11,8	14,4	3,6	5,0	11,0	3,1	2	4	79,6	70,5	81,9	72,0	76,4	1	M	E	Ch x
249	N.	160	15,5	18,2	13,0	13,2	3,0	5,5	10,7	3,0	1	4	85,2	69,0	98,5	54,6	81,1	1	B	L	L x
250	N.	179	15,8	20,2	13,0	15,2	3,6	5,2	12,2	3,4	1	3	78,2	77,2	85,6	69,2	80,3	4	M	M	L l
251	N.	179	14,7	18,6	12,8	13,8	3,4	5,6	10,6	2,8	4	4	79,0	72,1	92,8	60,7	76,8	4	M	L	L m
252	N.	163	15,0	20,0	12,0	13,9	3,2	5,4	10,9	3,1	1	3	75,0	72,7	86,3	59,3	78,4	1	D	M	L l
253	N.	168	15,5	18,4	11,0	14,0	3,4	4,9	11,2	3,2	5	4	84,2	72,3	78,6	69,4	80,0	2	B	E	L m
Torsken, 9 mænd.																					
254	N.	174	15,9	18,6	12,0	13,7	3,0	5,4	11,1	3,2	4	3	85,5	69,8	87,6	55,6	81,0	4	B	M	L x
255	N.	176	16.1	19,4	12,0	14,6	3,6	4,6	11,3	3,4	1	4	83,0	70,2	82,2	78,3	77,4	4	B	E	Ch x
256	N.	166	15,8	19,4	12,0	14,6	3,8	5,0	11,2	3,3	2	3	81,4	70,9	82,2	76,0	76,7	2	B	E	Ch l
257	N.	166	15,4	18,8	12,2	13,9	3,5	4,7	10,6	3,3	1	3	81,9	68,8	87,8	74,5	76,3	2	B	M	Ch l
258	N.	165	14,5	18,6	12,2	13,5	3,4	5,2	10,1	2,8	3	4	78,0	69,7	90,4	65,4	74,8	1	M	L	L m
259	N.	156	14,6	19,0	11,8	13,9	3,4	4,7	11,2	3,1	2	3	76,8	76,7	84,9	72,3	80,6	1	M	M	Ch l
260	N.	166	14,8	19,2	11,5	13,3	3,5	4,6	11,0	3,3	1	4	77,1	74,3	86,5	76,1	82,7	2	M	M	Ch x
261	N.	164	15,3	17,8	11,0	13,7	3,5	4,8	10,6	3,2	1	4	86,0	69,3	80,3	72,9	77,4	2	B	E	Ch x
262	N.	168	16,2	18,4	11,6	14,4	3,3	4,4	10,9	3,2	4	3	88,0	67,3	80,6	75,0	75,7	2	B	E	Ch x
Lenvik, 33 mænd.																					
263	N.	187	14,7	19,3	12,2	13,8	3,2	5,1	11,2	3,0	1	1	76,2	76,2	88,4	62,8	81,2	4	M	L	L l
264	N.	167	15,6	18,3	11,4	13,5	3,0	4,8	11,1	3,1	2	3	85,3	71,2	84,4	62,5	82,2	2	B	M	L l
265	N.	176	16,1	19,8	12,8	14,4	3,5	5,5	11,7	3,1	2	4	81,3	72,7	88,9	63,6	81,3	4	B	L	L x
266	N.	166	15,6	19,2	12,5	13,5	3,0	5,4	10,9	2,9	1	5	81,3	69,9	92,6	55,6	80,7	2	B	L	L x

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	10				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Formel: Høide	Hode	Ansigt	Næse	Pigment
267	N.	167	15,2	18,7	12,4	14,2	3,2	4,8	11,0	2,6	2	4	81,3	72,4	87,4	66,7	77,5	2	B	M	L	x
268	N.	163	16,3	19,4	12,2	14,3	3,6	5,0	11,0	3,0	1	1	84,0	67,5	85,3	72,0	76,9	1	B	M	Ch	l
269	N.	173	16,2	19,6	12,1	14,2	3,3	4,9	11,0	3,0	1	4	82,7	67,9	85,2	67,4	77,5	4	B	M	L	x
270	N.	167	15,4	18,8	12,0	13,5	3,4	4,8	11,1	3,1	1	4	81,9	72,1	88,9	70,8	82,2	2	B	L	Ch	x
271	N.	175	15,9	20,2	12,3	15,2	3,8	4,8	11,2	3,7	1	4	78,7	70,4	80,9	79,2	73,7	4	M	E	Ch	x
272	N.	182	15,8	20,0	12,4	14,8	3,3	4,6	11,6	2,9	1	1	79,0	73,4	83,8	71,7	78,4	4	M	E	Ch	l
273	N.	162	15,5	19,3	12,1	14,6	3,2	4,6	10,8	3,0	1	4	80,3	69,7	82,9	69,6	74,0	1	M	F	L	x
274	N.	165	14,4	19,0	11,6	13,3	3,4	4,7	10,6	3,0	5	5	75,8	73,6	86,5	72,3	79,7	1	D	M	Ch	m
275	N.	177	15,2	20,4	13,0	14,1	3,3	5,3	11,4	3,5	5	4	74,5	75,0	92,2	62,3	80,0	4	D	L	L	m
276	N.	178	15,6	19,6	13,2	14,0	3,7	5,2	11,4	3,4	3	5	79,6	73,1	94,3	71,2	81,4	4	M	L	Ch	m
277	N.	174	14,7	19,0	12,4	13,4	3,2	4,6	10,9	2,9	3	3	77,4	74,2	92,5	69,6	81,3	4	M	L	L	x
278	N.	164	14,8	19,1	11,7	13,5	3,5	4,5	10,8	3,2	1	3	77,5	73,0	86,7	77,8	80,0	1	M	M	Ch	l
279	N.	174	14,6	19,5	12,5	14,0	4,0	5,0	11,0	3,2	1	3	74,9	75,3	89,3	80,0	78,6	4	D	L	Ch	l
280	N.	173	15,1	19,0	11,6	13,8	3,2	4,9	10,6	2,9	1	4	79,5	70,2	84,1	65,3	76,8	4	M	M	L	x
281	N.	177	15,4	19,4	13,0	14,2	3,4	5,2	11,2	3,5	1	3	79,4	72,7	91,6	65,4	78,9	4	M	L	L	l
282	N.	166	15,3	19,8	12,2	13,6.	3,0	4,6	11,0	3,3	1	1	77,3	71,9	89,7	65,2	80,9	2	M	L	L	l
283	N.	160	15,0	19,0	11,6	13,4	3,3	5,4	10,7	3,6	2	3	79,0	71,3	86,6	61,1	79,9	1	M	M	L	l
284	N.	174	15,7	18,0	12,1	14,2	3,4	4,5	11,7	3,3	4	4	87,2	74,5	85,2	75,6	82,4	4	B	M	Ch	m
285	N.	166	15,6	18,6	11,4	13,6	3,2	4,8	11,2	3,1	1	2	83,9	71,8	83,8	66,7	82,4	2	B	E	L	l
286	N.	171	14,8	18,6	11,5	13,5	3,6	4,2	10,6	3,2	2	3	79,6	71,6	85,2	85,7	78,5	4	M	M	Ch	l
287	N.	168	14,4	19,1	11,4	13,8	3,5	4,9	11,4	3,3	1	1	75,4	79,2	82,6	71,4	82,6	2	D	E	Ch	l
288	N.	169	15,3	18,6	11,8	14,2	3,7	4,7	10,9	3,0	1	4	82,3	71,2	83,1	78,7	76,8	3	B	E	Ch	x
289	N.	171	15,0	20,1	12,6	14,4	3,8	5,0	11,4	3,6	1	3	74,6	76,0	87,6	76,0	79,2	4	D	M	Ch	l
290	N.	172	15,6	19,0	12,8	14,0	3,6	5,2	11,5	3,1	1	3	82,1	73,7	91,4	69,2	82,1	4	B	L	L	l
291	N.	171	15,8	19,8	12,4	14,4	3,6	5,4	11,8	3,7	2	4	79,8	74,7	86,1	66,7	81,0	4	M	M	L	x
292	N.	168	15,9	20,0	12,7	14,7	3,6	5,4	11,2	3,6	1	1	79,5	70,4	86,4	66,7	76,2	2	M	M	L	l
293	N. × L.	170	16,0	19,6	12,0	15,1	3,2	4,9	11,6	3,6	4	4	81,6	73,0	79,0	65,3	76,2	3	B	E	L	m

294	N.	172	16,3	19,9	12,8	15,2	3,2	5,2	11,6	3,8	3	4	81,9	67,5	84,2	61,5	76,3	4	B	M	L	m
295	N.	171	15,0	19,2	11,3	13,6	3,3	4,7	10,7	3,3	1	5	78,1	71,3	83,1	70,2	78,2	4	M	E	Ch	x
Hillesøy, 5 mænd.																						
296	N.	168	15,8	19,6	12,2	14,4	3,7	4,8	11,0	3,6	1	3	80,6	69,6	84,7	77,1	76,4	2	M	M	Ch	l
297	N.	159	15,3	19,4	10,8	13,0	3,2	4,4	10,4	3,2	3	3	78,9	68,0	83,1	72,7	80,0	1	M	E	Ch	x
298	K. × L.	159	14,0	18,4	11,2	14,6	3,2	4,6	11,1	3,5	3	5	79,9	75,5	76,7	69,6	76,0	1	M	E	L	m
299	N.	173	15,2	18,8	12,0	14,0	3,4	5,4	10,8	3,2	1	4	80,9	71,1	85,7	63,0	77,1	4	M	M	L	x
300	N.	179	15,5	19,4	13,4	13,3	3,3	5,7	10,4	2,8	2	1	79,9	67,1	100,8	57,8	78,2	4	M	L	L	l
Maalselv, 43 mænd.																						
301	N.	160	15,0	18,5	11,6	13,8	3,5	4,5	10,7	2,8	1	1	81,1	71,3	84,1	77,8	77,5	1	B	M	Ch	l
302	N.	185	15,2	18,6	12,4	14,2	3,4	5,4	11,0	3,4	2	3	81,7	72,4	87,3	68,0	77,5	4	B	M	L	l
303	N.	167	15,4	19,0	12,8	14,0	3,5	5,5	10,6	3,3	2	3	81,1	68,8	91,4	63,6	75,7	2	B	L	L	l
304	N.	174	15,2	20,1	11,6	14,0	3,8	5,0	10,6	3,4	1	3	75,6	69,7	82,9	76,0	75,7	4	D	E	Ch	l
305	N.	176	15,2	19,6	12,9	14,0	3,5	4,6	10,9	3,3	4	5	77,6	71,7	92,1	76,1	77,9	4	M	L	Ch	m
306	S. × N.	176	16,0	20,0	12,8	14,4	3,5	5,0	11,1	3,2	1	3	80,0	69,4	88,9	70,0	77,1	4	M	L	Ch	l
307	N.	179	15,2	19,9	13,5	14,0	3,5	5,0	11,4	3,4	1	3	76,4	75,0	96,4	70,0	81,4	4	M	L	Ch	l
308	N.	175	15,4	19,4	13,2	14,3	3,0	5,2	11,2	2,8	2	3	79,4	72,7	92,3	57,7	78,3	4	M	L	L	l
309	N.	180	16,0	20,8	13,2	13,6	3,7	5,4	10,9	3,2	1	4	76,9	68,1	97,1	68,5	80,2	4	M	L	L	x
310	N.	166	15,4	19,1	12,6	13,6	3,6	5,0	10,6	2,9	1	2	80,6	68,8	92,7	72,0	77,9	2	M	L	Ch	l
311	N.	166	14,8	18,9	12,2	13,5	3,4	5,0	11,4	3,0	2	5	78,3	77,0	90,4	68,0	84,4	2	M	L	L	x
312	N.	163	14,7	19,4	12,0	14,0	3,2	5,0	11,2	3,2	1	1	75,8	76,2	85,7	64,0	80,0	1	D	M	L	l
313	N.	173	15,2	19,1	12,5	13,4	3,4	5,2	11,0	3,0	1	1	79,6	72,4	93,3	65,4	82,1	4	M	L	L	l
314	N.	171	15,2	18,6	11,6	14,0	3,2	5,0	11,0	3,2	2	3	81,7	72,4	82,9	64,0	78,6	4	B	E	L	l
315	N.	169	15,0	19,5	11,9	14,0	3,7	4,6	10,3	3,2	1	3	76,9	68,9	85,0	80,4	73,6	3	M	M	Ch	l
316	N.	168	14,6	19,6	12,0	12,5	3,2	4,8	10,4	3,0	3	4	74,5	71,2	96,0	66,7	83,2	2	D	L	L	x
317	N.	171	15,4	18,7	12,1	13,5	3,8	5,2	10,9	3,2	1	1	82,4	70,8	89,6	73,1	80,7	4	B	L	Ch	l
318	N.	171	15,4	18,6	12,0	14,4	3,3	4,9	11,0	3,2	1	3	82,8	71,4	83,3	67,4	76,4	4	B	E	L	l
319	N.	171	15,7	19,5	11,7	14,3	3,5	5,0	11,2	3,7	2	4	80,5	71,3	81,8	70,0	78,3	4	M	E	Ch	x
320	N.	169	15,8	19,8	12,0	14,4	3,6	4,6	11,3	3,5	2	3	79,8	71,5	83,3	78,3	78,5	3	M	L	Ch	l
321	S. × N.	172	15,6	19,7	12,2	14,0	3,4	5,0	10,6	3,5	1	3	79,2	68,0	87,1	68,0	75,7	4	M	M	L	l
322	N.	168	15,9	20,2	12,3	13,6	3,3	5,0	11,0	3,1	1	4	78,7	69,2	90,4	66,0	80,9	2	M	L	L	x
323	N.	171	16,2	20,4	12,8	14,8	3,3	5,5	12,0	3,8	1	1	79,4	74,1	86,5	60,0	81,1	4	M	M	L	l
Balsfjord, 34 mænd.																						
324	N.	175	15,8	20,4	13,4	14,4	3,5	5,4	11,6	3,5	1	3	77,5	73,4	93,1	64,8	80,6	4	M	L	L	l
325	N.	166	15,2	19,2	12,4	13,6	3,6	4,8	10,7	3,3	1	4	79,2	70,4	91,2	75,0	78,7	2	M	L	Ch	x
326	L. × N.	161	15,8	18,9	11,8	14,4	3,5	4,9	11,2	3,2	2	3	83,6	70,9	81,9	71,4	77,8	1	B	E	Ch	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Høide	Hode	Ansigt	Næse	Pigment
327	N.	175	15,6	19,2	11,7	14,6	3,6	4,8	11,0	3,2	4	3	81,3	70,5	80,1	75,0	75,3	4	B	E	Ch	x
328	N.	166	16,2	19,1	11,7	14,4	3,7	5,2	11,3	3,4	4	5	84,8	69,8	81,3	71,2	78,5	2	B	E	Ch	m
329	N.	161	15,8	19,2	12,9	13,8	3,5	5,6	10,5	3,1	3	4	82,3	66,5	93,5	62,5	76,1	1	B	L	L	m
330	N.	175	15,8	19,4	13,2	14,2	3,2	5,4	11,3	3,2	1	3	81,4	71,5	93,0	59,3	79,0	4	B	L	L	l
331	N.	175	15,7	18,8	13,4	14,1	3,1	5,6	11,4	3,1	1	3	83,5	72,6	95,0	55,4	80,0	4	B	L	L	l
332	N.	175	16,4	19,2	12,4	14,6	3,9	6,0	11,0	3,2	2	4	85,4	67,1	84,9	65,0	75,3	4	B	M	L	x
333	N.	173	16,7	19,6	12,5	13,8	3,6	5,2	11,7	3,9	2	2	85,2	70,1	90,6	69,2	84,8	4	B	L	L	l
334	N.	174	15,7	18,7	11,8	13,9	3,6	5,0	10,9	3,3	1	3	84,0	69,4	84,9	72,0	78,4	4	B	M	Ch	l
335	N.	164	15,1	18,3	12,1	14,4	3,7	5,0	10,7	3,1	1	3	82,5	70,9	84,0	74,0	74,3	1	B	M	Ch	l
336	N.	167	15,3	19,4	11,2	13,4	3,2	4,5	10,5	3,5	1	4	78,9	68,6	83,6	71,1	78,4	2	M	E	Ch	x
337	N.	175	15,8	19,0	12,3	14,4	2,8	5,6	11,0	3,2	2	3	83,2	69,6	85,4	50,0	70,4	4	B	M	L	l
338	N.	180	15,3	19,4	11,8	15,0	3,8	4,4	11,4	3,4	1	1	78,0	74,5	78,7	86,4	70,0	4	M	E	Ch	l
339	N.	173	15,3	19,1	11,4	14,2	2,8	4,9	10,5	3,0	2	3	80,1	68,6	80,3	57,1	73,9	4	M	E	L	l
340	N.	179	15,5	19,4	11,9	14,3	3,5	4,7	11,2	3,1	1	1	79,9	72,3	83,2	74,5	78,3	4	M	E	Ch	l
341	N.	186	15,7	19,8	12,8	14,4	3,4	5,0	10,7	3,6	3	3	79,3	68,2	88,0	68,0	74,3	4	M	L	L	x
342	N.	166	15,5	19,3	11,8	13,8	3,8	4,6	11,2	3,4	1	4	80,3	72,3	85,5	82,0	81,2	2	M	M	Ch	x
343	N.	175	14,1	18,4	11,6	13,3	3,6	4,6	10,4	3,0	1	2	76,6	73,8	87,2	78,3	78,2	4	M	M	Ch	l
344	N.	184	15,6	20,3	13,0	14,2	3,4	5,5	11,4	3,1	2	4	76,9	73,1	91,5	61,8	80,3	4	M	L	L	x
345	N.	176	15,4	20,2	13,8	15,1	3,4	6,2	11,9	3,5	2	4	76,2	77,3	91,4	54,8	78,8	4	M	L	L	x
346	N.	179	15,1	19,3	12,9	14,3	3,0	5,5	11,6	3,3	1	4	78,2	76,8	90,2	54,6	81,1	4	M	L	L	x
347	N.	178	15,2	19,6	13,0	14,5	3,5	5,0	11,1	3,3	2	3	77,6	73,0	80,7	70,0	76,6	4	M	L	Ch	l
348	N.	167	14,7	19,3	11,8	12,9	3,6	4,8	10,7	3,3	2	3	76,2	72,8	84,0	75,0	77,0	2	M	M	Ch	l
349	N.	176	15,0	18,6	11,8	13,4	3,4	4,9	10,9	3,3	1	3	80,7	72,7	88,1	60,4	81,3	4	M	L	L	l
350	N.	174	15,0	19,0	12,7	13,4	3,2	5,0	10,9	3,2	1	4	79,0	72,7	94,8	64,0	81,3	4	M	L	L	x
351	N.	170	14,9	18,9	11,6	14,0	3,3	4,7	10,9	3,5	2	1	78,9	73,2	82,9	70,2	77,9	3	M	E	Ch	l
352	N.	171	15,2	18,2	13,4	13,8	3,4	4,8	10,2	3,2	1	1	83,5	67,1	97,1	70,8	73,0	4	B	L	Ch	l
353	N.	169	15,0	19,3	12,9	13,8	3,5	4,9	11,0	3,2	1	1	77,7	73,3	93,5	71,4	79,7	3	M	L	Ch	l

354	N.	171	15,4	18,6	13,0	13,5	3,5	5,3	11,4	3,6	1	4	82,8	74,0	96,3	66,0	84,4	4	B	L	L	x
355	N.	172	15,4	19,2	12,2	15,4	4,0	5,4	11,6	3,8	1	4	80,2	75,3	79,2	74,1	75,3	4	M	E	Ch	x
356	N.	171	15,4	18,9	12,6	14,2	3,6	5,4	11,2	3,0	1	1	81,5	72,7	88,7	66,7	78,9	4	B	L	L	l
357	N.	170	15,4	19,8	11,7	14,1	3,7	5,2	11,2	3,3	1	1	77,8	72,7	83,0	71,2	79,4	3	M	E	Ch	l
Malangen, 28 mænd.																						
358	N.	170	14,4	19,7	12,4	13,8	3,4	5,2	10,4	3,2	1	1	73,1	72,2	89,9	65,4	75,4	3	D	L	L	l
359	S. × N.	175	16,7	20,5	12,8	14,9	3,5	4,9	11,8	3,7	1	4	85,5	70,7	85,9	71,4	79,2	4	B	M	Ch	x
360	N.	166	15,6	18,2	11,9	13,6	3,6	4,7	10,4	3,1	1	1	85,7	66,7	87,5	76,6	76,5	2	B	M	Ch	l
361	N.	174	15,7	18,4	12,8	14,2	3,3	5,0	11,0	3,2	2	3	85,3	70,1	86,6	66,0	77,5	4	B	M	L	l
362	N.	167	15,7	18,4	12,0	14,3	3,7	4,7	10,8	3,7	1	4	85,3	68,8	88,1	78,7	75,5	2	B	L	Ch	x
363	N.	176	14,8	17,5	12,2	13,3	3,1	5,0	10,2	2,8	1	3	84,6	68,9	91,7	62,0	76,2	4	B	L	L	l
364	N.	167	15,4	19,0	11,9	13,5	3,5	4,7	10,6	3,2	1	3	81,1	68,8	88,2	74,5	78,5	2	B	L	Ch	l
365	N.	174	15,2	18,5	12,6	14,0	3,3	5,5	10,0	3,1	1	4	82,2	65,8	90,0	60,0	71,4	4	B	L	L	x
366	N.	162	14,9	19,2	11,5	13,7	3,0	4,8	11,0	3,2	1	1	77,6	73,8	83,9	62,5	80,3	1	M	E	L	l
367	N.	167	15,5	19,8	11,8	14,4	3,6	4,6	11,4	3,4	1	4	78,3	73,6	81,9	78,3	79,2	2	M	E	Ch	x
368	N.	166	16,7	21,0	11,9	14,4	3,4	4,6	11,2	3,1	1	1	79,5	67,1	82,6	73,9	77,8	2	M	E	Ch	l
369	N.	175	15,2	19,1	11,8	14,3	3,5	4,6	11,4	3,5	1	1	79,6	75,0	82,5	76,1	79,7	4	M	E	Ch	l
370	N.	185	15,8	20,0	12,5	14,2	3,6	4,5	11,2	3,6	4	5	79,0	70,9	88,0	80,0	78,9	4	M	L	Ch	m
371	N.	173	16,0	20,0	12,5	14,6	3,5	5,6	11,2	3,2	1	3	80,0	70,0	85,6	62,5	76,7	4	M	M	L	l
372	N.	164	14,7	18,6	12,0	14,0	3,2	5,0	10,6	3,0	1	3	79,0	72,1	85,7	64,0	75,7	1	M	M	L	l
373	N.	180	14,7	19,8	12,6	13,5	3,5	5,2	10,9	3,4	1	3	74,2	74,2	93,3	67,3	80,7	4	D	L	L	l
374	N.	170	15,1	19,3	11,6	13,8	3,5	4,6	10,8	3,1	1	4	78,2	71,5	84,1	76,1	78,3	4	M	M	Ch	x
375	N.	162	14,6	19,0	12,6	13,0	3,4	5,7	10,2	3,2	1	3	76,8	69,9	96,9	59,7	78,5	1	M	L	L	l
376	N.	176	15,8	19,0	11,2	14,6	3,4	4,6	11,3	3,4	1	3	83,2	71,5	76,7	73,9	77,4	4	B	E	Ch	l
377	N.	174	16,0	18,8	12,0	14,5	3,7	4,9	11,2	3,7	1	1	85,1	70,0	82,8	75,5	77,2	4	B	E	Ch	l
378	N.	166	15,8	19,2	11,8	14,4	3,4	5,0	11,2	3,4	2	3	82,3	70,9	81,9	68,0	77,8	2	B	E	L	l
379	N.	169	14,8	19,0	11,6	13,0	3,4	4,9	10,6	3,3	2	4	77,9	71,6	89,2	69,4	81,5	3	M	L	L	x
380	N.	172	15,0	18,5	11,7	13,5	3,6	4,7	10,8	3,4	1	4	81,1	72,0	86,7	76,6	80,0	4	B	M	Ch	x
381	N.	172	15,0	17,9	11,8	13,6	3,0	5,0	11,0	3,0	1	1	83,8	73,3	86,8	60,0	80,9	4	B	M	L	l
382	N.	169	15,0	19,5	11,6	13,7	3,5	5,0	10,8	3,2	2	1	76,9	72,0	84,7	70,0	78,8	3	M	M	Ch	l
383	N.	169	16,0	18,2	10,9	13,7	3,2	4,7	10,4	2,8	1	4	87,9	65,0	79,6	68,1	75,9	3	B	E	L	x
384	N.	171	15,7	19,1	12,3	13,8	3,2	5,2	10,8	2,9	3	3	82,2	68,8	80,1	65,5	78,3	4	B	L	L	x
385	N.	170	15,4	18,2	12,2	14,3	3,5	5,3	11,4	3,4	1	3	84,6	74,0	85,3	66,0	79,7	3	B	M	L	l
Tromsøysund, 46 mænd.																						
386	N.	168	15,4	19,3	11,1	13,6	3,2	4,7	10,4	2,5	3	4	79,8	67,5	81,6	68,1	76,5	2	M	E	L	m
387	N.	170	16,1	19,6	11,9	14,2	3,4	5,4	11,2	2,8	1	1	82,1	69,6	83,8	63,0	78,9	3	B	E	L	l
388	N.	172	16,0	19,4	11,8	14,3	3,2	4,8	10,8	3,0	1	3	82,5	67,1	82,5	66,7	75,5	4	B	E	L	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
Løpe-no.	Herkomst	Legemshoide	Hodets bredde	Hodets længde	Ansigtshoide	Ansigtsbredde	Næsens bredde	Næsens hoide	Pandebredde	Indre oienvinkelavstand	Oienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Formel				
																		Hoide	Hode	Ansigt	Næse	Pigment
389	N.	169	15,4	19,6	12,0	14,3	3,5	4,9	11,2	3,6	1	2	78,6	72,7	83,9	71,4	78,3	3	M	E	Ch	l
390	N.	172	16,5	20,9	12,0	15,2	3,4	4,5	12,2	3,8	1	1	79,0	73,9	79,0	75,6	80,3	4	M	E	Ch	l
391	N.	170	15,6	19,4	12,5	15,0	3,5	5,2	10,9	3,3	1	4	80,4	69,9	83,3	67,3	72,7	3	M	E	L	x
392	N.	171	14,7	18,5	11,5	14,0	3,6	4,1	11,2	3,3	1	1	79,5	76,2	82,1	87,8	80,0	4	M	E	Ch	l
393	N.	170	14,9	18,5	11,4	13,4	3,4	4,6	10,8	2,9	1	4	80,5	72,5	85,1	73,9	80,6	3	M	M	Ch	x
394	N.	171	15,0	18,4	12,6	13,9	3,6	5,1	11,0	3,2	3	4	81,5	73,3	90,7	70,6	79,1	4	B	L	Ch	m
395	N.	168	14,8	18,6	12,2	13,3	3,4	5,6	10,4	3,1	4	4	79,6	70,3	91,7	60,7	78,2	2	M	L	L	m
396	N.	168	15,0	18,7	12,3	14,2	3,4	5,6	11,0	3,5	1	1	80,2	73,3	86,6	60,7	77,5	2	M	M	L	l
397	N.	172	15,8	18,7	11,5	13,4	3,9	5,6	10,8	3,2	2	1	84,5	68,4	85,8	69,6	80,6	4	B	M	L	l
398	N.	169	15,7	18,5	11,6	14,2	3,4	5,0	11,2	3,4	3	4	84,9	71,3	81,7	68,0	78,9	3	B	E	L	m
399	N.	170	15,4	18,2	12,2	14,0	3,3	4,8	11,2	3,2	2	3	84,6	72,7	87,1	68,8	80,0	3	B	M	L	l
400	N.	168	15,8	17,8	12,6	14,0	3,5	5,2	11,0	2,8	2	3	88,8	69,6	90,0	67,3	78,6	2	B	L	L	l
401	N.	170	15,5	18,4	12,5	14,8	3,6	5,0	11,0	3,5	2	4	84,2	71,0	84,5	72,0	74,3	3	B	M	Ch	x
402	N.	178	15,6	19,6	12,4	14,1	3,4	5,0	11,1	2,9	3	4	79,6	71,2	87,9	68,0	78,7	4	M	M	L	m
403	F.	157	14,0	17,3	11,7	12,7	3,3	4,9	10,6	3,5	1	1	80,9	75,7	88,2	67,4	83,5	1	M	L	L	l
404	N.	178	15,4	19,4	13,8	14,0	3,0	5,4	11,3	3,3	1	5	79,4	73,4	98,6	55,6	80,7	4	M	L	L	x
405	N.	166	14,5	19,2	12,0	13,5	3,5	5,0	11,2	3,3	2	3	75,5	77,2	89,9	70,0	83,0	2	D	L	Ch	l
406	N.	160	14,5	19,4	11,9	12,7	2,8	4,8	10,6	3,3	2	3	74,7	73,1	93,7	58,3	83,5	1	D	L	L	l
407	N.	173	15,0	19,8	12,6	14,0	3,3	5,5	11,2	3,0	1	3	75,8	74,7	90,0	60,0	80,0	4	D	L	L	l
408	N.	163	15,0	20,2	11,4	13,3	3,5	4,5	11,4	3,0	2	3	74,3	76,0	85,7	77,8	85,7	1	D	M	Ch	l
409	N.	165	15,4	19,1	12,1	14,0	3,4	5,0	11,0	3,1	2	4	80,6	71,4	86,4	68,0	78,0	1	M	M	L	x
410	N.	161	15,0	17,2	10,5	13,6	3,4	4,1	11,4	3,4	2	4	87,2	76,0	77,2	82,9	83,8	1	B	E	Ch	x
411	N.	184	16,1	18,7	12,2	13,9	3,4	5,2	11,2	3,2	2	3	86,1	69,6	87,8	65,4	80,6	4	B	M	L	l
412	N.	176	15,2	19,1	11,5	13,8	3,5	5,0	10,9	2,9	1	4	79,6	71,7	83,3	70,0	79,0	4	M	E	Ch	x
413	N.	173	15,4	19,8	12,3	14,8	3,1	5,0	11,2	3,8	1	3	78,8	72,7	83,7	62,0	76,2	4	M	E	L	l
414	N.	163	15,	18,8	11,4	13,6	3,4	4,7	10,9	3,4	1	3	79,8	72,7	83,8	72,3	80,2	1	M	E	Ch	l
415	N.	176	15,1	19,8	11,8	14,2	3,4	5,4	11,7	3,4	1	3	76,3	77,5	83,1	63,0	82,4	4	M	E	L	l

416	N.	166	14,4	18,6	11,2	13,4	3,2	5,0	10,6	3,0	2	3	77,4	73,6	83,6	64,0	70,1	2	M	E	L	l
417	N.	181	15,5	19,6	11,8	14,6	3,4	4,6	11,4	3,6	2	4	79,1	73,1	80,8	73,9	78,1	4	M	E	Ch	x
418	N.	178	14,7	18,2	11,7	14,3	3,2	5,3	10,4	3,0	1	1	80,8	70,8	81,8	66,4	72,7	4	M	E	L	l
419	N.	162	14,6	19,2	13,0	13,8	3,2	5,4	11,0	3,1	3	3	76,0	75,3	94,2	59,3	79,7	1	M	L	L	x
420	N.	167	15,4	18,5	12,1	14,1	3,4	5,2	11,1	3,0	1	5	83,2	72,1	85,8	65,4	78,7	2	B	M	L	x
421	N.	173	16,0	19,0	12,9	14,5	2,8	5,1	11,0	2,9	2	5	84,2	68,8	89,0	54,9	75,9	4	B	L	L	x
422	N.	173	15,8	19,3	12,6	14,6	3,6	5,4	11,6	3,1	2	4	81,9	73,4	86,3	66,7	79,5	4	B	M	L	x
423	N.	164	15,4	18,4	11,0	14,3	3,4	4,5	11,6	3,2	1	3	83,7	75,3	76,9	75,6	81,1	1	B	E	Ch	x
424	N.	175	15,8	19,4	11,8	14,3	3,6	5,2	11,6	3,2	2	3	81,4	73,4	82,5	69,2	81,1	4	B	E	L	l
425	N.	165	15,7	18,6	11,5	14,2	3,2	5,6	11,2	3,2	2	3	84,4	71,3	84,0	57,1	78,9	1	B	E	L	l
426	N.	167	15,9	19,2	12,2	14,8	3,5	5,3	11,6	3,6	1	1	82,8	73,0	82,4	66,0	78,4	2	B	E	L	l
427	N.	164	15,2	18,5	11,3	13,9	3,4	4,4	11,0	3,5	1	3	82,2	72,1	81,3	77,3	79,1	1	B	E	Ch	l
428	N.	175	15,7	19,1	11,6	14,6	3,6	5,0	11,2	3,6	1	1	82,2	71,3	79,5	72,0	76,7	4	B	E	Ch	l
429	N.	180	15,3	19,4	12,1	14,3	3,4	5,4	11,0	3,1	3	3	87,9	71,9	84,6	63,6	76,9	4	B	M	L	x
430	N.	173	15,2	19,0	11,2	14,1	3,6	4,2	10,8	3,0	1	1	80,0	71,1	79,4	85,7	76,6	4	M	E	Ch	x
431	N.	167	15,0	19,2	11,3	14,3	3,4	4,4	11,6	3,4	1	3	78,1	77,3	79,0	77,3	81,1	2	M	E	Ch	l

Tromsø, 30 mænd.

432	N.	171	15,8	18,5	11,3	14,4	3,3	4,7	11,2	3,6	1	1	85,4	70,9	78,5	70,2	77,8	4	B	E	Ch	l
433	N.	157	14,3	19,2	11,3	14,2	3,2	5,0	11,4	3,0	1	3	74,5	79,7	79,6	64,0	80,3	1	D	E	L	x
434	N.	162	15,0	19,2	12,6	13,6	3,4	4,9	10,5	3,2	2	1	77,7	70,0	92,7	69,4	77,2	1	M	L	L	x
435	N.	177	15,2	19,2	12,2	13,6	3,1	4,5	11,2	3,4	2	5	79,2	73,7	80,7	68,0	82,4	4	M	L	L	x
436	N.	177	16,0	19,8	13,0	14,2	3,5	4,8	10,5	3,0	1	1	80,8	65,6	91,6	72,9	73,9	4	M	L	Ch	l
437	N.	175	14,8	19,0	11,7	13,0	3,4	4,7	10,4	3,0	2	1	77,9	70,3	90,0	72,3	80,0	4	M	L	Ch	l
438	N.	165	14,6	18,6	11,3	13,3	3,3	5,0	10,8	3,1	2	3	78,5	74,0	85,0	66,0	81,2	1	M	M	L	l
439	N.	167	15,0	19,6	12,5	13,8	3,0	5,6	10,6	3,0	2	1	76,5	70,7	90,6	53,6	76,8	2	M	L	L	x
440	N.	165	15,4	19,9	12,8	14,0	3,2	5,0	11,0	3,0	2	3	77,4	71,1	91,4	64,0	78,6	1	M	L	L	l
441	N.	163	14,7	19,5	12,6	13,6	3,6	5,0	11,6	3,6	1	3	75,4	78,0	92,7	72,0	85,3	1	D	L	Ch	l
442	N.	179	15,2	18,1	11,9	13,4	3,3	5,0	10,8	3,3	1	3	84,0	71,7	88,8	66,0	80,6	4	B	L	L	l
443	N.	164	15,0	18,5	10,8	13,6	3,0	4,7	11,2	3,2	1	5	81,1	74,7	79,4	63,8	82,4	1	B	E	L	m
444	N.	171	15,5	19,1	11,7	14,5	3,4	5,1	11,3	3,0	2	4	81,2	72,9	80,7	66,7	77,9	4	B	E	L	x
445	N.	163	15,5	19,1	10,2	13,8	3,3	4,8	11,5	3,9	2	4	81,2	74,2	73,9	68,8	83,3	1	B	E	L	x
446	N.	175	16,6	19,6	12,6	15,2	3,3	5,5	11,4	3,2	1	1	84,7	68,7	82,9	66,0	75,0	4	B	E	L	l
447	N.	176	16,3	19,5	12,0	14,6	3,4	4,7	11,4	3,2	1	4	83,6	69,9	82,2	72,3	78,1	4	B	E	Ch	x
448	N.	166	15,1	18,6	11,9	13,8	3,6	4,6	10,8	3,2	1	1	81,2	71,5	86,2	78,3	78,3	2	B	M	Ch	l
449	N.	163	15,2	20,2	11,8	14,0	3,4	5,4	10,7	3,6	2	1	75,3	70,4	83,7	63,0	75,9	1	D	E	L	l
450	N.	166	15,1	18,8	11,6	14,3	3,7	4,5	11,2	3,5	2	1	80,3	74,2	81,1	82,2	78,3	2	M	E	Ch	l
451	N.	167	16,0	19,8	12,2	14,0	3,3	5,0	11,3	3,1	1	3	80,8	70,6	87,1	66,0	80,7	2	M	M	L	x
452	N.	176	15,4	20,1	13,0	14,1	3,2	5,4	11,2	3,9	1	3	76,6	72,7	92,2	59,3	79,4	4	M	L	L	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Høide	Hode	Ansigt	Næse	Pigment
453	N.	176	16,1	17,8	11,7	13,7	3,3	5,2	11,0	2,8	1	1	90,5	68,3	85,4	63,5	80,3	4	B	M	L	l
454	N.	170	15,0	18,5	12,3	13,2	3,6	5,0	10,4	3,0	5	5	81,1	69,3	93,2	72,0	78,8	3	B	L	Ch	m
455	N.	169	14,5	19,3	11,8	13,6	3,3	4,8	11,1	3,1	3	4	75,1	76,6	86,8	68,8	81,6	3	D	M	L	m
456	N.	170	15,2	19,8	12,3	13,8	3,5	5,4	11,2	3,4	1	4	76,8	73,7	89,1	64,3	81,2	3	M	L	L	x
457	N.	171	15,4	18,6	11,5	13,6	3,5	4,9	10,6	3,0	1	3	82,8	68,8	84,6	71,4	77,9	4	B	M	Ch	l
458	N.	168	15,9	19,1	11,9	14,4	3,3	5,1	12,9	3,7	5	5	83,3	81,1	82,6	64,7	89,6	2	B	E	L	m
459	N.	169	15,5	19,8	11,6	13,8	3,7	5,0	11,3	3,3	1	3	78,3	72,9	84,1	74,0	81,9	3	M	E	Ch	l
460	N.	172	16,2	20,7	11,3	14,3	3,6	4,6	11,3	2,7	1	4	78,3	72,0	79,0	78,3	79,0	4	M	E	Ch	x
461	N.	172	15,4	19,4	11,8	14,2	2,9	5,6	10,8	3,0	1	3	78,9	70,1	83,1	51,8	79,1	4	M	E	l	l
Sørfjord, 14 mænd.																						
462	N.	172	16,3	19,5	12,2	14,3	3,5	5,3	11,1	3,7	3	3	83,6	68,1	85,3	66,0	77,0	4	B	M	L	x
463	N.	173	15,0	18,0	11,6	13,6	3,8	4,8	11,0	3,3	3	4	83,3	73,3	85,3	68,8	80,0	4	B	M	L	m
464	N. × L.	157	14,8	19,0	10,7	13,7	3,6	4,6	10,6	3,0	2	4	77,9	71,6	78,1	78,3	77,4	1	M	E	Ch	x
465	N.	160	15,1	19,4	11,3	13,6	3,3	5,0	10,6	3,2	2	4	77,8	70,2	83,1	66,0	77,9	1	M	E	L	x
466	N.	181	15,4	19,1	12,9	14,4	3,7	5,4	11,4	3,5	1	3	80,6	74,0	89,6	68,5	79,2	4	M	L	L	l
467	N.	181	15,2	19,6	12,6	14,4	3,2	5,4	11,5	3,4	1	3	77,6	75,7	87,5	59,3	79,9	4	M	M	L	l
468	N.	174	15,3	19,0	12,3	14,6	3,1	5,1	10,6	2,7	1	4	80,5	69,3	87,9	60,8	75,2	4	M	M	L	x
469	N.	166	15,6	17,5	11,7	13,6	2,7	5,1	11,2	3,0	3	4	89,1	71,8	86,0	52,9	82,4	2	B	M	L	m
470	N.	173	16,8	19,3	12,2	14,4	3,4	5,0	11,3	3,3	4	4	87,1	67,3	84,7	68,0	78,5	4	B	M	L	m
471	N.	158	16,8	19,4	11,8	14,8	3,6	5,2	11,5	3,5	1	1	86,6	68,5	79,7	69,2	77,7	1	B	E	L	l
472	N.	157	15,2	18,4	12,0	14,4	3,8	5,1	11,3	3,3	2	4	82,6	74,3	83,3	74,5	78,5	1	B	E	Ch	x
473	L. × N.	162	15,5	19,1	11,9	14,3	3,5	4,5	11,2	3,3	1	1	81,1	72,3	83,2	77,8	78,3	1	B	E	Ch	l
474	N.	172	15,1	18,8	11,9	14,5	3,9	4,9	11,7	3,4	1	3	80,3	77,5	82,1	79,6	80,7	4	M	E	Ch	l
475	N.	170	15,0	20,0	10,6	13,9	3,6	4,3	10,3	3,6	2	4	75,0	68,7	76,3	83,7	74,1	3	D	E	Ch	x

Lyngen, 72 mænd.

476	N. × F.	160	15,0	18,6	10,8	13,4	3,5	4,2	10,6	3,0	4	5	80,7	79,7	80,6	83,3	79,1	1	M	E	Ch	m
477	L.	166	14,9	19,4	11,6	14,0	3,8	5,0	11,0	3,1	2	3	76,8	73,8	82,9	76,0	78,6	2	M	E	Ch	l
478	F.	167	15,3	18,8	11,7	13,8	3,2	5,0	10,5	2,9	2	3	81,4	68,6	84,8	64,0	76,1	2	B	M	L	l
479	N. × F.	167	15,0	18,3	12,4	13,8	3,4	5,c	1 ,7	3,3	1	1	82,0	71,3	89,9	68,0	77,5	2	B	L	L	l
480	F.	162	15,6	19,2	11,6	13,6	3,5	4,7	10,6	3,0	1	1	81,3	68,0	85,3	74,5	77,9	1	B	M	Ch	l
481	N.	163	15,4	18,8	11,3	14,0	3,2	4,7	11,1	3,2	1	3	81,9	72,1	80,7	68,1	79,3	1	B	E	L	l
482	N.	167	15,6	19,0	11,8	14,5	3,5	4,0	11,0	3,2	2	4	82,1	70,5	81,4	87,5	75,9	2	B	E	Ch	x
483	N.	164	15,8	19,2	12,2	14,8	3,4	4,9	11,9	3,3	1	1	82,3	75,3	82,4	69,4	80,4	1	B	E	L	l
484	N.	163	15,8	19,0	12,0	14,2	3,3	5,4	11,0	3,3	5	3	83,2	69,6	84,5	61,1	77,5	1	B	M	L	x
485	N.	166	15,9	19,6	12,6	14,0	3,4	5,0	11,3	3,5	3	5	81,1	71,1	90,0	68,0	80,7	2	B	L	L	m
486	N.	176	15,8	19,0	12,5	13,8	3,2	5,0	10,4	2,8	4	3	83,2	65,8	90,6	64,0	75,4	4	B	L	L	x
487	L. × N.	161	15,8	18,9	12,4	14,6	3,2	5,0	11,2	3,0	5	5	83,6	70,9	84,9	64,0	76,7	1	B	M	L	m
488	N.	182	15,6	20,0	13,5	13,8	3,2	5,4	10,6	3,1	5	4	78,0	68,0	97,8	59,3	76,8	4	M	L	L	m
489	N. × S.	164	15,8	20,0	12,0	14,2	3,6	5,2	11,6	3,4	4	4	79,0	73,4	84,5	69,2	81,7	1	M	M	L	m
490	L.	163	15,6	19,0	12,4	13,9	3,6	4,6	10,9	2,9	3	4	82,1	69,9	89,2	78,3	78,4	1	B	L	Ch	m
491	N.	162	15,0	18,4	11,1	13,2	4,3	4,1	11,2	3,5	2	4	81,5	74,7	84,1	102,4	84,9	1	B	M	Ch	x
492	N.	173	16,2	19,4	12,6	14,5	3,6	4,9	11,8	3,8	1	3	83,5	72,8	86,9	73,5	81,4	4	B	M	Ch	l
493	N.	167	15,0	18,0	12,0	14,2	3,6	5,1	10,7	2,8	1	4	83,3	71,3	84,5	70,6	75,4	2	B	M	Ch	x
494	N.	173	14,7	17,7	12,8	14,1	3,5	5,3	11,0	3,0	1	3	83,1	74,8	90,8	66,0	78,0	4	B	L	L	l
495	N.	175	15,5	18,5	11,9	14,0	3,5	4,6	11,2	3,4	3	4	83,8	72,3	85,0	76,1	80,0	4	B	M	Ch	m
496	N.	173	16,0	19,0	12,2	14,0	4,0	5,0	11,0	3,0	3	4	84,2	68,8	87,1	80,0	78,6	4	B	M	Ch	m
497	N.	163	14,4	18,4	11,6	14,0	3,6	5,0	11,0	3,2	5	5	78,3	76,4	82,9	72,0	78,6	1	M	E	Ch	m
498	N.	175	15,6	18,8	12,4	14,0	3,6	5,6	11,3	3,3	5	4	93,0	72,4	88,6	64,3	80,7	4	B	L	L	m
499	N.	168	15,3	19,0	11,3	13,6	3,4	4,6	10,7	3,2	1	1	80,5	69,9	83,1	60,7	78,7	2	M	E	L	l
500	L. × L.	166	15,0	18,8	11,3	13,6	3,5	4,5	11,2	3,9	1	1	79,8	74,7	83,1	77,8	82,4	2	M	E	Ch	l
501	N.	163	15,9	20,2	11,7	14,8	3,6	5,2	11,2	3,3	1	3	78,7	70,4	79,1	69,2	75,7	1	M	E	L	l
5 2	F.	165	15,2	20,1	11,5	14,1	3,2	5,0	11,1	3,4	4	4	75,6	73,0	81,6	64,0	78,7	1	D	E	L	m
503	F. × N.	161	15,4	19,2	11,2	14,3	3,5	4,4	11,0	3,5	1	3	80,2	71,4	78,3	79,6	76,9	1	M	E	Ch	l
504	L.	163	15,3	19,6	11,9	13,8	3,0	5,5	11,5	3,2	2	4	78,1	75,2	86,2	54,6	83,8	1	M	M	L	x
505	F.	167	14,8	19,0	11,3	13,2	3,0	5,3	10,0	2,8	1	4	77,9	67,6	85,6	56,6	75,8	2	M	M	L	x
506	N. × F.	180	16,2	20,9	12,8	15,0	3,3	4,9	12,2	4,0	1	4	79,4	73,5	85,3	67,4	81,3	4	M	M	L	x
507	F. × N.	177	15,6	20,6	12,7	14,3	3,2	5,6	11,8	3,1	1	3	75,7	75,6	88,8	57,1	82,5	4	D	L	L	l
508	N.	163	15,5	19,0	10,9	14,0	3,4	4,9	10,9	2,7	4	1	81,6	70,3	77,9	69,4	77,9	1	B	E	L	x
509	N. × S.	162	15,0	17,2	12,5	14,0	3,8	5,2	10,8	4,0	2	3	87,2	72,0	89,3	73,1	77,1	1	B	L	Ch	l
510	L.	162	16,3	19,4	11,2	13,9	3,8	5,0	11,3	3,0	2	4	84,0	69,3	80,6	76,0	81,3	1	B	E	Ch	x
511	L.	157	15,8	19,1	11,5	14,0	3,6	4,4	11,0	3,5	1	4	82,7	69,6	82,1	81,8	78,6	1	B	E	Ch	x
512	F.	164	15,8	19,0	11,6	14,2	3,3	5,0	11,3	3,4	1	3	83,2	71,5	81,7	66,0	79,6	1	B	E	L	l

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Høide	Hode	Ansigt	Næse	Pigment
513	N.	161	15,3	18,9	11,9	14,3	3,5	5,4	11,5	2,7	1	1	81,0	75,2	83,2	64,8	80,4	1	B	E	L	l
514	N.	159	15,3	18,4	11,1	14,5	3,9	4,5	11,2	3,2	4	4	87,2	73,2	76,6	86,7	77,2	1	B	E	Ch	x
515	N.	175	15,5	18,4	11,8	14,1	3,1	5,3	11,1	3,2	5	5	84,2	71,6	83,7	58,5	78,7	4	B	E	L	m
516	N. × F.	163	14,6	18,0	11,0	13,8	3,3	4,8	10,8	3,6	1	4	81,1	74,0	79,7	68,8	78,3	1	B	E	L	x
517	F. × L.	161	15,2	18,2	10,9	13,6	3,3	4,6	11,4	2,9	1	3	83,5	68,4	80,2	71,7	76,5	1	B	E	Ch	l
518	F. × N.	168	16,2	17,8	12,5	14,5	3,5	5,2	10,6	3,3	5	5	91,0	65,4	86,2	67,3	73,1	2	B	M	L	m
519	L.	170	15,6	18,0	12,0	14,2	3,2	5,0	11,2	3,8	4	1	86,7	71,8	84,5	64,0	78,9	3	B	M	L	x
520	N. × L.	162	15,4	19,3	11,7	13,9	3,6	4,5	11,3	3,5	4	4	79,8	73,4	84,2	80,0	81,3	1	M	M	Ch	m
521	L.	161	15,4	19,3	11,8	13,8	3,5	4,8	10,8	3,1	4	1	79,8	70,1	85,5	68,8	78,3	1	M	M	L	x
522	N.	164	14,9	19,2	11,9	12,8	3,2	4,8	10,7	3,1	1	3	77,6	71,8	93,0	66,7	83,6	1	M	L	L	l
523	N.	180	17,0	21,2	12,9	14,9	3,6	5,4	11,8	3,7	1	1	80,2	69,4	86,6	66,7	79,2	4	M	M	L	l
524	N.	179	15,6	19,5	12,6	14,4	3,3	5,3	11,3	3,3	1	3	80,0	72,4	87,5	62,3	78,5	4	M	M	L	l
525	N.	165	16,0	18,5	12,2	14,6	3,7	5,0	11,0	3,4	1	3	86,5	68,8	83,6	74,0	75,3	1	B	E	Ch	l
526	F.	163	15,9	17,8	11,1	14,6	3,4	4,6	11,5	3,3	4	5	89,3	72,3	76,0	73,9	78,8	1	B	E	Ch	m
527	N. × S.	167	16,3	19,3	12,1	15,0	3,1	5,0	12,0	3,5	4	1	84,5	73,6	80,7	62,0	80,0	2	B	E	L	x
528	L.	168	15,5	19,3	11,1	13,9	3,6	5,2	11,8	3,6	4	4	80,3	76,1	79,9	69,2	84,9	2	M	E	L	m
529	N.	168	15,6	19,8	12,6	14,0	3,6	5,0	11,3	3,5	2	3	78,8	72,4	90,0	72,0	80,7	2	M	L	Ch	l
530	N.	168	15,6	19,4	12,3	13,9	3,3	4,8	11,6	4,0	1	1	80,4	74,4	88,5	68,8	83,5	2	M	L	L	l
531	N.	168	15,7	19,4	12,3	14,2	3,4	5,0	11,1	3,2	1	3	80,9	70,7	86,6	68,0	78,2	2	M	M	L	l
532	L. × F.	169	16,8	19,4	12,2	14,8	4,2	4,8	11,8	4,2	2	3	86,6	70,2	82,4	87,5	79,7	3	B	E	Ch	l
533	N.	170	15,8	19,1	10,9	14,0	3,2	4,4	11,2	3,3	1	1	82,7	70,9	77,9	72,7	80,0	3	B	E	Ch	l
534	N. × F.	172	15,4	19,1	11,9	14,0	3,5	4,9	11,5	3,3	3	4	80,6	74,7	85,0	71,4	82,1	4	M	M	Ch	m
535	L.	169	16,0	18,2	10,8	14,3	3,7	4,8	11,3	3,3	2	3	87,9	70,6	75,5	77,1	79,0	3	B	E	Ch	l
536	N.	168	15,9	19,1	11,6	14,4	3,4	4,9	11,6	3,7	4	5	83,3	73,0	80,0	69,4	80,0	2	B	E	L	m
537	N.	170	15,6	18,9	11,9	14,3	3,4	4,5	11,3	3,0	1	4	82,5	72,4	83,2	75,6	79,0	3	B	E	Ch	x
538	L.	170	16,5	19,0	12,2	15,0	3,4	4,7	11,5	3,4	1	3	86,8	69,7	81,3	72,3	79,7	3	B	E	Ch	l
539	F. × N.	168	15,5	19,9	12,2	14,1	3,5	4,6	11,6	4,0	1	4	77,9	74,8	86,5	76,1	82,3	2	M	M	Ch	x

540	N.	170	15,0	19,6	13,7	14,0	3,3	5,0	11,0	3,0	4	4	76,5	73,3	97,9	66,0	78,6	3	M	L	L	m
541	N.	171	15,3	19,5	12,1	13,6	3,2	5,1	11,2	3,4	1	4	78,5	73,2	89,0	62,8	82,4	4	M	L	L	x
542	N.	172	14,9	19,4	12,9	13,7	3,3	5,0	10,3	3,3	1	4	76,8	69,1	94,2	66,0	75,2	4	M	L	L	x
543	S. × N.	170	15,4	18,8	11,3	14,0	3,2	4,5	11,0	3,3	1	1	81,9	71,4	80,7	71,1	78,6	3	B	E	Ch	l
544	L.	171	15,6	19,0	12,0	14,0	3,4	5,0	11,3	3,0	4	4	82,1	72,4	85,7	68,0	80,7	4	B	M	L	m
545	F.	170	15,8	19,2	12,2	14,0	3,7	4,9	11,7	3,5	1	1	82,3	74,1	87,1	75,5	83,6	3	B	M	Ch	l
546	F.	169	15,4	19,1	12,6	13,8	3,0	5,2	10,6	2,8	2	4	80,6	68,8	91,3	57,7	76,8	3	M	L	L	x
547	N.	172	16,0	19,0	12,2	14,8	3,6	5,2	11,8	3,7	2	1	84,2	73,8	82,4	69,2	79,7	4	B	E	L	l

Karlsøy, 30 mænd.

548	N.	170	15,4	19,1	11,4	13,5	3,2	5,0	10,8	3,1	1	1	80,6	70,1	84,4	64,0	80,0	3	M	M	L	l
549	F. × L.	170	15,4	18,9	11,9	14,2	3,5	4,6	11,3	3,7	2	2	81,5	73,4	83,8	76,1	79,6	3	B	E	Ch	l
550	N.	171	16,0	19,2	11,5	14,5	3,8	5,0	11,8	3,3	1	1	83,3	73,8	79,3	76,0	81,4	4	B	E	Ch	l
551	N.	171	15,6	19,3	12,5	15,0	3,4	5,3	11,2	3,4	5	5	80,8	71,8	83,3	64,2	74,2	4	M	E	L	m
552	N.	172	16,0	20,2	12,2	15,2	3,8	4,5	11,7	4,0	1	3	79,2	73,1	80,3	84,4	77,0	4	M	E	Ch	l
553	N.	170	15,8	19,0	12,0	14,8	3,2	4,7	11,6	3,5	3	5	83,2	73,4	81,1	68,1	78,4	3	B	E	L	m
554	N.	169	15,7	18,0	12,1	14,4	3,6	4,5	11,6	3,3	1	3	87,2	73,9	84,0	80,0	80,6	3	B	M	Ch	l
555	N.	170	16,4	20,2	11,8	14,5	3,2	4,6	11,6	3,2	1	4	81,2	70,7	81,4	69,6	80,0	3	B	E	L	x
556	N.	168	16,2	19,6	11,5	14,2	3,0	5,0	11,5	3,2	1	3	82,7	71,0	81,0	60,0	81,0	2	B	E	L	l
557	N.	172	15,4	19,7	13,9	14,0	3,2	5,5	11,2	2,9	5	5	78,2	72,7	99,3	58,2	80,0	4	M	L	L	m
558	N.	165	15,0	18,9	12,2	14,3	3,5	5,0	11,2	3,4	1	1	79,4	74,7	85,3	70,0	78,3	1	M	M	Ch	l
559	N.	177	15,4	19,7	12,5	14,5	3,0	5,6	11,6	3,5	3	4	78,2	75,3	86,2	53,6	80,6	4	M	M	L	m
560	L. × N.	164	15,8	18,2	11,8	14,7	3,3	5,0	11,9	3,7	3	1	86,8	75,3	80,3	66,0	81,0	1	B	L	L	l
561	N.	167	16,2	18,4	11,4	14,1	3,6	4,5	11,3	3,5	1	3	88,0	69,8	80,9	80,0	80,1	2	B	E	Ch	l
562	N.	163	15,7	18,7	11,3	14,4	3,3	4,6	11,2	3,4	2	1	84,0	71,3	78,5	71,7	77,8	1	B	E	Ch	l
563	N.	176	15,3	18,9	12,2	13,8	3,5	4,8	11,1	3,2	4	5	81,0	72,6	88,4	72,9	80,4	4	B	L	Ch	m
564	N.	177	15,7	19,0	12,8	14,4	3,2	5,6	11,6	3,7	3	4	82,6	73,9	88,9	57,1	80,6	4	B	L	L	m
565	N.	148	15,0	18,4	11,7	13,3	3,2	4,9	10,4	3,2	1	3	81,5	69,3	88,0	65,3	78,2	1	B	L	L	l
566	N.	168	15,0	18,5	11,6	13,4	3,5	4,8	10,5	3,4	1	4	81,1	70,0	86,6	72,9	78,4	2	B	M	Ch	x
567	N.	171	15,8	18,8	11,2	14,0	3,4	5,0	10,5	2,9	3	4	84,0	66,5	80,0	68,0	75,0	4	B	E	L	m
568	N.	166	15,7	18,8	11,8	14,2	3,2	4,6	11,3	3,3	3	4	83,5	72,0	83,1	69,6	79,6	2	B	E	L	m
569	L.	164	15,0	18,4	11,5	13,4	3,3	4,6	10,3	3,4	1	3	81,5	68,7	85,8	71,7	76,9	1	B	M	Ch	l
570	L.	157	15,4	18,4	11,6	13,4	3,4	5,0	10,7	3,7	2	1	83,7	69,5	86,6	68,0	79,9	1	B	M	L	l
571	N.	167	14,6	18,6	11,3	14,3	3,6	4,7	10,9	3,2	1	3	78,5	74,7	79,0	76,6	76,2	2	M	E	Ch	l
572	N.	164	15,0	19,3	11,0	13,2	3,3	4,5	11,0	3,1	2	4	77,7	73,3	83,3	73,3	83,3	1	M	E	Ch	x
573	F.	161	15,4	19,3	12,2	14,2	3,3	5,2	11,3	3,7	2	3	79,8	73,4	85,9	63,5	79,6	1	M	M	L	l
574	N.	177	14,8	18,9	12,7	13,5	3,6	5,0	10,5	3,0	2	4	78,3	71,0	94,1	72,0	77,8	4	M	L	Ch	x
575	N.	167	14,8	18,5	11,8	13,6	3,3	4,4	11,2	3,6	2	4	80,0	75,7	86,8	75,0	82,4	2	M	M	Ch	x

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront.	Index facial.	Index nasalis	Index jugofrontal.	Høide	Hode	Ansigt	Næse	Pigment
576	N.	164	14,9	20,4	12,5	13,6	3,4	5,3	11,3	3,2	1	1	73,0	75,8	91,9	64,0	83,1	1	D	L	L	l
577	N.	165	15,0	18,7	11,6	13,6	3,6	4,7	11,0	3,3	2	4	80,2	73,3	85,3	70,6	80,9	1	M	M	Ch	x
Helgøy, 12 mænd.																						
578	N.	174	15,2	18,8	11,3	13,8	3,5	4,4	11,1	3,1	1	3	80,9	73,0	81,9	70,6	80,4	4	M	E	Ch	l
579	N.	158	15,2	18,8	10,8	13,5	3,5	4,6	10,8	3,3	2	1	80,9	71,1	80,0	70,1	80,0	1	M	E	Ch	l
580	N.	164	14,4	19,0	11,8	13,8	3,3	5,0	11,0	3,3	3	3	77,9	74,3	85,5	66,0	79,7	1	M	M	L	x
581	N.	179	15,3	19,6	12,4	14,3	3,5	5,3	11,6	3,3	3	1	78,1	75,8	86,7	66,0	81,1	4	M	M	L	l
582	N.	176	14,6	18,9	12,2	13,7	3,3	4,8	10,8	3,1	2	4	77,3	74,0	89,1	68,8	78,8	4	M	L	L	x
583	N.	165	14,8	18,0	11,3	14,4	3,9	4,4	11,6	3,4	2	3	82,2	78,4	78,5	88,6	80,6	1	B	E	Ch	l
584	N.	169	15,8	18,3	12,9	15,0	3,3	5,8	11,6	3,2	1	3	86,3	73,4	86,0	56,9	77,3	3	B	M	L	l
585	N.	170	15,8	20,3	12,7	15,0	3,8	5,1	12,0	3,5	1	1	77,8	76,0	84,7	74,5	80,0	3	M	M	Ch	l
586	N.	162	15,7	18,0	12,2	13,8	3,3	5,0	10,6	2,9	2	1	87,2	67,5	88,4	66,0	76,8	1	B	L	L	l
587	N.	174	15,9	19,3	10,9	13,8	3,4	4,2	10,7	3,7	4	1	82,4	67,3	79,0	81,0	77,5	4	B	E	Ch	x
588	N.	162	15,4	18,8	11,7	14,6	3,4	4,6	10,5	3,4	4	4	81,9	68,2	80,1	73,9	71,9	1	B	E	Ch	m
589	N.	171	15,0	18,8	10,7	14,8	3,4	4,7	11,6	3,1	1	3	79,8	77,3	72,3	72,3	78,4	4	M	E	Ch	l
Skjervøy, 55 mænd.																						
590	N. × F.	167	15,8	19,0	11,6	13,7	2,8	5,0	11,3	3,6	1	3	80,5	73,9	84,7	56,0	82,5	2	M	M	L	l
591	N. × F.	175	15,4	20,0	12,4	14,0	3,4	5,2	11,7	3,4	1	1	77,0	76,0	88,6	65,4	83,0	4	M	L	L	l
592	N.	163	15,4	20,5	13,8	14,4	3,4	5,3	11,8	3,8	1	4	75,2	76,6	95,8	64,2	81,0	1	D	L	L	x
593	N.	167	14,7	19,0	12,2	13,3	3,4	5,0	10,9	3,0	1	3	77,4	74,2	98,7	68,0	82,0	2	M	L	L	l
594	L.	157	15,2	17,2	11,6	14,2	3,4	4,8	11,4	3,3	2	4	88,4	75,4	81,7	70,8	80,3	1	B	E	Ch	x
595	L.	164	15,2	19,5	11,2	14,4	3,3	4,6	11,6	3,1	2	5	78,0	76,3	77,8	71,7	80,0	1	M	E	Ch	x
596	N.	176	15,3	20,5	12,0	14,3	3,6	5,0	11,6	3,4	1	1	74,6	75,8	83,9	72,0	81,1	4	D	E	Ch	l
597	L.	169	15,2	18,9	12,9	13,9	3,3	4,9	11,2	3,2	3	3	80,4	73,7	92,8	67,4	80,0	3	M	L	L	x
598	N.	169	15,0	19,9	12,0	14,1	3,0	5,4	10,8	2,8	3	3	79,0	72,0	85,1	55,6	79,6	3	M	M	L	x

599	N.	166	15,2	19,8	12,6	14,4	3,6	5,4	11,4	3,7	1	1	76,8	75,0	87,5	66,7	79,2	2	M	M	L	l
600	N.	163	15,2	19,3	11,7	13,8	3,6	5,6	10,5	2,9	1	1	78,8	69,1	84,8	64,3	76,1	1	M	M	L	l
601	N.	170	15,0	19,4	12,6	13,8	3,3	4,8	11,3	3,5	2	3	77,3	75,3	91,3	68,8	81,9	4	M	L	L	l
602	N.	179	15,4	19,6	13,9	14,4	3,5	5,3	10,9	3,2	1	1	78,6	70,8	96,5	66,0	75,7	4	M	L	L	l
603	N.	176	14,6	18,5	12,6	13,6	3,4	4,9	10,4	2,7	1	3	78,9	71,2	92,7	69,4	76,5	4	M	L	L	l
604	N. × F.	183	16,1	20,1	13,6	14,9	3,5	5,9	11,8	3,2	1	4	80,1	73,3	91,3	59,3	79,2	4	M	L	L	x
605	L. × F.	162	15,3	18,4	11,6	14,0	3,7	4,4	11,9	3,7	1	3	83,2	77,8	82,0	84,1	85,0	1	B	E	Ch	l
606	N.	174	14,8	17,0	11,8	13,6	3,3	4,0	11,0	3,0	3	3	84,1	74,3	86,8	71,7	80,9	4	B	M	Ch	x
607	N.	160	15,4	18,8	11,6	13,6	3,5	4,8	10,5	2,7	4	4	81,9	68,2	85,3	72,9	77,2	2	B	M	Ch	m
608	N. × L.	176	15,0	20,4	12,4	15,0	3,2	5,1	11,5	3,5	5	4	73,5	76,7	82,7	62,8	76,7	4	D	E	L	m
609	N. × F.	167	15,1	19,0	11,8	14,1	3,0	4,6	11,2	3,2	4	4	79,5	74,2	83,7	65,2	79,4	2	M	E	L	m
610	N. × L.	177	15,4	19,0	11,9	14,0	2,9	4,4	11,0	3,5	1	3	81,1	71,4	85,0	65,9	78,6	4	B	M	L	l
611	N.	165	15,3	19,3	11,2	14,1	3,3	4,8	10,8	2,7	1	1	79,3	70,6	70,4	68,8	76,6	1	M	E	L	l
612	F. × N.	167	14,5	18,2	10,7	13,9	4,1	4,0	10,3	3,2	1	4	79,2	71,0	77,0	102,5	74,1	2	M	E	Ch	x
613	F. × N.	160	15,6	19,3	11,0	13,5	3,6	4,8	11,0	3,2	1	3	80,8	70,5	81,5	75,0	81,5	1	M	E	Ch	l
614	F. × N.	164	15,0	19,2	11,8	14,2	3,6	5,1	11,3	3,4	2	4	78,1	75,3	83,1	70,6	79,0	1	M	E	Ch	x
615	N.	172	15,2	19,1	11,6	13,8	3,6	4,9	10,9	3,5	1	4	79,6	71,7	84,1	73,5	79,0	4	M	M	Ch	x
616	N.	170	14,9	19,0	11,4	13,6	3,4	4,7	11,2	3,4	3	4	78,4	75,2	83,8	72,3	82,4	3	M	E	Ch	m
617	L. × F.	170	15,2	18,9	11,6	11,4	3,3	4,8	11,3	3,2	1	4	80,4	74,3	80,6	68,8	78,5	3	M	E	L	x
618	N. × L.	170	15,0	18,4	12,0	13,6	3,2	4,8	11,2	3,3	2	5	81,5	74,7	88,2	66,7	82,4	3	B	L	L	x
619	N.	170	14,7	19,1	12,7	13,9	3,3	5,6	11,2	3,8	1	1	77,0	70,2	91,4	58,9	80,6	3	M	L	L	l
620	N.	156	15,1	17,5	10,3	14,1	3,6	5,0	10,9	2,9	1	1	86,3	72,2	73,1	72,0	77,3	1	B	E	Ch	l
621	N. × F.	165	14,6	18,7	11,3	13,7	3,4	4,7	11,1	3,2	3	4	87,1	76,0	82,5	72,3	81,0	1	B	E	Ch	m
622	N.	173	15,2	18,2	11,3	14,0	3,4	4,8	11,0	,7	1	1	83,5	72,4	80,7	70,8	78,0	4	B	E	Ch	l
623	N. × L.	173	15,1	18,1	11,8	14,2	3,4	5,0	11,3	3,1	1	4	83,4	74,8	83,1	68,0	77,5	4	B	E	L	x
624	F. × L.	167	15,2	18,3	11,8	14,3	3,1	4,7	11,2	3,0	2	1	83,1	73,7	82,5	66,0	78,3	2	B	L	L	l
625	N.	171	15,4	20,0	13,4	14,9	3,5	5,4	11,8	3,2	1	3	77,0	76,6	89,9	64,8	79,2	4	M	L	L	l
626	N.	168	16,2	20,0	13,5	14,4	3,6	5,8	11,6	3,4	3	3	81,0	71,6	93,8	62,1	80,0	2	B	L	L	x
627	N. × F.	162	15,1	18,3	11,8	13,8	3,4	4,8	10,8	3,0	1	4	82,5	71,5	85,5	70,8	78,3	1	B	M	Ch	x
628	F.	163	15,5	18,5	12,2	14,5	3,2	4,8	11,2	3,0	1	3	83,8	72,3	84,1	66,7	77,2	1	B	M	L	l
629	N.	173	15,4	18,7	12,4	14,5	3,4	4,9	11,5	3,1	1	1	82,4	74,7	85,5	69,4	79,3	4	B	M	L	l
630	N.	175	15,8	19,3	12,5	14,1	3,6	5,1	11,6	3,0	1	4	81,9	73,7	88,7	70,6	82,3	4	B	L	Ch	x
631	N.	176	15,4	19,0	12,6	14,3	3,6	5,4	10,4	3,4	1	4	81,1	67,5	88,1	66,7	72,7	4	B	L	L	x
632	N.	166	15,4	18,8	12,3	13,9	3,0	4,6	10,8	3,0	1	4	81,9	70,1	88,5	65,2	77,7	2	B	L	L	x
633	N. × L.	165	16,0	19,7	12,4	14,7	3,2	5,4	11,3	3,0	4	4 (5)	81,2	70,6	84,4	59,3	76,9	1	B	M	L	m
634	N.	164	16,0	19,0	12,4	14,3	4,0	5,4	11,5	3,5	1	3	84,2	71,9	86,7	74,1	80,4	1	B	M	Ch	l
635	N.	169	14,9	18,0	12,2	14,3	3,4	5,6	11,2	3,0	5	5	82,8	75,2	85,3	60,7	78,3	3	B	M	L	m
636	N. × L.	169	15,3	18,9	12,6	14,2	3,5	5,6	11,5	3,2	1	1	81,0	75,2	88,7	70,0	81,0	3	B	L	Ch	l
637	N.	169	15,0	19,3	11,6	13,6	3,3	4,8	10,6	3,1	1	5	77,7	70,7	85,3	68,8	77,9	3	M	M	L	x

Tabel 67 (forts.).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
																		Formel				
Løpe-no.	Herkomst	Legemshøide	Hodets bredde	Hodets længde	Ansigtshøide	Ansigtsbredde	Næsens bredde	Næsens høide	Pandebredde	Indre øien-vinkelavstand	Øienfarve	Haarfarve	Index cephalicus	Index parietofront	Index facial.	Index nasalis	Index jugofrontal	Høide	Hode	Ansigt	Næse	Pigment
638	N.	170	15,3	19,7	11,8	13,9	3,2	5,2	10,8	3,1	1	1	77,7	70,0	84,9	61,5	77,7	3	M	M	L	l
639	N.	168	15,6	19,0	11,6	13,8	3,4	5,0	10,6	2,8	1	5	82,1	68,0	84,1	68,0	76,8	2	B	M	L	x
640	L. × N.	172	15,6	19,1	11,2	14,0	3,2	4,8	11,2	2,9	1	1	81,7	71,8	80,0	66,7	80,0	4	B	F	L	l
641	N.	169	15,5	19,0	12,5	14,4	3,0	4,7	11,6	3,5	1	1	81,6	74,8	86,8	63,8	80,6	3	B	M	L	l
642	N.	172	16,2	18,7	12,2	14,6	3,4	4,7	11,6	3,3	1	4	86,6	71,6	83,6	72,3	79,5	4	B	E	Ch	x
643	L. × F.	170	15,6	19,5	11,2	14,0	4,0	5,0	10,6	3,2	5	4	80,0	68,0	80,0	80,0	75,7	3	M	E	Ch	m
644	N.	172	15,4	19,6	12,4	14,0	3,2	5,2	10,8	3,0	1	3	78,6	70,1	88,6	61,5	77,1	4	M	L	L	l
Nordreisa, 2 mænd.																						
645	L.	163	15,0	18,6	10,5	13,0	3,2	5,0	10,7	2,7	1	4	80,7	71,3	80,8	64,0	82,3	1	M	F	L	x
646	N.	170	15,0	18,8	11,8	14,4	3,9	5,3	11,2	3,1	1	4	79,8	74,7	81,9	73,6	77,3	3	M	L	Ch	x
Kvænangen, 16 mænd.																						
647	F.	173	15,2	18,3	11,7	14,2	3,4	4,5	11,6	3,4	3	4	83,1	76,3	82,4	75,6	81,7	4	B	E	Ch	m
648	N.	164	15,0	18,2	11,1	13,9	3,1	5,3	10,6	2,9	2	1	82,4	70,7	79,9	58,5	76,3	1	B	E	L	l
649	N.	176	16,4	19,2	12,2	15,0	3,0	5,3	11,4	3,4	1	1	85,4	69,5	81,3	56,6	76,0	4	B	E	L	l
650	F.	164	15,7	18,4	12,1	14,0	3,0	4,8	10,8	3,0	4	5	85,3	68,8	86,4	62,5	77,1	1	B	M	L	m
651	L. × N.	162	15,2	19,0	11,2	13,8	3,2	4,8	11,2	3,2	1	3	80,0	73,7	81,2	66,7	81,2	1	M	E	L	l
652	N. × F.	161	15,2	19,1	11,5	13,7	2,9	5,3	10,8	3,3	1	1	79,6	71,1	83,9	54,7	78,3	1	M	E	L	l
653	F.	175	15,0	18,6	11,7	13,7	3,4	5,2	10,8	2,9	3	5	80,7	72,0	85,4	65,4	78,8	4	M	M	L	m
654	N.	163	15,1	19,2	11,8	14,4	3,8	5,7	11,1	2,8	2	4	78,7	73,5	81,9	66,7	77,1	1	M	E	L	x
655	N. × F.	174	15,5	19,5	12,2	14,4	3,8	5,0	12,0	3,6	1	3	79,5	77,4	84,7	76,0	83,3	4	M	M	Ch	l
656	N.	174	15,8	19,8	12,8	14,4	3,0	5,5	11,0	3,4	2	4	79,8	69,6	88,9	54,6	76,4	4	M	L	L	x
657	F.	168	15,2	19,5	12,2	13,9	3,4	5,2	11,4	3,3	2	3	78,0	75,0	87,8	65,4	82,0	2	M	M	L	l
658	F.	168	15,6	19,1	12,9	14,3	3,4	4,7	11,4	3,3	1	5	81,7	73,1	90,2	72,3	79,7	2	B	L	Ch	x
659	N. × L.	171	15,7	18,9	12,2	14,8	3,5	4,9	11,4	3,0	4	4	83,1	72,6	82,4	71,4	77,0	4	B	E	Ch	m
660	F.	168	16,4	19,8	11,9	14,9	3,9	5,2	11,7	3,4	5	4	82,8	71,3	79,9	75,0	78,5	2	B	E	Ch	m
661	N.	171	15,7	19,3	12,5	14,1	3,4	5,4	11,4	2,8	1	1	81,4	72,6	88,7	63,0	80,0	4	B	L	L	l
662	N. × L.	171	15,6	19,4	12,8	14,2	3,4	4,9	11,0	3,3	1	1	80,4	70,5	90,1	69,4	77,5	4	M	L	L	l
90	N. × L.	171	15,4	19,3	13,0	14,2	2,9	5,4	11,2	3,3	1	3	79,8	72,7	91,6	53,7	78,9	4	M	L	L	l

XIV. Résume.

1. Norsk.

I. Undersøkelsen omfatter 662 mænd i alderen 20—21 aar, samtlige fra Troms fylke i det nordlige Norge. Man gaar nu ut fra at bebyggelsen hadde naadd hitop 1000 aar f. Kr.

Befolkningen her er meget uensartet. Grundstammen er utvilsomt norsk. Ca. 90 % regner sig som norske, 8 % regner sig for lapper, og ca. 2 % regner sig for finlændere. Gjennem mange generationer har dog norske, lapper og finner krydset indbyrdes. Man bør derfor være varsom med at tale om racerenhet heroppe. Av tabel 2 ser det ut som det norske element er i jevn vekst. Det er dog kun et selvbedrag. Bastardene regner sig nemlig som norske i 2den og 3dje generation. Og da raceeiendommelighetene ikke forsvinder, vil dette i virkeligheten si at den norske race i Troms fylke for hvert aar som gaar blir mere og mere forurenset med fremmede elementer. Langs fjordene og paa øene i Troms fylke bor en befolkning som vanlig benævnes „sjøfinner". Disse utgjør en ganske stor procent av den nuværende befolkning. Om disse sjøfinners herkomst er der endnu ikke enighet. Nogen mener at det kun er forarmede fjeldlapper. Andre mener at disse sjøfinner for en del er resten av en gammel „anarisk" befolkning, som har bodd heroppe før nordmændene kom hit.

II. **Legemshøiden** (M) er 169,287 cm. Standardavvikelsen (σ) er 6,78. Variationskoefficienten (υ) = 4,004. Legemshøiden er meget uensartet i de forskjellige herreder (se tabel 4). Mindst er den i de distrikter hvor der er mange lapper eller sjøfinner (Lyngen og Karlsøy). Størst er den i de distrikter hvor der er mange indflyttere fra det sydlige Norges største dalfører, Østerdalen og Gudbrandsdalen. Kurven for legemshøiden (fig. 3) har 6 vel markerte spidser og har et betydelig mere avlangt forløp end man ellers vanlig finder i Norge.

III. **Pigmentering.** Blaa-graa øine har 58,5 %, lyst melerte øine 19,9 %, mørkt melerte øine 8,9 %, brune øine 12,7 %. Brune øine svarer til Martins tavle 4 og 5. Flest brunøiede finder man i Lyngen herred (30,6 %), se tabel 11. Det er lappene og de saakaldte sjøfinner som tilfører befolkningen saa mange brunøiede individer. Hos de egte fjeldlapper har Mantegazza fundet følgende tal: blaaøiede 30 %, melerte øine 40 %, brune øine 30 %. De egte fjeldlapper har med andre ord ikke mørkere øine end befolkningen i Lyngen. Da nu mindst 50 % av befolkningen i

Lyngen er av ren nordisk herkomst og altsaa har hat blaa øine, synes det lite sandsynlig at befolkningen i Lyngen kan være blit saa sterkt brunøiet ved krydsning med fjeldlapper. Dette taler for at det maa være sjøfinnene som har tilført befolkningen i Lyngen saa mange brunøiede, og sjøfinnene maa da ha været mere brunøiet end lappene.

Det største antal blaaøiede individer findes i Bardu og Maalselv. Befolkningen her er for en meget stor del indflyttet hit for ca. 100 aar siden fra Østerdalen og Gudbrandsdalen. Av tabel 10 fremgaar ogsaa at øienfarven i Bardu og Maalselv paa det nærmeste svarer til hvad der nu er i Nordre Østerdalen. Det er et nyt bevis paa den seighet hvormed denne egenskap nedarves.

Haarfarven. Blandt samtlige undersøkte fandtes 23,4 % lyseblonde, 1,5 % rødhaarede, 34,0 % med lysebrunt haar, 33,9 % med mørkebrunt haar og 7,2 % sorthaarede. De fleste sorthaarede svarer til FISCHERS type nr. 4. De distrikter som har flest mørkhaarede, er de samme som hadde flest brunøiede og flest smaa folk. Det synes sikkert, at det er sjøfinnene som har tilført befolkningen saa mange sorthaarede. Hvis man sammenholder haarfarven hos befolkningen til eks. i Lyngen med hvad MANTEGAZZA har fundet blandt fjeldlapper, blir det klart, at det ikke er lappene som har tilført denne befolkning dens mørke haar. Der er færre sorthaarede blandt lappene end blandt denne befolkning. Paa fig. 5 er fremstillet pigmenteringsgraden i de forskjellige distrikter, naar haarfarve og øienfarve regnes under ett (pigmentindex).

IV. **Hodet.** Middellængden er 19,28 cm. blandt samtlige. Hos de norske er den 19,4 cm., hos lappene 18,5 cm. Middelbredden er 15,41 cm., hos lappene 15,6 cm.

Index cephalicus's gjennemsnitlige størrelse er 80,77. Lavest index findes i Bardu (79,3) og Maalselv (79,1). Forøvrig kan jeg henvise til indexkartet (fig. 8). Kurven for index cephalicus (se fig. 9) har en tydelig spids ved index 80, desuten to tydelige spidser ved index 83 og 87. Den sidste antages at skyldes lappene. Spidsen ved index 83 svarer helt til hvad man ogsaa ofte ellers finder i Norge, specielt paa Vestlandet.

Paa tabel 20 er fremstillet forholdet mellem hodets længde og bredde samt legemshøiden hos norske og hos lapper. Hos lappene utgjør hodets bredde ca 15,6 % av lagemshøiden, hvad enten denne sidste er stor eller liten. Hos norske derimot kun 15,2 %. Hodets længde utgjør hos lappene 18,0—18,4 % av legemshøiden, hos norske derimot fra 19,0—19,3 %. Jeg fandt 6 % dolichocephaler, 47 % mesocephaler, 39 % brachycephaler, 8 % hyperbrachycephaler.

V. **Ansigtets** middelhøide er 12,05, dets middelbredde er 14,14. Index facialis morphologicus er 85,1. Denne sidste varierer sterkt i de forskjellige herreder (se kartet fig. 10). De smaleste ansigter findes i Bardu og Maalselv, hvor man ogsaa finder den største legemshøide, den mindste index cephalicus, det største antal lyshaarede og lysøiede.

De bredeste ansigter findes i Helgoy (nr. 23 paa fig. 10). Dette er ganske paafaldende. Ti blandt de av mig undersokte fra Helgoy var ingen av lappisk herkomst, og det er jo i det hele lite sandsynlig, at lappene nogen gang skal ha bodd ute paa en o ved Nordishavet i en saadan mængde at de kunde paatrykke befolkningen sit stempel. Den nulevende befolkning maa derfor ha faat sit brede ansigt i arv fra en anden folketype end lappene. Kurven for ansigtsindex (index facialis morphologicus) er nedtegnet paa fig. 11 og har, som det vil sees, 3 spidser: ved index 83, 85 og 88.

I hele fylket har jeg fundet 37 % euryprosoper, 33 % mesoprosoper og 30 % leptoprosoper.

Index nasalis er 68,55. I kystdistriktene Helgoy, Torsken og Salangen findes en betydelig hoiere index, omkring 73, hvilket svarer til dens størrelse i de vestlandske brachycephale distrikter. Av samtlige undersøkte var 57 % leptorhine, 40 % mesorhine og 3 % chamærhine. Av lappene var 30 % leptorhine, 63 % mesorhine og 7 % chamærhine.

Den gjennemsnitlige avstand mellem de indre oienvinkler var 32,96 mm.

VI. **Plica marginalis** fandtes hos 12,8 % (se fig. 12). Den findes hos saavel norske som hos lapper og kvæner og i alle fylkets herreder. Men som jeg i et senere avsnit skal paavise, er denne eiendommelighet tilfort befolkningen ved krydsning med lappene.

Den gjennemsnitlige størelse av *mindste pandebredde er 11,09 cm.*

Den transversale fronto-parietale index (se tabel 29) er mindst hos lappene og storst hos kvænene. Forholdet mellem cephalindex og pandebredde fremgaar av tabel 31.

Blandt samtlige undersøkte er der 14 % stenometope, 37,5 % metriometope og 49,5 % eurymetope.

VII. Paa tabellene 33 til 37 er anfort de forskjellige kombinationer av haarfarver og øientyper. Det sees av tabel 34 at de lyse kombinationer, blaagraa øine med blondt og lysebrunt haar, forekommer hyppigst blandt dolichocephalene. Den mørkeste kombination (nr. 8), brune øine og sort haar, forekommer hyppigst blandt brachycephalene. Hvis jeg summerer sammen særskilt alle lyse træk og alle morke træk og gir dem værdi efter pigmenteringsgrad, finder jeg at den lyse blok inden denne befolkning utgjør 66 % og den morke blok 34 %. Hvis jeg gjør det samme for hver hodetype, finder jeg at den lyse blok har følgende størrelse: blandt dolichocephaler 68,7 %, blandt mesocephaler 70,3 %, blandt brachycephaler 63,9 %, blandt hyperbrachycephaler 62,3 %.

VIII. **Affinitetsundersøkelser.** Disse er utfort efter ANDREAS M. HANSENS metode, idet jeg mener at denne er at foretrække for beregning av korrelationskoefficienten efter BRAVAIS' formel.

Affinitetstallet er forholdet mellem den fundne brokdel av undersøkte hos hvem de to egenskaper findes kombinert, og det efter sandsynlighedsberegningen givne, naar de to egenskaper varierer uavhængig av hverandre. Et affinitetstal som er stort, tyder altsaa i almindelighet paa biologisk sammenhæng, medens et litet affinitetstal taler mot biologisk sammenhæng. Resultatet av disse undersøkelser findes paa tabellene 38 til 43.

Av disse undersøkelser fremgaar følgende:

1. At der indgaar i vor befolkning en stor mesocephal blok, leptoprosop, av stor legemshøide, eurymetop, med stor jugofrontal index, leptorhin, blond av haar og blaaøiet,

2. samt en mindre blok, brachycephal, euryprosop, av liten legemshøide, mesometop, med liten jugofrontal index, mesorhin, sorthaaret og brunøiet. Endelig indgaar der ogsaa

3. en endnu mindre, men hyperbrachycephal blok, sterkt euryprosopisk og av endnu mindre legemshøide end foregaaende gruppe, høigradig stenometop, chamærhin, brunhaaret og med lysere brune øine end foregaaende gruppe, samt med plica marginalis.

4. Ved affinitetsundersøkelse av lappene findes der ogsaa at indgaa i dem de samme 3 raceelementer. Lappene er derfor ingenlunde renracede. De er i høi grad præget av at være bastarder.

IX. **Befolkningens mosaikbillede ved kombination av de enkelte træk.** Jeg skal her gi en fremstilling av hvorledes de 6 vigtigste træk er kombinert, og jeg maa da indskrænke mig til det mindst mulige antal typer for hvert træk. Naar jeg regner med 4 hodetyper, 3 ansigtstyper, 2 næsetyper, 2 øientyper, 2 haartyper og 2 høidetyper, faar jeg i alt 192 mulige kombinationer. Av disse 192 tænkelige kombinationer blir dog en hel del ganske ubesat eller saa tyndt besat at man med én gang kan sætte dem ut av betragtning. Til gjengjæld samler andre linjer saa mange individer at man tydelig kan utpeke dem, og disse „linjer" gir saa at si befolkningen sit præg. For dolichocephalenes vedkommende er den mest markerte linje: *dolichocephali — leptoprosopi — leptorhini — lyse øine — lyst haar* (tab. 44).

Mesocephali følger nøiagtig den samme linje, nemlig: *mesocephali — leptoprosopi — leptorhini — lyse øine — lyst haar*, og man kan her med større sikkerhet tilføie at linjen ender i *stor legemshøide.* Da denne linje inden dolichocephalenes gruppe er den *eneste* som er markert og kontinuerlig, og som samtidig har høie affinitetstal, er det heller ingen grund til at tro at dolichocephalene inden denne befolkning repræsenterer nogen særskilt type. Dolichocephalene utgjør bare en *renere linje,* de er ÷-avvikere inden den store dolicho-mesocephale gruppe. Heller ikke er det inden disse to grupper mulig at øine nogen forskjel paa leptoprosoper og mesoprosoper. Leptoprosopene er kun at betragte som ÷-avvikere av den store leptomesoprosope gruppe. Jeg mener saaledes, at disse tabeller taler for at der i vor befolkning indgaar *en* stor dolichomesocephal gruppe med følgende træk: leptomesoprosopi — leptorhini — lyse øine — lyst haar — stor legemshøide. Denne type benævner jeg i det følgende *homo nordicus.*

Brachycephalene findes paa tabel 46. Av denne fremgaar at der hersker et biologisk motsætningsforhold mellem leptoprosopi og brachycephali, medens der utvilsomt er sterke biologiske baand som knytter brachycephali til meso-euryprosopi. Følger man denne linje videre, vil man se, at der er en sammenhængende biologisk velbegrundet række som gaar gjennem *mesoeury-prosopi — mesorhini — mørke øine — mørkt haar til liten legemsbygning*. Man gjenfinder altsaa her en række træk som samtlige er karakteristiske for *homo alpinus*.

Hyperbrachycephalene findes paa tabel 47. Nederst paa denne tabel finder man en ved høie affinitetstal sterkt markert og biologisk set vel sammenhængende linje som gaar gjennem *euryprosopi — mesorhini — mørke øine — mørkt haar til liten legemsbygning*. Vi gjenkjender straks disse træk som karakteristiske for den menneketype som av GIUFFRIDA-RUGGERI er kaldt den palæoarktiske, og som omfatter samojeder og lapper. Jeg vil i det følgende benævne denne type *homo palæoarcticus*. Fandtes hos 6,8 % hyperbrachycephale = 0,75 % av samtlige. Paa tabel 47 finder vi at den bedst besatte linje gaar gjennem hyperbrachycephali — euryprosopi — mesorhini — lyse øine — lyst haar til liten legemsbygning. Hele denne linje har ogsaa høie affinitetstal, og trækkene svarer helt igjennem til hvad vi nu finder hos lappene. Antropologisk set markerer denne bastard nr. 185 sig som en 1ste grads *bastard av homo palæoarcticus og homo nordicus*. Herhen kan ogsaa regnes bastard nr. 186—189. Jeg benævner i det følgende disse bastarder som *homo lapponicus*. Som 2den grads bastarder av homo nordicus og homo palæoarcticus maa bastardene nr. 177—184 betegnes. Disse er leptorhine; de karakteristiske lappetræk er sterkt utvandet i denne gruppe, som ogsaa er mêget sparsom i antal. 3dje grads bastarder er type nr. 161—176. Her har det norske element overtaket. De har kun hodeformen fra homo palæoarcticus. Betegnende er det ogsaa at inden denne gruppe er de høie i majoritet, medens ved 1ste og 2den grads bastarder de lave var i majoritet. Hvad ansigtsform angaar, maa hele denne gruppe nærmest betegnes som ÷-avvikere av den nordiske race. Ti leptoprosopi gaar meget daarlig sammen med hyperbrachycephali. Denne kombination forekommer kun hos 13 blandt samtlige undersøkte.

Brachycephalenes bastarder findes paa tabel 48. Den brachycephale urtypes oprindelige træk findes samlet kun hos 10 individer (type nr. 127) = 4,3 %. Den dolichocephale urtypes oprindelige træk fandtes samlet hos 24 %. Utregningen er da for begge typers vedkommende foretat i procent av hver enkelt types antal inden den nulevende befolkning. Det er da tydelig at den brachycephale blok har faat en ganske anderledes voldsom medfart, er blit ganske anderledes søndersplittet end den dolichocephale blok. Dette kan tænkes at bero paa at det nordiske element altid har følt sig som det overlegne. Draapevis, saa at si, har derfor det brachycephale element flytt ind i det nordiske element. Først naar dette har gaat for sig gjennem generationer, og den fremmede indblanding er begyndt at gaa i glemmeboken, har de bedre elementer av den nordiske race blandet sig med det fremmede element. Derfor er det brachycephale element blit saa sønderlemmet, medens det nordiske har holdt sig mere ubeskadiget. En anden forklaring er dog tænkelig, og den skal jeg komme tilbake til i et følgende avsnit.

Jeg har i dette avsnit prøvet, om der kan paavises typer som gir befolkningen sit præg. Jeg har hertil valgt 6 av de for menneskeracene mest karakteristiske træk. Hvert av disse træk er sandsynligvis avhængig av flere faktorpar. Da nu bare 10 faktorpar gir 1,048,576 mulige kombinationer, skulde man tro, at man inden en saa heterogen befolkning som denne vilde finde saa mange kombinationer at det ikke længer blev mulig at finde nogen orden i dette kaos. Av saa meget større interesse er det at se at en række hovedlinjer trær meget skarpt frem. Sammenhængen hermed er sandsynligvis følgende: Hver enkelt linnéisk art bestaar av mange forskjellige genotyper, som i sin sammensætning kan være en mere eller mindre fast gruppering av artens gener. En stor del av de teoretisk mulige genotyper er antagelig relativt lite levedygtige og gaar til grunde i kampen for tilværelsen allerede paa et tidlig stadium av sit liv. De linnéiske arters karakteristiske og ofte temmelig ensartede utseende skyldes temmelig sikkert, at mange av de krydsningsvarieteter som er mulige paa grund av artens gener, stadig holdes nede i kampen for tilværelsen.

Paa tabel 49 er anført, hvilke varieteter det er som i særlig grad præger den her beskrevne befolkning. De tykke streker antyder urtypenes træk, og de tynde streker er de hybride varieteters træk.

X. I dette avsnit søkes befolkningens mosaikbillede yderligere forenklet, idet her kun medtages 3 træk: 1. Index cephalicus, 2. Index facialis morphologicus, 3. Øienfarve. Jeg mener at man herved kan faa et meget skarpt og værdifuldt billede av en befolknings antropologiske sammensætning.

Inden denne befolkning finder jeg følgende 12 grupper (se fig. 13):

1. En dolichomesocephal, leptomesoprosopisk, lysøiet, 33,2 %, *homo nordicus.*
2. En brachycephal, euryprosopisk, brunøiet, 4,0 %, *homo alpinus.*
3. En hyperbrachycephal, euryprosopisk, brunøiet, 0,3 %, *homo palæoarcticus.*
4. En dolichomesocephal, leptomesoprosopisk, brunøiet, 6,6 %, *homo nordicus fuscus.*
5. En dolichomesocephal, euryprosopisk, lysøiet, 14,0 %, *homo nordicus var. euryprosopicus.*
6. En dolichomesocephal, euryprosopisk, brunøiet, 2,0 %, *homo alpinus var. dolichocephalicus.*
7. En brachycephal, leptomesoprosopisk, brunøiet, 16,4 %, *homo nordicus var. brachycephalicus.*
8. En brachycephal, leptomesoprosopisk, brunøiet, 4,8 %, *homo alpinus var. nordicus.*

9. En brachycephal, euryprosopisk, lysøiet, 9,5 %, *homo alpinus lividus.*
10. En hyperbrachycephal, leptomesoprosopisk, lysøiet, 4,5 %, *homo lapponicus var. nordicus.*
11. En hyperbrachycephal, leptomesoprosopisk, brunøiet, 1,1 %, *homo lapponicus var. alpinus.*
12. En hyperbrachycephal, euryprosopisk, lysøiet, 3,6 %, *homo lapponicus.*

XI. Jeg har i de foregaaende avsnit gjort rede for utbredelsen av de væsentligste antropologiske karaktertræk inden den nulevende befolkning. Den senere tids arvelighetsforskning har bragt paa det rene at flere av disse træk er overmaade stabile. De kan indgaa nye forbindelser, men de blir ellers uforanderlige. Dette gjælder særlig index cephalicus, index facialis og øienfarven. Professor E. Fischers og andre forskeres undersøkelser taler for at de nævnte træk ved krydsning følger de Mendelske lover. Vor kjendskap til de faktorer som fremkalder de her nævnte træk, er endnu lik nul. Sandsynligheten taler dog for at der er særskilte faktorer for hodets bredde og hodets længde, ansigtets høide og ansigtets bredde o.s.v. I en undersøkelse som denne vil det imidlertid være mest praktisk at betragte disse karaktertræk som arvelige enheter.

Ved den taksinometriske undersøkelse kom jeg til det resultat, at den her omhandlede befolkning er opstaat ved krydsning av 3 urtyper: en nordisk, en alpin og en lappoid i forholdet 66 : 30 : 4. Disse tal kan naturligvis ikke gjøre krav paa nogen matematisk nøiagtighet. I avsnit X gjorde jeg rede for utbredelsen av de nulevende bastarder.

Hvorledes svarer nu denne fordeling av bastardene til det man vil faa, om urtypene har krydset sig i det mængdeforhold som jeg har forutsat. Resultatet vil naturligvis avhænge av hvilke træk som er dominerende og hvilke recessive.

Om jeg tænker mig at to „rene" racer krydses, saa vil selvfølgelig i F_1-generationen alle recessive træk forsvinde saafremt de to blokker som krydses, har nøiagtig samme størrelse. I F_2-generationen vil de igjen komme frem, men i mindre antal end før krydsningen, medens de dominerende træk har øket i tilsvarende grad. Ved den fortsatte krydsning (panmiksi) vil de procentforhold som fandtes i F_2-generationen, forbli uforandret. Om den ene blok fra første stund har været større end den anden, saa vil selvfølgelig dette medføre at dennes karaktertræk forekommer i et større procenttal i F_2-generationen. Og dette vil ogsaa bli tilfældet i de senere generationer. Vi har herigjennem et utmerket middel til at utdype vor forstaaelse av et menneskesamfunds raceologiske oprindelse.

Jeg har nu paa en række tabeller utregnet, hvorledes det vil gaa hvis de 3 av mig forutsatte urtyper krydses panmiktisk. Paa tabel 55 findes utregnet resultatet, hvis hyperbrachycephali dominerer over brachycephali og dolichomesocephali, brachycephali over dolichomesocephali, euryprosopi over leptomesoprosopi, brune øine over lyse øine. Resultatet er opført i kolonne 10, og i kolonne 11 findes angit det av mig fundne antal av hver av disse varieteter. Det vil med én gang sees at efter disse lover kan krydsningen ikke være foregaat.

Jeg har derefter prøvet alle andre muligheter og kommer til slut til følgende resultat:

1. Den av mig undersøkte befolkning er opstaat ved krydsning av 3 forskjellige urtyper i de av mig forutsatte mængdeforhold.

2. Krydsningen er foregaat i alt væsentlig overensstemmende med de Mendelske lover og saaledes at hyperbrachycephali dominerer over brachycephali og dolichomesocephali, brachycephali dominerer over dolichomesocephali, leptoprosopi dominerer over euryprosopi. De brune og de mørkt melerte øine eier ikke fuld dominans over de blaagraa øine, idet heterozygotene har mellemfarvede øine. Under disse forutsætninger vil ialfald resultatet av krydsningen bli saaledes som fremstillet paa fig 15 a. Nu er resultatet av min undersøkelse saaledes som fremstillet paa fig. 15 b. Uoverensstemmelsene er, som man vil se, ganske smaa og uvæsentlige og er hovedsagelig begrænset til den hyperbrachycephale gruppe.

XII. **De fremmede elementer** bestaar av *lapper* og *kvæner*. Om de norske *lappers* høide kan denne undersøkelse ikke gi nogen oplysning, da alle de smaa lapper ved utskrivningen er slettet som utjenstdygtige. Det er værd at lægge merke til at ingen av de av mig undersøkte lapper var høiere end 171 cm. Disse lapper har jo i høi grad præg av at være bastarder; de har faat den nordiske races haar og øienfarve, men ingen har faat den nordiske races middelhøide. Dette taler ikke til gunst for den opfatning, at stor legemshøide dominerer over liten legemshøide ved krydsning. Ved de aller fleste krydsninger har moren været lap, og disse lappebastarders ringe legemshøide taler for at den kvindelige part av forældrene har en dominerende betydning ialfald for dette træks vedkommende.

Hodets bredde var 15,63 cm. og hodets længde 18,54 cm. Bredden svarer til 9,5 % og længden til 11,8 % av legemshøiden. Hodets ørehøide er 12,56 cm. Lappekraniets kapacitet blir da 1444 cm.^{3}.

Index cephalicus var 84,29. Ansigtsindex var 82,98. Index nasalis 73,9. Paa tabel 62 findes angit haarfarven. Øienfarven var hos 30 % blaagraa, hos 50 % melert, hos 20 % brun. Karakteristisk for lappene er den ringe pandebredde. Blandt nordmændene var der 14 % stenometope, 37,5 % metriometope og 49,5 % eurymetope. Blandt lappene derimot 50 % stenometope, 20 % metriometope og 30 % eurymetope. Sammenligner man de av mig fundne middeltal og serier med Mantegazzas, saa blir det klart at selv disse reneste norske lapper dog er sterkt opblandet med fremmede elementer.

Kvænenes legemshøide (M) var 166,2 cm. Deres index cephalicus var 82,06. Hodets ørehøide var 13,06 cm. Kraniets kubikindhold blir da 1432 cm.^{3}. Deres ansigtsindex var 84,29 cm. Ansigtet er relativt firkantet, idet kjævebredden er meget stor. Deres index nasalis var 67,35. De er meget lyse baade av haar og øine, men naar dog i denne henseende paa langt nær op mot den norske befolkning. Jeg fandt lyse oine hos 65 0/0 og mørke oine hos 35 0/0, lyst haar hos 53 0/0 og morkt haar hos 47 0/0.

XIII. I dette avsnit gives en kort oversigt over de enkelte herreders antropologi.

Opsummeret i faa ord maa man si om den her beskrevne befolkning, at den er hoi av vekst (169,3 cm.), subbrachycephal (ind. 80,7), mesoprosopisk (ind. 85,1), leptorhin (68,5), lys av oine og haar.

Kyst- og øbefolkningen er av samme slags som den saakaldte vestnorske befolkning, som vi kjender vest fra Jæderen og Sondmor.

Jordbruksdistriktenes befolkning og indlandsbefolkningen til eks. i Bardu og Maalselv svarer i alt væsentlig til indlandsbefolkningen i Sydnorge (Østerdalen). De fremmede elementer (som lapper og kvæner) er saa sparsomme at de ikke kan sætte noget præg paa befolkningen.

2. Deutsch.

I. Die Untersuchung umfaßt 662 Männer im Alter von 20—21 Jahren, sämtlich aus Troms Amte im nördlichen Norwegen. Man nimmt jetzt an, daß die Besiedelung 1000 Jahre v. Chr. hier herauf gelangt war.

Die Bevölkerung ist hier sehr ungleichartig. Der Grundstamm ist zweifellos norwegisch; 8 0/0 halten sich selbst für Lappen und 2 0/0 für Finnländer. Durch viele Generationen haben sich jedoch Norweger, Lappen und Finnen untereinander gekreuzt. Man darf daher hier oben nur mit Vorsicht von Rassenreinheit reden. Aus der Tabelle 2 scheint hervorzugehen, daß das norwegische Element in gleichmäßigem Wachstum begriffen ist. Dieses ist jedoch nur ein Selbstbetrug. Die Bastarde rechnen sich nämlich als norwegisch in der 2ten und 3ten Generation. Da nun die Rasseeigentümlichkeiten nicht verschwinden, wird dieses in der Wirklichkeit sagen, daß die norwegische Rasse im Troms Amte für jedes Jahr, das vergeht, immer mehr durch fremde Elemente verunreinigt wird. An den Fjords entlang und auf den Inseln im Troms Amte wohnt eine Bevölkerung, die gewöhnlich „Sjöfinner" (Seefinnen) genannt werden. Diese bilden einen ziemlich großen Prozentsatz von der jetzigen Bevölkerung. Über die Herkunft dieser Seefinnen ist man noch nicht einig. Einige meinen, daß es nur verarmte Gebirgslappen sind. Andere meinen, daß diese Seefinnen zum Teil die Reste einer alten „anarischen" Bevölkerung sind, die hier oben gewohnt haben, ehe die Norweger dahinkamen.

II. **Die Körperhöhe** (M) ist 169,287 cm. Die Standardabweichung (σ) beträgt 6,78. Der Variationskoefficient (υ) = 4,004. Die Körperhöhe ist in den verschiedenen Bezirken sehr ungleich (siehe Tabelle 4). Am geringsten ist sie in den Bezirken, wo es viele Lappen oder Seefinnen gibt (Lyngen und Karlsöy). Am größten ist sie in den Bezirken, wo es viele Zugezogene aus den größten Tälern, Österdalen und Gudbrandsdalen, des südlichen Norwegens gibt. Die Kurve für die Körperhöhe (Fig. 3) hat 6 sehr deutliche Spitzen und hat einen viel mehr langgedehnten Verlauf, als man sonst für gewöhnlich in Norwegen findet.

III. **Pigmentierung.** Blaugraue Augen haben 58,5 %, hell melierte Augen 19,9 %, dunkel melierte Augen 8,9 %, braune Augen 12,7 %. Braune Augen entsprechen MARTINS Tafeln 4 und 5. Die meisten braunäugigen findet man im Bezirke Lyngen (30,6 %), sie Tabelle 11. Es sind die Lappen und die sogenannten Seefinnen, die der Bevölkerung hier so viele braunäugige Individuen zuführen. Bei den echten Gebirgslappen hat MANTEGAZZA folgende Zahlen gefunden; blauäugige 30 %, melierte Augen 40 %, braune Augen 30 %. Die echten Gebirgslappen haben demnach nicht dunklere Augen als die Bevölkerung in Lyngen. Da nun mindestens 50 % von der Bevölkerung in Lyngen von rein nordischer Herkunft sind, und also blaue Augen gehabt haben, erscheint es wenig wahrscheinlich, daß die Bevölkerung in Lyngen durch Kreuzung mit Gebirgslappen so stark braunäugig geworden sein kann. Dieses spricht dafür, daß es die Seefinnen sein müssen, die der Bevölkerung in Lyngen so viele braunäugige zugeführt haben, und die Seefinnen müssen dann mehr braunäugig gewesen sein als die Lappen.

Die größte Anzahl blauäugige Individuen findet man in Bardu und Maalselv. Die Bevölkerung hier ist zum großen Teil vor ca. 100 Jahren aus Österdalen und Gudbrandsdalen zugezogen. Aus der Tabelle 10 geht auch hervor, daß die Augenfarbe in Bardu und Maalselv derjenigen sehr nahe steht, die jetzt im nördlichen Österdal vorherrscht. Das ist ein neuer Beweis für die Zähigkeit, womit diese Eigenschaft vererbt wird.

Die Haarfarbe. Unter sämtlichen untersuchten Individuen fanden sich 23,4 % hellblonde, 1,5 % rothaarige, 34,0 % mit hellbraunem Haar, 33,9 % mit dunkelbraunem und 7,2 % mit schwarzem Haar. Die meisten Schwarzhaarigen entsprechen FISCHERS Typus Nr. 4. Diejenigen Bezirke, wo die meisten Dunkelhaarigen vorkommen, sind dieselben, welche die meisten Braunäugigen und die meisten kleinen Leute aufzuweisen hatten. Es scheint sicher zu sein, daß es die Seefinnen sind, die der Bevölkerung so viele Schwarzhaarige zugeführt haben. Wenn man die Haarfarbe der Bevölkerung z. B. in Lyngen mit dem vergleicht, was MANTEGAZZA bei den Gebirgslappen gefunden hat, erscheint es klar, daß es nicht die Lappen sind, die der Bevölkerung ihre dunklen Haare gebracht haben. Es gibt weniger Schwarzhaarige unter den Lappen als bei dieser Bevölkerung.

In Fig. 5 ist der Pigmentierungsgrad für die verschiedenen Bezirke dargestellt, indem Haarfarbe und Augenfarbe zusammengerechnet worden sind (Pigmentindex).

IV. **Der Kopf.** Die mittlere Länge ist für sämtliche Individuen 19,28 cm. Bei den Norwegern ist sie 19,4 cm., bei den Lappen 18,5 cm. Die mittlere Breite ist 15,41 cm., bei den Lappen 15,6 cm.

Die durchschnittliche Größe des Index cephalicus ist 80,77. Den niedrigsten Index findet man in Bardu (79,3) und Maalselv (79,1) Im übrigen kann ich auf die Indexkarte (Fig. 8) hinweisen. Die Kurve für Index cephalicus (siehe Fig. 9) hat eine deutliche Spitze bei Index 80, außerdem zwei deutliche Spitzen bei Index 83 und 87. Es ist anzunehmen, daß die letztere den Lappen zuzuschreiben ist. Die Spitze bei Index 83 entspricht ganz dem, was man auch sonst in Norwegen, besonders im westlichen findet.

In der Tabelle 20 ist das Verhältnis zwischen Länge und Breite des Kopfes samt Körperhöhe bei Norwegern und Lappen dargestellt. Bei den Lappen beträgt die Kopfbreite ca. 15,6 % von der Körperhöhe, diese möge nun groß oder klein sein. Bei Norwegern dagegen nur 15,2 %. Die Länge des Kopfes beträgt bei den Lappen 18,0—18,4 % von der Körperhöhe, bei den Norwegern dagegen von 19,0—19,3 %. Ich fand 6 % Dolichoceph., 47 % Mesoceph., 39 % Brachyceph., 8 % Hyperbrachyceph.

V. Die mittlere Höhe des *Gesichts* ist 12,05, die mittlere Breite 14,14, Der Index facialis morphologicus ist 85,1. Dieser letztere ist sehr verschieden in den verschiedenen Bezirken (siehe Karte Fig. 10). Die schmalsten Gesichter findet man in Bardu und Maalselv, wo man auch die größte Körperhöhe, den kleinsten Index cephalicus, die größte Anzahl Blondhaarige und Helläugige hatte.

Die breitesten Gesichter findet man in Helgöy (Nr. 23 in Fig. 10). Dieses ist recht auffällig. Denn unter den von mir Untersuchten aus Helgöy war niemand von lappischer Herkunft, und es ist ja überhaupt wenig wahrscheinlich, daß die Lappen jemals in solcher Anzahl auf einer Insel im Eismeer gewohnt haben sollten, daß sie der Bevölkerung ihren Stempel einimpfen konnten. Die jetzige Bevölkerung muß daher ihr breites Gesicht einem anderen Volkstypus als den Lappen verdanken. Die Kurve für den Gesichtsindex (Index facialis morphologicus) ist in Fig. 11 gezeichnet und hat, wie man sieht, 3 Spitzen: bei Index 83, 85 und 88.

Im ganzen Amte habe ich 37 % Euryprosopen, 33 % Mesoprosopen und 30 % Leptoprosopen (siehe Tabelle 24) gefunden.

Der Index nasalis ist 68,55. In den Küstenbezirken Helgöy, Torsken und Salangen findet man einen beträchtlich höheren Index, etwa 73, was ungefähr dessen Größe in den westländischen brachycephalen Bezirken entspricht.

Von sämtlichen Untersuchten waren 57 % leptorhin, 40 % mesorhin und 3 % chamärhin.

Die durchschnittliche Entfernung zwischen den innern Augenwinkeln war 32,96 mm.

VI. **Plica marginalis** war vorhanden bei 12,8 % (siehe fig. 12). Sie kommt vor sowohl bei Norwegern wie bei Lappen und Finnen und in allen Bezirken des Amtes. Wie ich aber in einem späteren Abschnitt nachweisen werde, ist diese Eigentümlichkeit der Bevölkerung durch Kreuzung mit den Lappen zugeführt worden.

Das durchschnittliche Maß der *kleinsten Stirnbreite ist 11,09 cm.*

Der transversale fronto-parietale Index (siehe Tabelle 29) ist am kleinsten bei den Lappen und am größten bei den Kvänen. Das Verhältnis zwischen Cephalindex und Stirnbreite geht aus der Tabelle 31 hervor.

Von sämtlichen Untersuchten sind 14,0 % stenometop, 37,5 % metriometop und 49,5 % eurymetop.

VII. In den Tabellen 33 bis 37 sind die verschiedenen Kombinationen von Haarfarbe und Augentypus angeführt. Man sieht aus der Tabelle 34, daß die hellen Kombinationen: blaugraue Augen mit blondem oder hellbraunem Haar, bei den Dolichocephalen am häufigsten vorkommen. Die dunkelste Kombination (Nr. 8), braune Augen und schwarzes Haar, kommt am häufigsten unter den Brachycephalen vor. Wenn ich alle hellen und alle dunklen Züge für sich addiere und ihnen ihren Wert nach dem Pigmentierungsgrade gebe, finde ich, daß der helle Block innerhalb dieser Bevölkerung 66 %, und der dunkle Block 34 % umfaßt. Wenn ich für jeden Haupttypus ebenso verfahre, finde ich, daß der helle Block folgende relative Größe hat: bei den Dolichocephalen 68,7 %, bei den Mesocephalen 70,3 %, bei den Brachycephalen 63,9 %, bei den Hyperbrachycephalen 62,3 %.

VIII. **Affinitätsuntersuchungen.** Diese sind nach dem Verfahren des Dr. ANDREAS M. HANSEN ausgeführt, das nach meiner Meinung der Berechnung von Korrelations-Koefficienten nach der Formel BRAVAIS vorzuziehen ist.

Die Affinitätszahl ist das Verhältnis zwischen dem gefundenen Bruchteil von Untersuchten, bei denen die zwei Eigenschaften zusammen vorkommen, und dem aus der Wahrscheinlichkeitsberechnung hervorgehenden Bruchteil, wenn die zwei Eigenschaften als von einander unabhängige Variable auftreten. Eine große Affinitätszahl deutet also im allgemeinen auf einen biologischen Zusammenhang, während eine kleine Affinitätszahl gegen den biologischen Zusammenhang spricht. Das Resultat dieser Untersuchungen ist aus den Tabellen 38 bis 43 zu ersehen.

Aus diesen Untersuchungen geht Folgendes hervor:

1. Es besteht in unserer Bevölkerung ein großer mesocephaler Block, leptoprosop, von großer Körperhöhe, euryprosop, mit großem jugo-frontalem Index, leptorhin, mit blonden Haaren und blauäugig,

2. sowie ein kleinerer Block, brachycephal, euryprosop, von kleiner Körperhöhe, mesometop, mit kleinem jugo-frontalem Index, mesorhin, schwarzhaarig und braunäugig. Endlich haben wir auch

3. einen noch kleineren, aber hyperbrachycephalen Block, stark euryprosopisch und von noch geringerer Körperhöhe als die vorhergehende Gruppe, hochgradig stenometop, chamärhin, mit braunem Haar und helleren braunen Augen als die vorhergehende Gruppe, sowie mit Plica marginalis.

4. Bei der Affinitätsuntersuchung unter den Lappen findet man auch bei ihnen dieselben 3 Rasseelemente wieder. Die Lappen sind daher durchaus nicht reinrassig. Sie haben in hohem Grade das Gepräge von Bastarden.

IX. **Das Mosaikbild der Bevölkerung** bei Kombination der einzelnen Züge. Ich werde hier eine Darstellung davon geben, wie die 6 wichtigsten Züge kombiniert sind, und muß mich dabei für jeden Zug auf eine möglichst geringe Anzahl Typen beschränken. Wenn ich 4 Kopftypen, 3 Gesichtstypen, 2 Nasentypen, 2 Augentypen, 2 Haartypen und 2 Höhentypen rechne, werde ich im ganzen 192 mögliche Kombinationen haben. Von diesen 192 denkbaren Kombinationen bleibt doch ein ganzer Teil unbesetzt oder so schwach besetzt, daß man sie gleich außer Betracht setzen kann. Dafür umfassen andere Linien so viele Individuen, daß man diese deutlich zeichnen kann, und diese „Linien" geben der Bevölkerung so zu sagen ihr Gepräge. Für die Dolichocephalen ist die am stärksten markierte Linie: *Dolichocephalie — Leptoprosopie — Leptorhinie — helle Augen — helles Haar* (Tab. 44). Die Mesocephalie folgt genau derselben Linie, nämlich: *Mesocephalie — Leptoprosopie — Leptorhinie — helle Augen — helles Haar*, und man kann hier mit größerer Sicherheit hinzufügen, daß die Linie mit *großer Körperhöhe* abschließt.

Da innerhalb der Gruppe der Dolichocephalen diese Linie die *einzige* scharfe und kontinuierliche ist und gleichzeitig hohe Affinitätszahlen hat, liegt auch kein Grund zu der Annahme vor, daß die Dolichocephalen innerhalb dieser Bevölkerung einen gesonderten Typus darstellen. Die Dolichocephalen bilden nur eine *reinere Linie*, sie sind die ÷-Abweichenden innerhalb der großen dolichomesocephalen Gruppe. Es ist auch innerhalb dieser zwei Gruppen nicht möglich, einen Unterschied zwischen Leptoprosopen und Mesoprosopen zu entdecken. Die Leptoprosopen sind nur als ÷-Abweichende von der großen leptomesoprosopen Gruppe anzusehen. Nach meiner Meinung sprechen demnach diese Tabellen dafür, daß in unserer Bevölkerung *eine* große dolichomesocephale Gruppe besteht und zwar mit folgenden Zügen: Leptomesoprosopie — Leptorhinie — helle Augen — helles Haar — große Körperhöhe. Diesen Typus werde ich im folgenden *Homo nordicus* nennen.

Die *Brachycephalen* findet man in der Tabelle 46. Aus dieser geht hervor, daß zwischen Leptoprosopie und Brachycephalie ein Gegensatz besteht, während zweifellos starke biologische Bande die Brachycephalie mit der Mesoeuryprosopie verbinden. Verfolgt man diese Linie weiter, wird man sehen, daß es eine zusammenhängende, biologisch wohl begründete Reihe gibt, die durch *Mesoeuryprosopie — Mesorhinie — dunkle Augen — dunkles Haar* zu *kleinem Körperbau* geht. Man findet also hier eine Reihe von Zügen wieder, die sämtlich für *Homo alpinus* charakteristisch sind.

Die *Hyperbrachycephalen* findet man in der Tabelle 47. Unten in dieser Tabelle findet man eine durch hohe Affinitätszahlen scharf gekennzeichnete und biologisch gut zusammenhängende Linie, die durch *Euryprosopie* — *Mesorhinie* — *dunkle Augen* — *dunkles Haar* zu *kleinem Körperbau* verläuft. Diese Züge erkennen wir gleich als für denjenigen Menschentypus charakteristisch, der von GIUFFRIDA-RUGGERI der paläoarktische genannt wird, und der Samojeden und Lappen umfaßt. Im folgenden will ich diesen Typus *Homo palæoarcticus* nennen. 6,8 % von den Hyperbrachycephalen oder 0,75 % von sämtlichen gehörten zu diesem Typus.

In der Tabelle 47 finden wir, daß die am besten besetzte Linie durch Hyperbrachycephalie — Euryprosopie — Mesorhinie — helle Augen — helles Haar zu kleinem Körperbau geht. Diese ganze Linie hat auch hohe Affinitätszahlen, und die Züge entsprechen durchaus dem, was wir jetzt bei den Lappen finden. Anthropologisch gesehen zeichnet sich dieser Bastard Nr. 185 aus als *Bastard ersten Grades des Homo palæoarcticus und Homo nordicus*. Hierzu kann man auch die Bastarde Nr. 186—189 rechnen. Ich werde im Folgenden diese Bastarde als *Homo lapponicus* bezeichnen. Als Bastarde zweiten Grades von Homo nordicus und Homo palæoarcticus muß man die Bastarde Nr. 177—184 bezeichnen. Diese sind leptorhin, die charakteristischen Lappenzüge sind stark verwässert in dieser Gruppe, die auch der Zahl nach nur spärlich vertreten ist.

Bastarde dritten Grades sind die Typen Nr. 161—176. Hier hat das norwegische Element die Oberhand. Sie haben nur die Kopfform vom Homo palæoarcticus. Bezeichnend ist es auch, daß innerhalb dieser Gruppe die hohen Menschen in der Majorität sind, während bei den Bastarden ersten und zweiten Grades die kleinen in der Majorität waren. Was die Gesichtsform anbetrifft, so wird diese ganze Gruppe wohl am richtigsten als ÷-Abweichende von der nordischen Rasse bezeichnet. Denn Leptoprosopie geht sehr schlecht mit Hyperbrachycephalie zusammen. Diese Kombination kommt nur bei 13 von sämtlichen Untersuchten vor.

Die Bastarde der Brachycephalen stehen in der Tabelle 48. Die ursprünglichen Züge des brachycephalen Urtypus findet man alle zugleich nur bei 10 Individuen (Typus Nr. 127) = 4,3 %. Die ursprünglichen Züge des dolichocephalen Urtypus findet man zusammen bei 24 %. Die Ausrechnung ist hier für beide Typen in Prozent von der Anzahl jedes einzelnen Typus innerhalb der jetzigen Bevölkerung ausgedrückt. Es erscheint da deutlich, daß der brachycephale Block eine ganz andere gewaltige Einwirkung erlitten hat, ganz anders zersplittert worden ist als der dolichocephale Block. Dieses kann vielleicht darin begründet sein, daß das nordische Element sich immer als das überlegene gefühlt hat. Tropfenweise ist daher das brachycephale Element so zu sagen in das nordische Element eingesickert. Erst wenn dieses durch Generationen stattgefunden hat und die fremde Einmischung angefangen hat in's Vergessen zu geraten, haben die besseren Elemente der nordischen Rasse sich mit dem fremden Elemente vermischt. Aus diesem Grunde ist das brachycephale Element so sehr zerstückelt worden, während das nordische Element sich mehr unbeschädigt erhalten hat. Eine andere Erklärung ist allerdings auch denkbar, auf die ich weiter unten zurückkommen werde.

In diesem Abschnitt habe ich festzustellen versucht, ob Typen nachgewiesen werden können, die der Bevölkerung ihr Gepräge geben. Ich habe hierzu 6 von den charakteristischen Zügen gewählt. Jeder von diesen Zügen ist wahrscheinlich von mehreren Faktorpaaren abhängig. Da nun schon 10 Faktorpaare 1,048,576 mögliche Kombinationen geben, sollte man glauben, daß man innerhalb einer so heterogenen Bevölkerung, wie die vorliegende, so viele Kombinationen finden würde, daß es nicht mehr möglich wäre, in dem Chaos eine Ordnung zu finden. Um so interessanter ist es zu sehen, daß eine Reihe von Hauptlinien sehr scharf hervortreten. Dieses hängt wahrscheinlich, wie folgt, zusammen: Jede einzelne Linnéische Art besteht aus vielen verschiedenen Genotypen, die in ihrer Zusammensetzung eine mehr oder weniger feste Gruppierung von den Genen der Art sein können. Ein großer Teil von den theoretisch möglichen Genotypen ist wahrscheinlich verhältnismäßig wenig lebensfähig und geht schon in einem frühen Stadium seines Lebens im Kampfe um's Dasein zugrunde. Das charakteristische und oft ziemlich gleichartige Aussehen der Linnéischen Arten ist ziemlich sicher dem Umstande zuzuschreiben, daß viele von den Kreuzungsabarten, die mit Rücksicht auf die Genen der Art möglich sind, ständig im Kampfe um's Dasein niedergehalten werden.

In der Tabelle 49 sind die Varietäten angeführt, die die hier beschriebene Bevölkerung besonders prägen. Die dicken Linien deuten die Züge der Urtypen an und die dünnen diejenigen der hybriden Varietäten.

X. In diesem Abschnitt werden wir trachten, das Mosaikbild der Bevölkerung weiter zu vereinfachen, indem wir nur 3 Züge mitnehmen: 1. Index cephalicus, 2. Index facialis morphologicus, 3. Die Augenfarbe. Ich bin der Ansicht, daß man auf diesem Wege ein sehr scharfes und wertvolles Bild von der anthropologischen Zusammensetzung einer Bevölkerung erhalten kann.

In dieser Bevölkerung finde ich folgende 12 Gruppen (siehe Fig. 13):

1. Eine dolichomesocephale, leptomesoprosopische, helläugige, 33,2 %, *Homo nordicus.*
2. Eine brachycephale, euryprosopische, braunäugige, 4,0 %, *Homo alpinus.*
3. Eine hyperbrachycephale, euryprosópische, braunäugige, 0,3 %, *Homo palæoarcticus.*
4. Eine dolichomesocephale, leptomesoprosopische, braunäugige, 6,6 %, *Homo nordicus fuscus.*
5. Eine dolichomesocephale, euryprosopische, helläugige, 14,0 %, *Homo nordicus var. euryprosopicus.*
6. Eine dolichomesocephale, euryprosopische, braunäugige, 2,0 %, *Homo alpinus var. dolichocephalicus.*

7. Eine brachycephale, leptomesoprosopische, braunäugige, 16,4 %, *Homo nordicus var. brachycephalicus.*
8. Eine brachycephale, leptomesoprosopische, braunäugige, 4,8 %, *Homo alpinus var. nordicus.*
9. Eine brachycephale, euryprosopische, helläugige, 9,5 %, *Homo alpinus lividus.*
10. Eine hyperbrachycephale, leptomesoprosopische, helläugige, 4,5 %, *Homo lapponicus var. nordicus.*
11. Eine hyperbrachycephale, leptomesoprosopische, braunäugige, 1,1 %, *Homo lapponicus var. alpinus.*
12. Eine hyperbrachycephale, prosopische, helläugige, 3,6 %, *Homo lapponicus.*

XI. In den vorhergehenden Abschnitten habe ich das Auftreten der wesentlichsten anthropologischen Charakterzüge bei der jetzigen Bevölkerung dargelegt. Die Erblichkeitsforschung der neueren Zeit hat den Beweis erbracht, daß mehrere dieser Züge außerordentlich stabil sind. Sie können neue Verbindungen eingehen, bleiben aber sonst unveränderlich. Dieses gilt besonders vom Index cephalicus, Index facialis und der Augenfarbe. Die Untersuchungen Professor E. FISCHERS und anderer Forscher sprechen dafür, daß die genannten Züge bei Kreuzungen den Mendelschen Gesetzen folgen. Unsere Kenntnisse über diejenigen Faktoren, die die hiergenannten Züge hervorrufen, sind bis jetzt gleich Null. Die Wahrscheinlichkeit spricht jedoch dafür, daß es besondere Faktoren gibt für die Breite und Länge des Kopfes, die Höhe und Breite des Gesichtes u. s. w. Für eine Untersuchung wie die vorliegende wird es jedoch am praktischsten sein, diese Charakterzüge als erbliche Einheiten zu betrachten.

Bei der taxinometrischen Untersuchung kam ich zu dem Resultate, daß die hier besprochene Bevölkerung durch Kreuzung von 3 Urtypen: einer nordischen, einer alpinen und einer lappoiden im Verhältnis 66 : 30 : 4 entstanden ist. Diese Zahl kann selbstverständlich nicht auf irgend welche mathematische Genauigkeit Anspruch machen. Im Abschnitt X habe ich die Verbreitung der heute lebenden Bastarde besprochen.

Wie weit stimmt nun diese Verteilung der Bastarde mit dem, was man erhalten muß, wenn die Urtypen sich in dem von mir angenommenen Mengenverhältnis gekreuzt haben? Das Resultat wird naturgemäß von der Frage abhängen, welche Züge dominierend und welche recessiv sind.

Wenn ich mir vorstelle, daß zwei „reine" Rassen sich kreuzen, so werden selbstverständlich in der Generation F_1 alle recessiven Züge verschwinden, wenn die zwei sich kreuzenden Blöcke genau gleich groß sind. In der Generation F_2 werden sie wieder zum Vorschein kommen, jedoch in geringerer Zahl als vor der Kreuzung, während die dominierenden Züge im entsprechenden Grade zugenommen haben. Bei der fortgesetzten Kreuzung (Panmixie) werden die prozentualen Verhältnisse, die man bei der Generation F_2 fand, unverändert bleiben. Wenn der eine Block von Anfang an größer gewesen ist als der andere, so wird die Folge selbstverständlich die sein, daß die Charakterzüge desselben in der Generation F_2 in einem größeren prozentualen Verhältnis vorkommt. Und dieses wird auch in den späteren Generationen so sein. Wir haben hier ein ausgezeichnetes Mittel um unser Verständnis für den rasseologischen Ursprung einer Menschengemeinschaft zu vertiefen.

In einer Reihe von Tabellen habe ich nun ausgerechnet, wie es sich gestalten wird, wenn die 3 von mir vorausgesetzten Urtypen panmiktisch gekreuzt werden. In der Tabelle 55 findet man das Resultat ausgerechnet für den Fall, daß Hyperbrachycephalie gegenüber Brachy- und Dolichomesocephalie dominiert, Brachycephalie über Dolichomesocephalie, Euryprosopie über Leptomesoprosopie, braune Augen über helle Augen. Das Resultat ist in der Kolonne 10 angegeben, und in der Kolonne 11 ist die von mir gefundene Anzahl von jeder einzelnen dieser Varietäten angegeben. Man wird sofort sehen, daß die Kreuzung nicht nach diesen Gesetzen stattgefunden haben kann.

Ich habe darnach alle anderen Möglichkeiten geprüft und komme schließlich zu folgendem Ergebnis:

1. Die von mir untersuchte Bevölkerung ist durch Kreuzung von 3 verschiedenen Urtypen in den von mir vorausgesetzten Mengenverhältnissen entstanden.

2. Die Kreuzung hat in allem Wesentlichen mit den Mendelschen Gesetzen in Übereinstimmung stattgefunden und zwar so, das Hyperbrachycephalie über Brachycephalie und Dolichomesocephalie dominiert, Brachycephalie über Dolichomesocephalie, Leptoprosopie über Euryprosopie. Die braunen und die dunkel melierten Augen haben keine volle Dominanz über die blaugrauen Augen, indem die Heterozygoten mittelfarbige Augen haben. Unter diesen Voraussetzungen wird jedenfalls das Resultat der Kreuzung so werden, wie in der Fig. 15 a dargestellt. Nun ist das Resultat von meiner Untersuchung so wie in der Fig. 15 b dargestellt. Die Differenzen sind, wie man sieht, ganz klein und unwesentlich und sind hauptsächlich auf die hyperbrachycephale Gruppe beschränkt.

XII. **Die fremden Elemente** bestehen aus *Lappen* und *Kvänen.* Über die Höhe der norwegischen *Lappen* kann diese Untersuchung keine Auskunft geben, da alle die kleinen Lappen bei der Aushebung als dienstuntauglich ausgeschaltet sind. Es ist bemerkenswert, daß keiner von den von mir untersuchten Lappen höher war als 171 cm. Diese Lappen haben ja in hohem Grade die Merkmale der Bastarde; sie haben das Haar und die Augenfarbe der nordischen Rasse, aber keine von ihnen haben die mittlere Höhe der nordischen Rasse erreicht. Dieses spricht nicht zu Gunsten der Auffassung, daß bei Kreuzung große Körperhöhe über kleine Körperhöhe dominiert. Bei den aller meisten Kreuzungen ist die Mutter Lappin gewesen, und die geringe Körperhöhe dieser Lappenbastarde spricht dafür, daß die weibliche Seite der Eltern jedenfalls diesen Zug betreffend eine dominierende Bedeutung hat.

Die Breite des Kopfes war 15,63 cm. und seine Länge 18,54 cm. Die Breite entspricht 9,5 % und die Länge 11,8 % von der Körperhöhe. Die Ohrenhöhe des Kopfes ist 12,56 cm. Die Kapacität des Lappenkraniums wird dann gleich 1444 $cm.^3$.

Der Index cephalicus war 84,29. Der Gesichtsindex war 82,98. Der Index nasalis 73,9. In der Tabelle 62 findet man die Angaben über die Haarfarbe. Die Augenfarbe war bei 30 % blaugrau, bei 50 % meliert, bei 20 % braun. Charakteristisch für die Lappen ist die geringe Stirnbreite. Unter den Norwegern waren 14 % stenometop, 37,5 % metriometop und 49,5 % eurymetop. Unter den Lappen dagegen waren 50 % stenometop, 20 % metriometop und 30 % eurymetop. Wenn man die von mir gefundenen Mittelzahlen und Serien mit denen MANTEGAZZAS vergleicht, so erscheint es klar, daß selbst diese reinsten norwegischen Lappen doch stark mit fremden Elementen vermischt sind.

Die Körperhöhe der Kvänen (M) war 166,2 cm., ihr Index cephalicus 82,06, die Ohrenhöhe des Kopfes 13,06 cm. Der Kubikinhalt des Kraniums wird demnach 1432 $cm.^3$. Ihr Gesichtsindex war 84,29 cm. Ihr Gesicht ist relativ viereckig, weil die Kiefernbreite sehr groß ist. Ihr Index nasalis war 67,35. Sie sind sehr hell sowohl in bezug auf die Haare wie in bezug auf die Augen, können aber doch in dieser Beziehung bei weitem nicht mit den Norwegern verglichen werden. Helle Augen fand ich bei 65 % und dunkle Augen bei 35 %, helles Haar bei 53 % und dunkles Haar bei 47 %.

XIII. In diesem Abschnitt wird eine kurze Übersicht über die Anthropologie der einzelnen Bezirke gegeben.

In wenige Worte zusammengefaßt muß man von der hier beschriebenen Bevölkerung sagen, daß sie von hohem Wuchs ist (169,3 cm.), subbrachycephal (Index 80,7), mesoprosopisch (Index 85,1), leptorhin (68,5), mit hellen Augen und Haaren.

Die Bevölkerung der Küste und der Inseln ist von derselben Art wie die sogenannte westnorwegische Bevölkerung, die wir aus dem Westen, aus Jäderen und Söndmör kennen.

Die Bevölkerung der landwirtschaftlichen Gegenden und des Binnenlandes z. B. in Bardu und Maalselv entspricht in allem wesentlichen der Bevölkerung des Binnenlandes im südlichen Norwegen (Österdalen). Die fremden Elemente (wie Lappen und Kvänen) sind so spärlich, daß sie der Bevölkerung kein besonderes Gepräge verleihen können.

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Trykt den 26. april 1922.