Bathymetry and bottom sediments off the coast of Iceland.

John K. Hartsook

Hydrographic Office Mar 1950

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by

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The purpose of this report is to present the results of a reconnaissance study of the bottom sediments and bathymetry off the coast of Iceland made during the winters of 1947-48, 1948-49, and 1949-50.

The report consists of (1) six British Admiralty hydrographic charts; (2) one index chart showing the location of the above; and (3) a written description and interpretation of the charts. The six hydrographic charts, ranging in scale from 1: 254,000 to 1:287,468, show the distribution of the various bottom types. They completely encircle Iceland, showing all of the coastline and the waters covering the surrounding submarine shelf. The index chart, scale 1:750,000, shows all of Iceland, the submarine shelf, and the submarine slope beyond the shelf. All charts were obtained through the courtesy of the U.S.Hydrographic Office.

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by the author. However, it is hoped that this report may be useful as a guide to future investigators in this field.

Beside the purely descriptive analysis of sediment distribution, an attempt has been made in places to interpret the geology of the seabottom from the submarine relief, from the pattern of the bottom types, and from the known geological history of the adjacent land.

In this report distances are measured in nautical miles. The latitude subdivisions along the sides of the charts may be used for a graphic scale, with each minute of latitude equalling one mile.

Types of Bottom

Six bottom types are portrayed on the charts. These are: sand, sand and mud, mud, rock, gravel, and coral. A diagonal overprint is used to indicate the presence of shells in any of the above types.

Since bottom notations are the chief source of information the authenticity of the bottom types outlined depends upon the accuracy of the notations. Shepard, in his report on the continental shelf sediments, written for the symposium, "Recent Marine Sediments"

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(24,p.xii) states that, although loamy is geological terminology, the agronomist usually describes the sample as faithfully as a geologist would without microscopic examination. Sand and gravel are almost always terrigenous materials. The finer sediments, termed "mud", may be interpreted geologically as silt and clay, sometimes containing a small proportion of sand. The term "ooze" when used on continental shelves is probably applied to "soft liquid mud which resembles deep-sea ooze in appearance but is not of organic origin (19,p.xviii)."

Regarding rock bottom, in the passage from "Recent Marine Sediments" Shepard states the following:

> "The term 'rocky' is generally based either on the finding of rocks or cores at the sampling localities or on the presence of angular rock fragments in the sample. Such observations do not prove that ledge rock has been encountered, as both the scratches and the angular fragments could come from the presence of sporadic boulders carried out by ice or by vegetation rafts. On the other hand, where the report of rocky bottom is indicated by several observations from one area it appears unlikely that sporadic fragments could be the cause, and, therefore, one can be fairly confident that ledge rock crops out on the bottom."

Topographic Setting

The following descriptions of the topography and geology of Iceland are based on the works of Thoroddsen (25; also, 24,pp.lxi,lxi,lxii,lxiii,lxiv-lxvi), Iwan

(19, pp.11,20), Gregory (8,p.13); and, Nielsen (17,p.272).

Topographically Iceland is a plateau fringed in places by coastal lowlands and traversed by long, narrow alluviated valleys. The lowlands are most extensive along the southeastern and southwestern coasts, where for convenience they are called in this report the Southeastern Lowland and the Southwestern Lowland. The long, narrow valleys, for the most part, trend northward from the interior and open into fjords indenting the northern coast.

The interior plateau is essentially an uninhabitable sand and lava desert, lying 700 to 1000 meters above sealevel. Rising 600 to 1000 meters above the southern portion of this plateau, and 1400 to 2000 meters above the southeastern and southwestern lowlands along the coast is a series of ice-capped, dome-shaped mountains. Where lowlands are lacking, as along the eastern and the northwestern coasts, the sea beats directly against the eroded cliffs of the plateau edge.

Connected to the northwestern corner of Iceland by a narrow neck of land is a triangular-shaped peninsula, whose coasts are deeply indented by fjords. The surface of this peninsula is a plateau averaging 870

meters elevation above the sea. Its coastline is the cliffed plateau edge. For convenience this peninsula is called in this report the Northwestern Peninsula.

Geologic Setting

Iceland is a remnant of a volcanic plateau which, during early Tertiary times probably spanned the entire North Atlantic. This plateau is believed to have been broken up by block faulting and subsidence in the Miocene epoch which left Iceland an island with its coasts 25 to 50 miles further out on all sides than now. Other remnants of this plateau are the Faeroe Islands, the islands of Mull and Skye off the western coast of Scotland, Antrim in northeastern Ireland, and the basalt region of eastern Greenland.

Subsidence continued through the Pliocene until the strand line was over 100 meters above the present strand line. Shell-bearing beds of sandstone, which correlate tentatively with the Pliocene Red Crag formation of England, were deposited at this high level. Apparently the island shelf was planed by wave action during this period of subsidence.

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At the end of the Miocene epoch the Iceland
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the present 150-fathom line. The submerged valleys which now extend outward from the main bays and fjords (see index chart E.A.505) were cut at that time, when the shelf was exposed to subaerial erosion.

During the Pleistocene epoch the island submerged again until the strand line lay at about the same level as it did before; i.e. 100 meters or more above the present strand line. Again, as before, shell beds were deposited at the highest level. These date the time of maximum re-submergence as mid-Pleistocene. Since that time the land has been emerging, with halts long enough to permit the formation of several marine terraces.

In the Pleistocene epoch at least twice the entire island was covered by an ice sheet through which a few peaks projected, as in Greenland today. The ice covered the coastal lowlands and apparently extended past the present strand line, as large amounts of moraine have been found at various places on the seabottom off the mouths of the fjords.

Vulcanism, which was active during the early and middle part of the Tertiary, apparently ceased during the Pliocene epoch until the period of emergence at the end. It then broke forth, and during the Pleistocene a number of large volcanoes were active. This activity

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has continued into recent times.

The island is built mostly of basalt flows, with associated tuffs and breccias. Craters of Hawaiian type are scattered throughout the island, and golden fg. found along the southeastern coast. Interbedded in the basalt in places are a few clayey layers having plant remains of probable Miocene age. In some of these layers the carbonaceous material is abundant enough to form lignite. On the peninsula of Tjörnes, in northern Iceland, shallow-water sandstone of red clay has given the fossil shell of Pelecypoda. Extensive glacial moraines, some interbedded with basalt, occur in many places over the island. For the most part these are Pleistocene in age.

Submarine outline

On Murray's chart showing the bathymetry of the north Atlantic (fg.) a submarine ridge several hundred miles wide and less than 100 fathoms deep, or somewhat over depths of 1000 fathoms or more on the adjacent bottom, extends from Greenland southeastward across the Atlantic ocean to Scotland. Iceland is perched on this ridge at about its mid-point, and the Faeroe Islands, near the Scotland end. It presumably represents the submerged portion of the north Atlantic volcanic plateau mentioned on

page 7.

Mendel's chart (9, Part 1, Plate 1), showing greater detail than Murray's, indicates a trough 600 fathoms deep cutting halfway through this ridge from the north between Iceland and Greenland, and, at the same place, another trough over 700 fathoms deep cutting into it from the south. The saddle between these two troughs lies from 300 to 400 fathoms deep. This saddle and part of the northern trough may also be seen in the northwest corner of the index chart in this report (s.i.,565).

As shown on Mendel's chart, southeastward from Iceland the bottom slopes gradually down to 270 fathoms about midway between Iceland and the Faeroe Islands, and remains at that depth until the incline up to the Faeroes is reached. Iwan (10,p.183) gives a southeast-northwest profile of this ridge which shows the deepest spot to be at the Faeroes end, at the base of the incline.

According to Sveggild (9, Part 3, Plate 1), this portion of the ridge southeast of Iceland is mantled with "grey, deep-sea clay", characterized in the text as "a generally rather fine and even variety of clay of a greyish color." In view of the proximity of active volcanoes on Iceland this clay should contain a large proportion of volcanic material. Andrée (1, p.479) states that a later bottom sediment chart by Sveggild indicates volcanic

Wandel's chart (3, inset 1, Plate 1), showing
greater depth than Murray's, indicates a steady 200
fathom deep swelling belowy through this ridge from
the notch between Iceland and Greenland, and, at the more
place, sweeps through over 700 fathoms deep cutting into
it from the south. The saddle between these two shoals
lies from 300 to 400 fathoms deep. This saddle and part
of the Norwegian trough may also be seen in the continent-
ower of the inner ocean in this report (B.V.382).

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Iceland the bottom slopes gradually down to 371 fathoms
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According to Wandel (3, part 3, Plate 2),
this portion of the ridge consists of Tertiary to Recent
"clay, deep-sea silt", characterized by the rare or
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on Iceland this clay cannot contain a large proportion
of volcanic material. Under (3, part 1.b.140) states that a
layer beyond volcanic ash and pumice lies on the bottom
of the Iceland and Faeroes ridges.

and covering the ridge. The ocean basins north and south of the ridge are floored with globigerina ooze.

Surrounding Iceland, and extending from the shore out to depths of from 100 to 150 fathoms is a discontinuous submarine platform. This is the equivalent of the continental shelves off the various continents, and in this report is called "the island shelf", or simply " the shelf". Accordingly, the submarine slope from the outer edge of the shelf down to the ocean basins on the north and south, or to the Greenland-Faeroe ridge on the east-southeast and west-northwest, is called "the island slope". Boeggild (9,Part 3,Plate 1) classifies the sediments covering the shelf as "shallow-water deposits", and it is mainly with these sediments that this report is concerned.

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The sediments covering the shelf as "shelf-water deposits", one is in mainly with those sediments that cover the gently inclined slope". Boeggild (Report 3,-Note 1) classifies the sand-sediment and water-sediment, is called "the mud and sand", or to the Greenland-Iceland ridge on outer edge of the shelf down to the ocean basins as the " the shelf". Accordingly, the submarine slope from the in this report is called "the island shelf", or simply the continental shelves of the various continents", and continuous submarine platform. This is the equivalent of shore out to depths of from 100 to 150 fathoms in a dis-

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[illegible]

B.A.2711 (approximate scale 1:250,000)

General Statement

This chart shows the shelf off the southwestern coast and southern half of the western coast of Iceland. It extends from the light at Eyrarbakki (latitude 64 degrees 46 minutes N., longitude 21 degrees W.) on the southern coast to the volcano called Snæfellsjökull (latitude 64 degrees 48 minutes N., longitude 23 degrees 43 minutes W.) on the north side of the bay, Faxaflói.

B.A.1961, on the east, extends to longitude 19 degrees 40 minutes W., giving an overlap with this chart of about twenty-two miles of shoreline. Particulars as to soundings on either chart within this overlap have been transferred to the other in order to show all available information on both charts. This practice has been followed with the remainder of the charts also.

Extra data have been added from larger scale charts in the following places: on the shelf from shoreline to southern edge of the chart between the Ölfusá River and Eyrarbakki, from B.A.1964 (1:111,100); in the eastern half of Faxaflói, from B.A.1201 (approximately 1:87,450) and B.A.1729 (1:184,000).

Presence of shells in the sediment

All sandy areas on this chart bear the bottom notation "fine sand and shells". Many of the areas of gravel and mud may also contain shells in greater or lesser degree. However, since the bottom notations make no mention of this the author was not indicated their presence in the gravel and mud.

The shelf from Kyrdalsvik to the Markarfljót River

The coast from Kyrdalsvik to the south of the Markarfljót River is, for the most part, low and sandy, with the ice-capped mountains of Kyrdalsjökull and Eyjafjalla Jökull rising abruptly from the plain at distances of from 2 to 3 miles inland. As seen on the index chart, H.A.565, the offlying shelf for about two-thirds of this distance between Kyrdalsvik and the Markarfljót increases in depth fairly regularly out to 100 fathoms, about eight miles offshore. Beyond this depth the bottom drops rapidly to 500 fathoms or more in less than 5 miles. The "mud line", or boundary with the mud, has been placed approximately at the 100-fathom depth curve. This mud is Boeggild's grey, deep-sea clay (see page 10).

West of longitude 19 degrees 15 minutes W. the shelf is indented by Dufa Djúp. This is a submarine valley which, as shown by the greater sounding detail on H.A.2766, divides

Lessons of Shelly in the Sedimentary

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The Shelf from Perpendicular to the Kennebec River

The coast line perpendicular to the mouth of the Kennebec River is, for the most part, low and sandy, with the ice-capped mountains of Mount Katahdin and Chairtie 100ft visible clearly from the light at distances of from 2 to 3 miles inland. As seen on the inset chart, c.1957, the outlying shelf for about two-thirds of this distance between Pyramid and the Kennebec Entrance is sandy fairly regularly out to 100 fathoms, about eight miles offshore. Beyond this depth the bottom stops rapidly to 300 fathoms or more in less than 3 miles. The "mud line", as denoted with the mud, has been placed chiefly at the 100-fathom depth curve. This mud is described simply as "bottom clay (see page 10)."

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into two branches, one bearing north toward the mouth of the Ra Fjarfljót and the other heading north-northwest and north to a point a little over one mile east of Álidrey, the easternmost of the Vestmannaeyjar Islands. The mud line reflects the bathymetry by swinging into an west of Longitude 19 degrees 45 minutes W. and shoaling to about fifty fathoms. It then curves southwestward and westward around the submarine ridge between the two branches of Mars Djúp, then northwestward and northward up the west branch, and finally runs off the coast a long the southeastward side of the submarine platform bearing the Vestmannaeyjar Islands. The shoaling of the mud line in Mars Djúp may be explained by the lack of slurry dropoff at the 100-fathom line such as obtains east of Longitude 19degrees 45 minutes W.

Except for rocky areas at Myrdalsvik and Portland, the strand between Myrdalsvik and the Markarfljót is bordered offshore by a belt of sandy bottom. For about half this distance the belt averages 1½ miles in width, and is bordered to the seaward by a belt of gravel 4 to 6 miles wide extending out to the mud line. East of Longitude 19 degrees 30 minutes W. the gravel belt tapers off rapidly and seems to an end. The sandy belt widens to 6 miles here, coming in direct contact with the zone of mud, then narrows again to 3 miles

north of the Vestmannaeyjar Islands. This sand is composed of volcanic rock and mineral particles. According to Thoroddsen (1a, p.244) quartz sand does not occur in Iceland.

Vestmannaeyjar Islands

The rocks on the Vestmannaeyjar Islands, and presumably on the submarine platform on which they lie, consist of basalt flows, tuffs, and breccias of post-Pleistocene age (?). Areas and patches of rock bottom surround the islands and form numerous shoals to their southwest, west, and east. Surrounding this group of rocky islands and shoals is an irregular-shaped area of gravel measuring 17 miles east-west and 15 miles northwest-southwest, the result of wave and current action plus probably some submarine vulcanism.

The author has shown a small zone of gravel extending west from the rocky shoal, Danskgrunn, about five miles north of Heimey, the largest island. This is based on a small but pronounced submarine ridge indicated by the soundings on H.A.2968.

The Shelf from the Markarfljót River to Reykjanes

Northwest of the Markarfljót River the mountains give way to the great Southwestern Lowland, described on page 6. This lowland extends 40 miles along the coast to the Night called Thorlák Hoe, just west of the

mouth of the Ölfusa River. For about half this distance the strand consists of a barrier beach backed by lagoons and marshes and the alluvial expanse of the lowland. Northwest of the mouth of the Thjórsá River (longitude 20 degrees 49 minutes W.) the coast is rock-fronted, with the zone of reefs and isolated rocks extending from 1/4 to 1 mile offshore. These reefs represent the eroded edge of a post-Pleistocene basalt flow (24, p. 419).

From Thorlák head 35 miles west to the end of the peninsula of Reykjanes the coast is, for the most part, rocky and steep, and is backed by low mountains. This entire region, including both lowland and peninsula, is subject to violent earthquakes and volcanic activity.

Except for shoaling connected with the Vestmannaeyjar Islands, depths offshore in this region increase slowly and fairly regularly southward to the limits of the chart. On E.-W. lay the shelf is seen to increase over three time in width as compared to its width east of the Vestmannaeyjar Islands. The 100-fathom curve runs westward roughly forty-five miles past Reikanes before it again turns northward into a submarine valley called Selvogr Dyb on E.-W. 273) and Grindavikur Djúp on E.-W. 315. If depth curves are drawn every 25 fathoms or less around Selvogr Dyb they will outline a gentle but distinct tributary valley trending east-northeastward from the northeast

corner of the deep toward the mouth of the Ölfusá. This may indicate a tectonic or a pre-submergence drainage relationship between Selvogur ýb and the Southwestern Lowland.

With the exception of several large muddy zones, the bank between Hafs Djúr and Selvogur ýb is covered with sand and shells throughout the eastern half, opposite the lowland, and with gravel throughout the western half, south of the Reykjanes peninsula. The sand can, without doubt, be attributed to the many large glacial rivers (the Jökulsá and Thverá, from Tindfjalla Jökull and others; the Thjórsá, from Vatna Jökull and Hofs Jökull; the Ölfusá, from Langjökull) flowing across the lowland.

The gravel is less easy to explain. Shepard (19,p.1036) has advanced the hypothesis that areas of gravel far out on the continental shelves may be residual from the Pleistocene epoch, when much of the shelves was exposed to subaerial conditions, or at least more effective wave erosion, as a result of lowered sea level. In Iceland during the Pleistocene the relative sea level probably rose rather than fell. However, at the end of the Miocene it did fall, so that in essence Shepard's explanation may account for the gravel south of the Reykjanes peninsula, as well as the gravel east of Hafs Djúp.

Relation with the rest of Iceland.

West of Selvogs Dyb lies Reykjanes Dyb, another submarine valley separated from Selvogs Dyb by a long, narrow submarine ridge. Cutting deep the head of Reykjanes Dyb, the Reykjanes Tabb is so much so as to suggest it was formed later than the valley, is a high, narrow submarine ridge extending southwestward from Reykjanes. A line of shoals, reefs, and islets (Eldey, the Geirfuglasker, Eldeyjarboði) marks the top of this ridge. It is interrupted by two channels over 100 fathoms deep; one, 7 miles southwest of Reykjanesrastur in the Geirfuglasker, and the other, 7 miles south-southwest of Eldeyjarboði.

Like the Reykjanes peninsula, this submarine ridge is the site of pronounced volcanic activity. Flames and explosions have been reported at various times from the sea over this ridge, and several islands have appeared and disappeared within the historical period (14,p.370; 22,pp.501-512).

C.F.Wandel, in his report on the soundings taken by the Danish "Thetis" expedition of 1879 (8,vol 1, p.1) and Plate 1; describes the sub-sea of the ridge to the southwest at least as far as latitude 61 degrees N. later work by the German survey ship, the "Meteor", done

Interpretive Essay and Test of Reading Speed

Most of Delvay's like Derleiner's, emerges
impressive reality, especially from Delvay's
nation schematic ridge, cutting across the area of Lady-
Jones Dyk, and terminating into the river a mile or so
suggest it was formed later than the valley, in a time
nation schematic ridge extending southeastward from
Derleiner. A line of models, mostly, and lines, ridges,
the Caterpillar, Hedgehog, models were the use of wide
ridge. It is interrupted by the township over the
Telmore deep; one, 7 miles southeast of Derleiner
in the Saturnian, for the other, 7 miles northwest
southeast of Hedgehog.

Like the Derleiner peninsula, this remarkable
ridge is the site of considerable valuable
Pleman and explosions have been reported at various
time from the sun over this ridge, and several planes
have operated and disappeared while the pilot
period [M.,p.371; 25,M.,211-212].

O.K. Wedel, in his report on the expedition
taken by the Denton "Depth" expedition of July 19--, I
p.19 and Plate I) describes the extension of the ridge
to the southeast at least as far as Jefferson in Carroll
later work by the Denton survey party, the "Denton", some

in 1930, points toward the possibility of a connection between the Reykjanes Ridge and the Middle Atlantic Ridge (6, p.348-349).

The author has shown gravel and sandy areas surrounding the reefs and islets and, to a great extent, covering the landmass of the ridge. Much of the gravel is placed on theory only, with the 50-fathom depth curve chosen arbitrarily as the boundary. It is believed that, as in the Westmannaeyjar Islands, wave action upon the exposed rock plus submarine volcanism would produce considerable amounts of gravel.

Mud covers the seabottom in Selvogs Dyb and Reykjanes Dyb, on the low, narrow ridge between them, on saddles in the ridge extending southwestward from Reykjanes, and on the shelf as far as 5 miles north of Alnaeyjarundi. This is Bowgild's clay, terrestrial clay.

Faxafloi, Bathymetry

Faxafloi is the wide, moderately deep bay between the Reykjanes peninsula on the south and the Snaefellsness peninsula, which bears Snaefellsjökull, on the north.

The general slope of the bottom is from the north, east, and south toward Faxafloi Nyr (called Faxafloadjup on U.S.C.S.), the submarine valley which heads into Faxafloi from the west. In the southern

hal, at Isafjörður the basin Vestribrun, with least depth of 8 fathoms 1 foot (latitude 66 degrees 17 minutes N., longitude 22 degrees 11 minutes W.), and Hjarðardjúp, with least depth of 8 fathoms (latitude 66 degrees 16.7 minutes N., longitude 22 degrees 22 minutes W.), interrupt this general eastward descent. In the northern part of the bay Ísafjarðardjúp, with least depth of 44 fathoms (latitude 66 degrees 14.3 minutes N., longitude 23 degrees 11.1 minutes W.), rises by 1 fathoms above the surrounding floors. Numerous other knolls of small extent occur throughout the bay, imparting a differential relief of 46 fathoms to the bottom. Two shallow fjords, Hvalfjörður and Borgarfjörður, indent the eastern shore of the bay.

Faxaflói represents a recently submerged low-land(Thoroddsen, p.133; Ingólfur, p.24, 41). The 40-fathom depth curve outlines a similar submarine valley, which commences 10 miles south of Hjörsey, runs eastward and northward past Hjörsey, and then westward and opens up north of Vestribrun. Depth curves of 100, 1201 and 1,400 show smaller submarine valleys continuing outward from the small bays and fjords, which indent the coast, and entering this main submarine valley from the west. These are highly suggestive of a once-submerged stream drainage system which at one time emptied westward into Faxaflói bay.

12 5-fathom depth curves are drawn on the bottom in the remainder of [illegible] small submarine valleys [illegible] seem to continue eastward from shore [illegible] and open to the south and west toward Fatsfield [illegible].

[illegible] [illegible]

West of longitude 23 degrees W. the bottom is covered by sand and shells, with a few scattered cobbles and areas of gravel. East of longitude 23 degrees W. the pattern of sediment types becomes more [illegible]. Mud is still the predominant sediment. However, a [illegible] irregular-shaped area of gravel also [illegible] of Hvammstangi, probably extending farther south than the author has shown to include the [illegible] 10-fathom depth curve, a [illegible] area of gravel, [illegible] rectangular in [illegible], covers Vestfirdir and Isafjardardjup. A [illegible] area of gravel averaging 3 miles in [illegible], commences about [illegible] southwest of Vestfirdir and extends due west for 20 miles just [illegible] from the west end of the [illegible] peninsula.

The southern end of the main submarine valley south and east of Vestfirdir is floored with mud to within about four miles southeast of that [illegible]. The southern boundary of this mud area has been placed [illegible] at the 10-fathom depth curve. The strip of bottom between

this curve and the shore has been depicted as sandy on the basis of the sand-bottom symbols used on this chart and on B.A.3201.

East of longitude 22 degrees 21 minutes W. the pattern of sediment zones is exceedingly complex, reflecting the greater detail portrayed on the large scale charts B.A.3201 and B.A.2729. If the portion of Faxaflói west of that meridian were shown on charts of comparable scale the pattern would probably be as involved as it is east of it.

An irregular belt of gravel 2 miles wide at its widest trends slightly west of north for 11 miles from latitude 64 degrees 3.5 minutes N., longitude 22 degrees 3 minutes W. past the mouths of Hvalfjörður and Akrafjörður to latitude 64 degrees 11 minutes N., longitude 22 degrees 4 minutes W. Here it joins at its midpoint a belt of gravel of similar width running east-west and lying partway across the mouth of Hvalfjörður. A similar belt of gravel lies [illegible] mouth of Borgarfjörður. These three gravel belts may represent morainal material deposited by glaciers formerly [illegible] the fjords, possibly prior to submergence of the region. The areas covered by them are not notice-

of the region. The areas covered by them are not notice-

ably elevated above the surrounding bottom. However, the fact that the broad depressions, especially the basins are covered with gravel lends weight to the probability the bottom of Faxaflói may once have been subject to glacial deposition from the east. The three banks could have been formed, in part at least, by the heaping together of debris from merging ice lobes, or by the deposition of debris from one or more lobes onto the sides and tops of pre-existing elevations. Following emplacement, current eddies would no doubt tend to sweep out the finer constituents from the surface of the morainal banks and leave gravel as the bottom material. According to Kuenen's geological map VIII, glacial debris in the region surrounding Faxaflói will indicate ice motion from the north, east, and southeast into Faxaflói.

Glaciation may also be invoked to account for the overall complexity of patterns shown on B.A.3201 and B.A.2729, particularly north of Reykjavik (latitude 64 degrees 9.7 minutes N., longitude 21 degrees 56.7 minutes W.), here the extremely varied and changing mixture of sand, gravel, mud, and rock conforms to the description of a typical reworked and winnowed moraine, as given by Shepard (26,p.225).

only elevated above the surrounding bottom. However, the fact that the banks Vesturhraun, Syðrahraun, and Jökulgrunn are covered with gravel lends weight to the probability the bottom of Faxaflói may once have been subject to glacial deposition from the east. The three banks could have been formed, in part at least, by the merging together of debris from adjoining ice tongues, or by the deposition of debris from one or more lobes onto the sides and tops of pre-existing elevations. Following emergence, current action would no doubt tend to winnow out the finer constituents from the surface of the original moraine and leave gravel as the dominant sediment. According to Thoroddsen's geological map (49), glacial striae in the region surrounding Faxaflói all indicate ice motion from the north, east, and southeast into Faxaflói.

Glaciation may also be invoked to account for the overall complexity of pattern shown on Fig. 6 and Fig. 7, particularly north of (latitude 64 degrees 6.7 minutes N., longitude 22 degrees 26.7 minutes W.), where the extremely varied and complex mixture of sand, gravel, mud, and rock conforms to the description of a typical sediment off a glaciated coast, as given by Shepard (38, p.225).

The shoreline on the north, east, and south of Reykjavík is fringed with reefs of basalt of Tertiary, which rocks form the hills and mountains of the region. Even the sandy Seltjarnarnes northwest of Reykjavík is skirted by a line of reefs and rocky islets 1 mile wide. This zone continues into Borgarfjörður along the northwest side for nearly half its length. It is matched on the southwest side by a similar zone, which extends into the fjord an equal distance.

Hvalfjörður, likewise, is fringed by rocky reefs. Unlike Borgarfjörður, however, which is sandy throughout its entire length and breadth, Hvalfjörður has a strip of mud bottom down its center from south to head. In the Sailing Directions (18,p.795) the following description is given of Hvalfjörður:

> "...There are a number of dangerous rocks in the fjord and in its approaches, particularly in the entrance and on the southern side of its outer stretch. Further eastward the rocks lie close to shore. In the deeper parts of the fjord the bottom consists of sand and shells in the entrance and of mud farther in. In the shallower parts it is mostly rock, with mud, sand, and shells in some places."

description is given of Hvalfjörður:

> "...There are a number of dangerous rocks in the fjord and in its approaches, particularly in the entrance and on the southern side of its outer extent. Further southward the coast lies close to shore. In the deeper parts of the fjord the bottom consists of mud and clay, in the entrance and of mud further in. In the innermost parts it is mostly rock, with mud, sand, and shells in some places."

B.A.2976 (scale 1:287,414)

General Statement

This chart shows the shelf off the northern half of the western coast of Iceland, from Snæfellsnes to the northernmost point of the Northwestern Peninsula. B.A.2713, on the south, extends to latitude 66 degrees 50 minutes N., giving a 20-mile overlap with this chart. All pertinent data within this overlap, which consists of the northern half of Faxaflói, is portrayed on both charts.

Extra data from large scale plans have been made use of in the following places on the Northwestern Peninsula:

Djúpa Fjord, from B.A.2998 (approximately 1:62,475)
Hesteyri Fjord, a tributary to Ísa Fjord and Önundar Fjord from the north, from B.A.3000 (approximately 1:51,325)
Ísafjörður, from B.A.2999 (this section 1:26,670)
Sveinseyri anchorage, in Tálkna Fjord, from B.A.2999 (1:9,830) "
Flateyri anchorage, in Önundar Fjord, from B.A.2999 (this section 1:12,035)
Arnarfjörður, a tributary to Ísa Fjord from the south, from B.A.2999 (this section 1:12,070)
Bíldudalr anchorage, on the south side of Arnar Fjord, from B.A.2999 (this section 1:12,000)

Bathymetry in Breiðafjörður

This bay, roughly the same length from east to west as Faxaflói, and about two-thirds the width of

B.V.3000 (scale 1:62,500)

General statement

This sheet shows the chart of the northern
half of the western coast of Lenkin, from Greenhithe
to the northernmost point of the Kirkwestern Peninsula,
B.V.3713, on the south, exclusive to Ardlands (B. Lenkin
30 minutes N.; Eastings 20-miles covering with full chart.
All pertinent data within this quality, which contains
of the northern belt of Kanelia, is notarized on each
chart.

Extra data from large scale plans have been
made use of in the following places on the northwestern
peninsula:

Dyke Point, from B.V.3704 (approximately 1:25,000)
Keepsyth Point, a strumbery to Ice Point and
Tomala Island from the north, from B.V.3700
(approximately 1:31,333)
Jetnik Island, from B.V.3711 (the western
two-thirds, approximately
1:26,670)
B.V.3333 (1:3,333)
B.V.3333 (this section 1:12,333)
B.V.3333 (this section 1:12,333)
Kilgweir anchorage, on the north side of
the north, from B.V.3333 (this section
1:30,000)
Other Point, from B.V.3333 (this section
1:12,000)

Peninsula in Great Point

This bay, roughly the same length from east
to west as Foxcliff, and about two-fifths the width of

Faxaflói, lies between the long, narrow peninsula of Snæfellsnes, on the south, and the southern shore of the Northwestern Peninsula, on the north. At its inner end it divides into two branches, with [illegible] the head of the southern branch and Gils fjord at the head of the northern.

Like Faxaflói, Breiði fjord is a submerged lowland (6,p.139;17,p.276). Submergence is due to subsidence, probably along peripheral fractures [illegible] intervening peninsula of Snæfellsnes representing a [illegible] positive element (17,p.[illegible], p.264).

According to the [illegible] Directions [illegible], the land in this region is rising:

> "There is no use to suppose that depths in Breiði fjord are decreasing, both in the bay proper and in Hvamms fjord and the northern branch fjord. The charts, which are based mainly on surveys made between the years 1896 and 1929, must not, therefore, be entirely relied upon. It appears that the land is rising, and in many places depths less than those shown on the charts may be found."

Thom also describes this recent rise of the land (1, p.103), as shown by uplifted wave-cut terraces. He points to evidence, likewise, of recent uplift to the extent of 10 meters in the fjords of the Northwestern Peninsula.

is Breiði fjörður bathymetric relief is greater and steeper than is normal. For example: from the 5-fathom sounding at latitude 65 degrees 2.1 minutes N., longitude 23 degrees 11.1 minutes W. the bottom falls off northwestward to 120 fathoms in 1-1/4 miles; from the 11-fathom sounding at latitude 65 degrees 11.4 minutes N., longitude 23 degrees 8.6 minutes W. the bottom falls off southeastward to 7; fathoms in 1¼ miles.

Also, it shows a strong northwest-southeast alignment of relief elements not present in Faxaflói. Kollafjörður, a comparatively narrow, steep-sided submarine valley opening to the southwest, runs up into Breiði fjörður just northwest of Snæfellsjökull, at which point it reaches a depth of 180 fathoms. Twelve miles west of Snæfellsjökull the valley comes to an end. However, directly in line with it a series of enclosed, basin-shaped submarine basins, with intervening ridges, continues northeastward into the northern bounds of Breiði fjörður. This zone widens rapidly until it includes practically all of Breiði fjörður northeast of the 20-fathom depth curve off Snæfellsnes.

If 10-fathom depth curves are drawn throughout the fjord they will bring out the character and extent of these submarine basins and ridges. They are undoubtedly

on a much smaller scale of the basins and ridges occurring on the continental shelf off the coast of southern California. It is believed they, together with part of Kelluhil, represent arcuate and borate, as do the California submarine basins and ridges. The remarkably close spacing and consistent parallelism of faults necessary to form such basins, 1 to 2 miles wide and 5 to 10 miles long, is known to exist on land in many parts of the Basin-Range Lowland (17,p.277;23).

Southward of the basin-ridge zone lies a shallow coastal shelf 3 to 6 miles wide, enclosed between the 20-fathom depth curve and the northern shore of Unalaska. This coastal shelf extends from near Kalligagun (latitude 64 degrees 55 minutes N., longitude 23 degrees 53 minutes E.) to the mouth of Iwuna Fjord. It bears a number of shoals, reefs, and small islands, all considerably lacking the linear character of the basins and ridges northwest of them. In Cook's guidebook (13,p.38) many of the islands and reefs are considered to be portions of submarine volcanoes.

Northwest of Kelluhil and of the basin-ridge zone for as far east as longitude 23 degrees 35 minutes E. the bottom rises in a smooth, flat curve more than 20 miles northward to the stream line. East of that meridian a

a small belt of reefs, islets, and generally foul ground extends from the north side of Breidi Fjord to Ella Fjord, distant approximately by the 5-fathom depth curve on the north, the zone reaches a maximum width of over fifteen miles at longitude 40 degrees W.

From Ella Fjord it extends along the southeast side of Breidi Fjord's south branch to Ymers Fjord. Here it "overflows" the eastern end of the coastal chain of Amerellimmy and forms a bar across the mouth of Ymers Fjord which dries almost completely at low tide (19, pp. 328, 329).

The strait called Syd-Fiol extends up the middle of the south branch of Breidi Fjord, narrowing to a bottleneck entrance as it approaches this fjord at the head. The basin-ridge zone also continues up the north branch of Breidi Fjord to the head. It is apparently widened enough to include: (1) bits of the rocky, shoal belt along the southern side of the north branch; (2) Syd-Fiol, with an isolated shoal area of reefs and islets in its middle (latitude 61 degrees 53 minutes N.; longitude 40 degrees 30 minutes W.); and, (3) much of the rocky shoal belt along the northern side of the north branch. In short, it covers nearly the entire north branch of Breidi Fjord up to, and probably including, Ella Fjord.

The linear shape of many of the reef and islet groups along the northern side of Breidi Fjord indicates the basin-ridge zone approaches to within at least five miles of the shore. Another system of faults with different orientation is known to exist on the adjacent land. However, hydrographic information is too scanty to place exactly the boundary between the system on land and the system in the fjord.

Bottom Sediments in Breidi Fjord

Along the entire southwestern coast of Iceland, including Faxaflói, the sandy areas without exception contain shells (see B.A.#733), suggesting an environment favorable to the development of shell fish. This can probably be attributed to the ameliorating influence of the Irminger Current, a terminal branch of the Gulf Stream which flows westward along the south coast of Iceland, from about the longitude of the Vestmannaeyjar Islands, and northward along the west coast.

In Breidi Fjord, however, from head to mouth and out to sea as far as the chart extends only a few small areas are found. The largest of these is about ten miles long by three miles wide and lies along the meridian of Longitude 23 degrees W. at about Latitude 65 degrees 20 minutes N. The author can offer no explan-

The linear maps of many of the reef and
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is too scanty to place exactly the boundary between
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Bottom Sediments In Breidi Fjord

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erably areas not found. The instrument is about
ten miles long by three miles wide and lies right the
meridian of longitude 23 degrees , so about initially
63 degrees 50 minutes N. The meteor can enter no entire-

[illegible] for this absence of shells, except to suggest the possibility of an influx of cold, fresh water from the land, such as occurs in the fjords of the Scandinavian Peninsula.

Sand is the dominant sediment off the mouth of Breidi Fjord. From the west side of the chart eastward to longitude 21 degrees 8 minutes W. it covers the entire bottom except for a few scattered gravel patches of uncertain size and shape. The largest of these lies just west of the end of Snaefellsnes.

In Breidi Fjord sand covers much of the bottom. However, between longitude 21 degrees 8 minutes W. and 21 degrees 30 minutes W., a large, irregular-shaped area of gravel, 12 miles wide from north to south, occupies the middle of the fjord, mantling basins and ridges alike. There is nothing in the shape or location of this gravel area that is diagnostic of its origin. It may very well be moraine gravel, for the land on all sides of Breidi Fjord has been glaciated.

The belt of fast ground (see page 29) which encircles the shore in the north branch of Breidi Fjord and extends across the mouth of Ytrafjord is indicated at each echo whenever such echoes occur. The little information is shown on the chart, however, to ensure that the entire belt is rocky. There must be some channels, more or

expire just in time. There must be some connection, only it
escapes the grasp on the chart, however, to explain that
poor Dutton adventure more simply again. The little indi-
viduals drove the model of Planet 19 relentlessly
ruthless too since in the whole course of Dwight Flood and
Dutton's life only the first two days were pleasant.

The pair of lost planet lovers (4) might
Flood-Dee Dwight.

well be nothing Dwight, as the last on all rules of Dwight
Chart Dee Yes to disconcerting of ice ORIENT. In and
time, there is nothing in the whole of invention of this
idea the middle of the flood, wrestling passion and Eighty
rise of Dwight, it which with from rules the ocean, Octa-
ron 23 degrees 30 minutes -, a jump, Intergalactic-Dwight
Dutton. Forever, between longitude of degrees X minute ',

In World Flood away covers away of the
last war of the end of Uncertainty.

of uncertainty the end ship. The target of them Flo
capitol Dutton cannot for a few moments alone! between
way to longitude 37 degrees X minutes ', it causes the
of Point Flood. From the west edge of the chart zone

Dwight is the Continent medium on the moon
Continental.

the moon, ship be course in the Point of the universe',
the possibility of an Indian of ship', Jason moon Jupi-
ter for ship command it ship', cruise at moment

axis Deep (Latitude 65 degrees 30 minutes N., Longitude 23 degrees 9 minutes W.), extending out from the small fjords in the coast which would contain sand or mud. For example, the channel in which the island, Hrísey occurs (Latitude 65 degrees 22.3 minutes N., Longitude 23 degrees 54 minutes W.) probably contains mud at least as far north as a channel is indicated.

Eyðafjörður and the channel extending northeastward to Hills fjord are also shown as containing mud, even though no bottom notations occur northeast of a line through the island, Stæglev (Latitude 65 degrees 11.8 minutes N., Longitude 22 degrees 50.5 minutes W.).

The coastal shelf off the north side of Skagafjörður is largely mantled with sand and occasional patches of gravel. However, many of the shoals, and all of the offshore reefs and islet groups are rock. Rock also fringes the shore in some places, as at Drangey (Latitude 65 degrees 58.2 minutes N., Longitude 19 degrees 22 minutes W.) and Skallabúðir (Latitude 65 degrees 6.7 minutes N., Longitude 21 degrees 10.5 minutes W.).

Grundar fjord (Latitude 64 degrees 57 minutes N., Longitude 23 degrees 17 minutes W.) and Kolgrafa fjord (Latitude 64 degrees 57 minutes N., Longitude 23 degrees 8 minutes W.) contain mud in their central portions.

With the exception of a narrow belt of rock and sand along the coast, and some isolated rocky mountain tops, ranges from 1,000 to 2,000 feet,

The Vestfirdir Peninsulas

Between Steingrim Fjord (latitude 65 degrees 41 minutes N., longitude 21 degrees 32 minutes W.) and Kalda Bak (latitude 65 degrees 41.5 minutes N., longitude 23 degrees 11 minutes W.) the western coast of the Northwestern peninsula is deeply indented by numerous fjords, which are known collectively as the "Vestfirdir" or "Westmost Fjords", consisting of the Isafjord (Isa-fjardar djup) (lat. 66.1.7 N), the fjords of Dyra Fjord " which cut into considerable distances northeastward between high, rocky coasts, are much indented by smaller fjords, separated by a series of low ridges, consisting of shingle and sand, which are the remains of the terminal moraines of the Ice Age."

All of the Vestfirdir have submarine valleys leading out from their mouths, most of these seem to end well before the 100-fathom depth curve is reached, however. Djupifi, and Isafjord (or Isafjardardjup), both reach depths of nearly two hundred fathoms (see p. 345). The

These valleys are believed to have been formed by subaerial erosion at the end of the Pliocene epoch, when the strand line was lower than at present. Djúpáll, however, may owe some of its depth to the Pleistocene glaciation (Ó Dochartaigh, 1978; this work).

Although in existence before Pleistocene glaciation commenced, the Vestfirðir received their present form by the glaciers which passed through them. Like all typical glacial troughs the fjords are steep-walled and relatively flat-bottomed, many of them possess raised basins separated from the outer depths by thresholds and rock bars.

The two embayments of the Vestfirðir, Ísafjarðardjúp and Tálknafjörður, possess basins of over thirty fathoms depth behind a common transverse system of bars. Inner Fjord, northeast of Tálknafjörður, has a steep-walled basin, reaching 40 fathoms, throughout much of its length; the threshold is 24 fathoms at its deepest. Lyng Fjord, northeast of Inner Fjord, likewise contains a basin, 37 fathoms at its deepest, also behind a 24-fathom threshold. The deep in Inner Fjord, the largest of the Vestfirðir, reaches 40 fathoms; the threshold, 23 fathoms. Mjóa Fjord, the third tributary to form the mouth of Inner Fjord, is 20 fathoms deep in its inner reaches but only 14 fathoms at its mouth.

Rock bars are found across the mouths of Keet Fjord, Hjörl Fjord, and Seyðjar Fjord, all tributaries of Ísa Fjord. Sugandi Fjord, just southwest of the mouth of Ísa Fjord, has a shoal at its mouth which, according to Iwan (10, Figure 71), is an impassable rock bar.

Bottom Sediments in the Vestfirdir

Due to lack of data the author has theorized to a great extent in portraying bottom sediments in the Vestfirdir. However, enough notations and symbols are shown on the chart and large scale plans to permit outlining in some of the fjords a pattern very typical of fjord sedimentation --namely, a belt of mud along the deeper, axial portion, with belts of sand with some gravel and rock along the sides. Hetrix Fjord, Ísa Fjord, and Hesteyri Fjord definitely show this pattern. Dyra Fjord also shows it; however, the very deepest part of its basin is floored with sand while only the inner half, which is somewhat shoaler, is floored with mud.

The mud shown in Talkna Fjord is based solely on the likelihood that the enclosed basin, 10 fathoms deeper than the surrounding bottom, should be the site of accumulation of finer sediments. The mud shown at the upper end of the fjord, southeast of Svolvaeyri, also is based on theoretical considerations. It is

believed the inner reaches of a fjord, even if not particularly deep, may be the site of mud deposition if (1) the configuration of the shoreline gives some protection from waves and currents, and if (2) streams entering at the head do not carry heavy loads of coarse sediments. For the same reason mud has been shown in Ömunder Fjord, northeast of Lyrø Fjord, even though no bottom notations appear on the chart or the large scale plan at that place. Mud is also shown in Sugands Fjord. In both this fjord and Ömunder Fjord a point of land or a shoal partially shuts off the inner portion.

Each of the mud zones described above in Tolkne Fjord, Ömunder Fjord, and Sugands Fjord may, of course, have greater or lesser extent than shown. For example, the mud line in the upper end of Ömunder Fjord is placed arbitrarily along the outer edge of the area of sandy (stippled) bottom; no such area, however, is shown in Sugands Fjord, so mud has been shown as flooring the entire fjord up to the head.

Arnar Fjord has only one mud notation, located at its mouth. It is considered almost certain, though, that the mud zone extends throughout much of the fjord, flooring the steep-walled, branching deep that runs down its center.

Of the tributaries to Ísa Fjord only the first, Seutils Fjord, contains enough data on its chart and plan to show mud bottom with assurance. Hlíta Fjord, Leydis Fjord, and Nest Fjord are all unsurveyed, so no attempt has been made to outline the sediment pattern in them. It is quite probable that Nest Fjord contains considerable amounts of mud, since it is cut off from Ísa Fjord by a shoal rock bar.

The deep basin in Skötu Fjord has been shown as floored with mud, although no sediment notations are present on the chart.

Ajóri Fjord, Leykjar Fjord, and the head of Ísa Fjord are unsurveyed. Ajóri and Leykjar, like Nest Fjord, probably contain mud, since they have rock bars across their mouths.

Veidileysa Fjord, east of Hesteyri Fjord, is assumed to have a mud bottom, since no shallow basin is present and there are no shoals or promontories of land to cut off one portion from the rest. Lóns Fjord, Krefna Fjord, and Leirn Fjord, southeast of Veidileysa Fjord, are all unsurveyed.

On the shelf northwest of the Vestfirdir the predominant sediment is sand and shells. There

are, however, a number of oval-shaped patches of mud and of gravel. The position of the largest of these, opposite the mouths of Patrix Fjord, Talkna Fjord, and Hyrn Fjord, and of a smaller one opposite the mouths of Gunnar Fjord and Suganda Fjord suggests that they may be glacial moraines. However, like the gravel belts off the mouths of Hvalfjörður and Borgarfjörður in Faxaflói, these diatoms no control over the bathymetry.

Although positive evidence is scarce, it would appear that the bottom sediments of the Westfjords are essentially devoid of shells. An arbitrary line, based on bottom notations, has been drawn between shelly and supposedly non-shelly bottom. This line cuts directly across Isa Fjord at its mouth; it then continues west and south from Sugandi Fjord to Patrix Fjord at a distance of from 2 to 6 miles out from the fjord mouths.

One reason for the absence of shells could be the discharge of cold, fresh water into the fjords from the streams at their heads. Iwan (10,p.34) reports that the comparatively warm oceanic waters have little effect in the bays and fjords of the western coast of Iceland. Also, according to the Sailing Directions (15, p.336), in some of the Westfjords the outgoing surface current of fresh water is sufficient to stop tidal

currents 1 or 2 miles in from the mouth.

On the shelf outside the fjords shells are quite abundant. Attention is called to the numerous shell notations off the west end of the peninsula between Patrix Fjord and Breidi Fjord; also, in the vicinity of Litr Huk and Straumnes, north of the mouth of the fjord. Thoroddsen (24,p.244) mentions quantities of decomposed mussel shells occurring as calcareous dust along the coast of the Northwestern peninsula.

Judging by bottom notations on this chart and on H.O.2977, the region of abundant shells is bounded on the northeast by a line running from latitude 66 degrees 27 minutes N., longitude 22 degrees W. northwestward to the edge of the chart. This sudden cessation of shells in the sediments may be apparent rather than real, since the "Ingolf" (9,Part 3,p.77) found a larger percentage of shells off the peninsula of Snaefell (see H.O.2977) than anywhere else in Icelandic waters except west from North Cape. The use of a different technique in sounding and sample collecting by the ships surveying the north coast, or even the presence of different personnel among the hydrographers, could conceivable be responsible for the change.

However, the cessation of shells may be real.

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On the shelf outside the fjords shells are quite abundant. Attention is called to the numerous shell notations off the west end of the peninsula between Patrix Fjord and Breidi Fjord; also, in the vicinity of Ritr Huk and Straumnes, north of the mouth of Isa Fjord. Thoroddsen (24,p.241) mentions quantities of decomposed mussel shells occurring as calcareous dust along the coast of the Northwestern Peninsula.

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However, the cessation of shells may be real.

if so, it would possibly be due to the temperature of the Irminger Current falling below a certain critical point as it rounds the northwestern peninsula and sets to the east. Or, perhaps it could be attributed to the effect of drift ice from the Arctic ocean. Quite often, in the spring of the year, this ice is carried by the East Greenland current down to the vicinity of the northwestern Icelandic. The main mass goes southwestward through Denmark Strait, between Iceland and Greenland. Part, however, is frequently picked up by the Irminger Current and carried eastward along the northern coast of Iceland.

The western boundary of the zone of shelly bottom is not known. It has been shown as extending out to the edge of the chart, based on bottom soundings.

Occurrence of coral along the Northeastern Zone

The presence of coral in Isafrix Fjord, in Eyra Fjord, and on the shelf east of about 19° (latitude 66 degrees 45 minutes N., longitude 17 degrees 30 minutes W.) is noted by the sailor with particular interest. It is believed that coral is living rather than fossil coral, even though it occurs, in the one, in cold fjord waters and, in the other, along a coast subject to severe ice blockades. Live, fresh or

colonial coral have been found in the cold waters of the Bering Sea along the Aleutian Arc [15,p.47], and also in the North Atlantic off the coast of northern Norway [].

It is, of course, very possible that the Icelandic coral is,after all, fossil. If so, that occurring in the fjords could be no older than Pleistocene, as the fjords received their present forms then. The coral occurring out on the shelf east of North Cape could be either Pleistocene or late Tertiary.

fleischsame or into Jurgen".

ing one on the small coast of North Cape could be either
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Icelandic coral is"also oil" Spell". It so" that occurring

It is" of course" very possible that the
in the Lord Atlantic oil the coast of northern Norway [1]".
Spring can alone the Aphrican are (15°N,17)" and also
colonial coral have been found in the cold waters of the

B.A.2977 (scale 1:261,260)

General Statement

This chart shows the western half of the northern coast of Iceland, including part of the Northwestern Peninsula. It extends from North Cape to Siglu fjord (Latitude 66 degrees 10 minutes N., Longitude 18 degrees 5½ minutes W.). B.A.2976 on the west overlaps with this chart along a north-south strip 111 miles long by 13 miles wide. All data within this overlap is shown on both charts. Also, more detailed information has been added in Hruta fjordur from chart B.A.931 (scale 1:100,000 for entire chart; 1:20,000 for inner half), in Skagastrand harbor from plan B.A.3001 (scale approximately 1:10,000), and in Siglu fjord from plan B.A.3001 (scale this section approximately 1:20,000).

Bathymetry off the North Coast of Iceland

Off the northern coast of Iceland the bathymetry is characterized by a series of great north-trending deeps separated by banks which extend in places almost fifty miles out from the coast (see B.A.565). The deeps are continuous with fjords and basins on the coast. The fjords, in turn, head in valleys which continue southward, trenching the interior highland (see page 6). The banks, outlined by the 100-fathom depth curve, lie off the peninsulas that separate the fjords.

As shown on B.A.565 the deeps and banks from west to east are: Strandagrunn (Strands Grund on B.A.2977), Hånefloa Djåp (Håne Flak deep on B.A.2977), Skaga Grunn (Skaga Grunn on B.A.2977), Skagafjarðaráðjåp (Skaga Fjord Deep on B.A.2977), Flæjðus Grunn (Strauness Flak on B.A. 2977), Ayjafjarðaráll (Ayja Fjarðar Ayt on B.A.2978), Grimseyjargrunn (Grimsey Flak on B.A.2978), Fjörugrunn (ne neyja Flak on B.A.2978), Axarfjarðardjåp (Axar Fjarðar Ayt on B.A.2978), Skjálfandagrunn (Skjalfanda Flak on B.A.2978), Thistilfjarðardjåp (Thistil Fjarðar Ayt on B.A.2978), a nd Thistilfjarðar Grunn (Fjöldar Banks on B.A.2978).

The deeps are fault troughs, formed, at least as far east as Ayja Fjarðar Ayt, by movements sometime during the Pleistocene epoch (1), p.277). The deeps east of Ayja Fjörður Ayt (generally are related to recent faulting to be described later. Some of the western deeps may have been subjected to glacial scour in their inner portions as their corresponding fjords show evidence of glaciation.

In the fjords much of the former depth has been filled in by sand and silt from the large rivers and streams entering at their heads (25). Shallower basins and thresholds, such as occur in the Vestfirðir and in the fjords of the east coast, are generally lacking

in the fjords of the north coast.

Strands Grund, Bathymetry and Bottom Sediments

The easternmost of the banks, Strands Grund, extends slightly over fifty miles northeastward from North Cape. Along its northern edge it is covered with mixtures of mud, sand, and gravel. Between this outer zone and North Cape the chief sediment is sand, continuous with the sand covering the shelf off the western coast of Iceland.

The entire southeastern half of Strands Grund, from the coast out to the northeastern end of the bank, is covered with gravel, forming a great irregular-shaped belt paralleling Kunafloi Deep. A 10 to 15-mile wide zone of rocky reefs and shoals, called Strandabrekur, extends almost completely across this gravel belt at its shoreward end.

Three shoal patches in the vicinity of Latitude 66 degrees 41 minutes N., Longitude 21 degrees 50 minutes W. bear mud notations. The author believes these may be of glacial origin. The sinuous, esker-like ridge at Latitude 66 degrees 33 minutes N., Longitude 22 degrees 2 minutes W. and the enclosed basin of Grung All at Latitude 66 degrees 27 minutes N., Longitude 21 degrees 50 minutes W. likewise are features probably produced by glaciation.

On the shelf just off the coast between Horn Cape and Steingrimms Fjord there is not sufficient data to show the bottom sediments. It is, however, generally rocky and the coast is fringed with many reefs. The mud in Steingrimms Fjord is based only on the presence of an enclosed basin reaching 61 fathoms in depth. It is not known whether this mud is continuous with the mud in Skagastrand Bay. Kolla Fjord, south of Steingrimms Fjord, may very well contain mud also since it is nearly closed off by a rock bar across the mouth.

Hunaflói Deep, Bathymetry and Bottom Sediments

This great deep, lying between Strands Grund and Skaga Grund, reaches depths of over two hundred fathoms near its outer end. The 100-fathom depth curve, bounding the deep, runs unbroken as far south as Latitude 66 degrees N. while isolated basins over 100 fathoms deep continue 17 miles further south. An isolated submarine ridge, rising from 20 to 50 fathoms above the surrounding bottom, lies at Latitude 66 degrees 11 minutes N., Longitude 20 degrees 55 minutes W. This ridge may owe its origin to the faulting which formed Hunaflói Deep.

For the most part Hunaflói Deep is floored with mud. A few patches and areas of sand, gravel, and

mixed sand and mud occur throughout its length. The mud is Boeggild's gray, deep-sea clay (9, Part 3, Plate 2).

Hunaflói Deep runs southward up into Skagastrand Bay, between the Northwestern Peninsula and the peninsula of Skagen. This, in turn, bifurcates into Hruta Fjordur on the west and Huna Fjord on the east.

A narrow isthmus, measuring 4 miles in width and 228 meters in maximum height above sea-level, separates Bitru Fjord, west of the mouth of Hruta Fjordur, and Gils Fjord, at the head of Breidi Fjord. If this isthmus were not present the Northwestern Peninsula would be an island. The orientation of Bitru Fjord and Gils Fjord suggests that the inferred northeast-trending fault system of Breidi Fjord (see page 28) may cut across the isthmus and intersect or merge with the system outlining Hruta Fjordur and Hunaflói Deep.

The mud in Hunaflói Deep is shown as extending southward to the mouth of Hruta Fjordur. This is considered to be a continuous belt following the channel that runs into Hruta Fjordur.

A second, narrower belt of mud lies along the axis of the inner half of Hruta Fjordur. The sandy area on either side of this belt, and possibly the belt itself, contains shells, in contrast to the Isafirdir (see page 38). One possible explanation for this may be that the

deeply inset inner portion of the fjord is to some extent protected from the Arctic drift ice which frequently besets the northern coast. Also, no icy glacial streams pour their waters into Hrute Fjordur as they do in some of the Vestfirdir; the stream entering the upper end of Hrute Fjordur heads in a small lake in the Highlands 10 miles to the south (25).

Rock fringes the eastern and western shores of Hrute Fjordur, both at the mouth of the fjord and halfway back toward the head.

Mid Fjord, east of Hrute Fjord, contains no bottom notations on the chart. The author has shown a belt of mud along its axis at the mouth, based on the presence of a 60-fathom enclosed basin.

The mud zone of Hunaflói Deep is lobate to a limited extent toward Huna Fjord. The mud line is shown running along the eastern side of a gentle trough leading into Huna Fjord. It swings northward opposite the point of land called Vatnsnes, then southward again into Hrute Fjordur. A band of gravel 3 to 4 miles wide flanks this lobe of mud on the east and south.

Sand, with some rock and a few patches of mud, floors Huna Fjord proper. The amount of sediments delivered to Huna Fjord by the numerous streams emptying

into it is considerable. According to Bisiker (4,p.192), the Blandá, which enters from the east, is one of the largest rivers in Iceland; it drains from two glaciers, Lang Jökull and Hofs Jökull, in the interior, and carries much silt in the form of rock flour. Thoroddsen's geological map (25) shows an extensive alluvial fill in the valleys at the head and on the east side of the fjord.

Skaga Grund, Bathymetry and Bottom Sediments

The bank, Skaga Grund, extends more than forty miles north-northeastward from Skagen peninsula. It is about twenty miles wide near the coast and tapers to about ten miles wide at the outer end.

The pattern of bottom sediments on Skaga Grund is remarkably symmetrical with respect to the plan and east-west profile of the bank. A belt of sand varying from 3 to 7 miles wide, lies along the eastern and northern coasts of the Skagen peninsula. Seaward of this a belt of gravel, 3 to 8 miles wide, extends entirely across the bank, from Hunaflói Deep to Skaga Fjord Deep, forming a crude V pointing northward. From the apex of this V a narrower belt of gravel, 3 to 4 miles wide, extends northward along the shoalest portion of the bank to within 7 miles of its end. The author believes this gravel, as well as the gravel on Stranda Grund and in Skagastrand

Bay, may be residual from a former time of lowered sea-level.

Irregular-shaped belts of sand lie on either side of the north-trending central gravel belt, covering the remainder of the bank except for the outer end where mud is the predominant sediment. The sand belts, in turn, are flanked by the mud of Hamerfå Deep and Skaga Fjord Deep. Two isolated, linear-shaped areas of sand extend north-northeastward along the eastern and western sides of the bank at its outer end.

Skaga Fjord Deep, Bathymetry and Bottom Sediments

This deep is well-defined out to about latitude 66 degrees 27 minutes N., reaching 158 fathoms there. Two isolated submarine ridges lie in the vicinity of latitude 66 degrees 20 minutes N. The easternmost of these rises 45 fathoms above the channel east of it, while the westernmost rises from 10 to 30 fathoms above the surrounding bottom. They may be due to faulting, especially the westernmost, which is linear-shaped, or they may possibly be due to glacial deposition.

Skaga Fjord Deep is floored with mud southward to latitude 66 degrees 5 minutes N. Flanking it on the east, along the edge of Strandunes Flak, is a belt of sand from 1½ to 4 miles wide. Strandunes Flak itself is covered, for the most part, with gravel, but contains

the remarkable symmetry of pattern observed in Kunaflói Deep and Skaga Grund.

Bottom Sediments in Skaga Fjord

Skaga Fjord Deep runs up into Skaga Fjord to the south. A north-trending belt of mud is shown lying in the western part of the fjord, following the channel there. Its exact extent to the north is unknown. Intervening between it and the mud of Skaga Fjord Deep, further to the north, is a zone of gravel which connects on the east with the gravel of Straumnes Flak.

The chief sediment throughout the remainder of Skaga Fjord, i.e. in the eastern half, at the head, and in a coastal strip along the western side, is probably sand. One possible exception may be the channel shown by soundings to run up the east side of the fjord; this may contain some mud, although none has been shown on the chart.

It is certain that a great amount of sand and silt has been, and is being, emptied into Skaga Fjord. On Thoroddsen's map (25) the river entering at the head of the fjord is shown to drain from Hofs Jökull in the interior. Also, all streams entering from the east head in valleys below small local glaciers in the highlands between Skaga Fjord and Lyja Fjord. The large alluvial

the remarkable symmetry of patterns observed in Dunstaffnage and Glen Orchy.

Motions continuing in Scour Ploye

Glen Ploye body runs in the Glen Ploye to the south. A north-trending belt of mud is shown lying in the western part of the floor, following the channel there. Its exact extent to the north is unknown. Interval between it and the end of Loch Ploye Deep, further to the north, is a zone of gravel with channels of the gravel of Kilmaree Flat.

The relief evidence therefore, the terminations of Glen Ploye, i.e. in the eastern half, at the head, and in a central strip along the western side, is generally sand. The possible explanation may be the current known by geologists to run up the west side of the Firth by Cowrie and, although more are been shown on the charts.

It is certain that a great amount of sand and silt has been, and is being, carried into Loch Ploye. A Inverscaddle map (3) the river entering at the east of the floor is shown to drain from Loch Ploye in its Interlor. Also, all streams entering from the west have it valleys below small local glaciers in the Kilmaree Hills between Glen Ploye and Glen Ploye, further to the west. A north-trending belt of mud is shown lying in the western part of the floor, following the channel there. Its exact extent to the north is unknown. Interval between it and the end of Loch Ploye Deep, further to the north, is a zone of gravel with channels of the gravel of Kilmaree Flat.

The relief evidence therefore, the terminations of Glen Ploye, i.e. in the eastern half, at the head, and in a central strip along the western side, is generally sand. The possible explanation may be the current known by geologists to run up the west side of the Firth by Cowrie and, although more are been shown on the charts.

It is certain that a great amount of sand and silt has been, and is being, carried into Loch Ploye. A

fill in the valleys at the head and along the eastern side indicates that Skaga Fjord at one time extended farther south and that smaller, tributary fjords opened into it from the east(25).

Occurrence of Coral Along the Western Half of The Northern Coast

B.A.2977 shows coral notations in three localities: (1) at Strandebreker, on Strands Grund; (2) in Bruts Fjord; and (3) off the northern and eastern coasts of the Skagen peninsula. No data are available for determining whether or not these are living coral forms. As previously mentioned, colonial coral has been found living in cold-water environment in other parts of the world. It may therefore occur along this coast also.

B.A.2978 (Approximate Scale 1:261,260)

General Statement

This chart shows the eastern half of the northern coast of Iceland, extending from Siglu Fjord to Bjareda Flói, 45 miles south-southeast of Kontrim s t the outer extremity of the Langanes peninsula.

The overlap with B.A.2977 on the west consists of a north-south strip only two miles wide. More detailed information in Siglu Fjord and in Eyja Fjord has been obtained from plan B.A.3001 (approximate scale this section 1:20,000) and chart B.A.3453 (scale 1:90,500) respectively.

Pattern of Bottom Sediments off the Eastern Half of the Northern Coast of Iceland

The outstanding feature on this chart, as on B.A.2977, is the series of north-trending deeps and banks-- seaward continuations of the large fjords and broad peninsulas which characterize the northern coast.

In the western half of the chart these deeps and banks control the sedimentation, giving rise to the same rudely symmetrical pattern observed on B.A.2977;i.e. mud flooring the deeps and gravel, flanked by sand, covering the banks. East of Axar Fjordur Dyp, however, deeps a nd banks alike are, to a great extent, covered with sand. The several patches of mud in Thistil fjordur Dyp, Thistil

H.O. 2272 (Approximate Scale 1:[illegible])

General Statement

This chart shows the eastern half of the northern coast of Iceland, extending from [illegible] fjord to [illegible], 45 miles east-northeast of [illegible] at the outer extremity of the [illegible] peninsula.

The overlap with H.O. 2277 on the west consists of a north-south strip only two miles wide. More detailed information in [illegible] fjord and in [illegible] fjord has been obtained from plan H.O. [illegible] (approximate scale 1:[illegible]) and chart H.O. [illegible] (scale 1:[illegible]) respectively.

Pattern of Bottom Sediments Off the Eastern Half of the Northern Coast of Iceland

The outstanding feature on this chart, as on H.O. 2277, is the series of north-trending banks and basins— seaward continuations of the large fjords and broad peninsulas which characterize the coastline here.

In the western half of the chart these deeps and banks control the sedimentation, giving rise to the same nicely symmetrical pattern observed on H.O. 2277; i.e., mud floors the deeps and gravel, formed by waves, covers the banks. East of [illegible], however, deeps and banks alike are, to a great extent, covered with sand. The general pattern of mud in [illegible] [illegible],

Fjord, and Langanes Dyk and the patches and areas of gravel on Selrakka Flak, Kjölsen Banke, and Langanes Flak suggest that the symmetrical pattern of sediments formerly existed here also, but has been masked by a great flood of sand.

Lyja Fjardar Dyb and Lyja Fjord, Bathymetry and Bottom Sediments

Lyja Fjardar Deep merges with Langanes Deep and Skaga Fjord Deep to the west (see B.A.2977 and B.A.565) and is bounded on the east by Grimsey Flak. It reaches depths of over two hundred fathoms north of latitude 66 degrees 22 minutes N. Like the other deeps to the west, it is floored with mud.

Lyja Fjardar Dyb runs up into Lyja Fjord, which, in turn, heads in a long, narrow valley trenching the interior highlands for a distance of almost thirty-five miles south of the fjord head. According to Nielsen (17,p.77), this depression, extending from the interior far out to sea, is probably a fault trough formed during the Pleistocene epoch.

The pattern of bottom sediments in Lyja Fjord is similar to the pattern in other large fjords. Mud floors all of the deeper portion continuously from head to mouth. This is flanked on either side by narrow belts of sand covering most of the shallower portions.

The shoreline throughout much of its length is rocky and fringed with reefs.

Sandy and stony deltas have been built out into the fjord from the mouths of several of the streams, as the Fnoská, the Horgá, and the stream entering at the fjord head, south of Akureyri. The sand and gravel flooring Olafs Fjord, near the mouth of Eyja Fjord, and extending out into the main fjord is undoubtedly derived from the stream at its head. The spit called Oddeyri, north of Akureyri, is a partially-submerged terminal moraine reworked by tidal currents (10, p.81).

Grimsey Flak, Bathymetry and Bottom Sediments

This bank reaches over thirty miles to seaward from the peninsula between Eyja fjord and Skjalfandi. This peninsula for convenience will be called the Gjögr peninsula after the northernmost point on it.

Extending northward along its backbone, from shore to outer end, is an irregular belt of gravel ranging from 2½ miles to 10 miles wide. Along either side of this gravel lie belts of sand from 1 to 3 miles wide.

Post-Pleistocene Subsidence

A great belt of downfaulting intersects the northern coast of Iceland between the Gjögr peninsula and the western end of the Langanes peninsula. Subsidence

has taken place since the end of the Pleistocene epoch, and the belt is marked by active vulcanism and frequent earthquakes. Beginning the count from the south, it continues northward into the sea, and occasionally submarine volcanic eruptions occur in coastal regions.(24,p.229).

North of Grimsey rise the gravel-covered Svörtuloft bank and Groves bank, as well as the island of Grimsey, may be recent volcanic accumulations. They are close enough to the seaward extension of the belt of subsidence to be in the zone of marginal faulting and attendant vulcanism. In 1868 volcanic activity was reported at the island of Svalbrynjar, north of the Tjörnes peninsula.(22,p.511).

Thoma describes this belt of subsidence as follows (21,p.265):

> " Its western edge is continued from the ... north along the western border of the Skjálfandi fjord, and thence for a distance of 150 kilometers towards the south as a steep basaltic cliff rising 500-600 meters above the bottom of the trough. The western edge runs along the base of the peninsula of Langanes. Skjálfandi fjord, Húsavik, Tjörnes, Axar fjord, and Thistil fjord lie within the subsidence. In this region earthquakes are of frequent occurrence. The downthrown bend is traversed....by numerous fissures which strike north and south, parallel to the margins of the fault trough. They separate lofty horsts from deep fault troughs; hot springs and volcanoes accompany their course like beads on a thread;great lava floods have proceeded from them."

This belt of subsidence can be traced southward to the center of Iceland, and from there southwestward to the southwest coast, where it forms the great southwestern Lowland described previously. The zone of crustal weakness along the northwestern side of the trough in southern Iceland is represented by the volcanic peninsula of Reykjanes and its submarine extension to the southwest. The southeastern boundary is represented by the volcanoes , Tindfjalla Jökull and Eyjafjalla Jökull, and the volcanic islands of the Vestmannaeyjar.

Skjálfandi Dyb, Bathymetry and Bottom Sediments

This deep, lying between Grimsey Flak on the west and Manseyja Flak on the east, reaches depths of 20 fathoms or more near its outer end. It is floored with mud, which in places is consolidated enough to warrant a "hard" classification by the hydrographers. This is portrayed by Bourgild (9,Part 3,Plate 1) as grey,deep-sea clay.

The belt of mud in Skjálfandi Dyb extends southward through the bay of Skjálfandi to within 5 miles of the bay head. The remainder of the bottom is covered with sand which is continuous with the sand of Grimsey Flak and Manseyjar Flak.

The river, Skjalfanda Flict, which flows into

the head of Skjálfandi, heads at the northwestern edge of the ice sheet Vatna Jökull, 100 miles to the south. Accordingly, its waters deliver great amounts of glacial silt to the sea, as well as sand and pumice derived from the volcanic region through which it flows.

Kaneyjar Flak, Bathymetry and Bottom Sediments

This bank extends 26 miles northward from the peninsula of Tjörnes.

It bears two rocky shoal patches: Kaneyjar (Latitude 66 degrees 17.5 minutes N., Longitude 17 degrees 7 minutes W.) and Eyjarbrekka (Latitude 66 degrees 19.5 minutes N., Longitude 17 degrees 8 minutes W.). Gravel surrounds these shoals and extends along the backbone of Kaneyja Flak in discontinuous belts and patches to within 10 miles of the northern end of the bank. The gravel surrounding Kaneyjar, and perhaps the gravel further north also, is believed to have resulted from submarine volcanism. Gravel skirts the northern coast of the Tjörnes peninsula, forming a 1½-mile wide band. This can probably be attributed to wave erosion on the rocky coast.

Axar Fjorder Dyb and Axar Fjord, Bathymetry and Bottom Sediments

Lying between Kaneyja Flak and Eyjarbrekka Flak, this deep trends north-northwestward from Axar Fjord. It apparently coalesces with Skjálfandi Djúp about

thirty-five north of Björnes, and the combined deep continue northwestward from there.

Soundings over Axar Fjarder Dyb attain the depths of Arnarfjardardjúp and the other great deeps to the west. At latitude 66 degrees 40.5 minutes N., longitude 16 degrees 57 minutes W. a sounding of 154 fathoms marks the deepest spot so far measured; several soundings of 144 fathoms occur south of here.

Three discontinuous belts of mud occur in Axar Fjord and Axar Fjarder Dyb. The numerous "stiff clay" and "hard" notations in these belts indicate that the sediment is probably Koegrild's gray, deep-sea clay.

A slightly shoaler tongue of sand, 7 miles wide, crosses Axar Fjarder Dyb, separating the largest of the above belts of mud from the mud in the outer portion of the deep. This sand, which is of a part with the sand of Hvanneyri Flat and Melrakka Slak, is obviously a rill, cutting across a previously continuous belt of mud running up the deep.

The remainder of Axar Fjarder Dyb and Axar Fjord is covered with mud and a little gravel.

The Jökulsá River, which empties into Axar Fjord, flows from Vatna Jökull in the interior through a region of active vulcanism. Like the Skjálfandi Flói,

it is therefore heavily laden with sand and silt which is discharged into the sea. Thoroddsen (22,p.506) cites one instance in 1717 when large quantities of pumice were carried to the sea from an eruption in the interior.

Bathymetry of the shelf from Melrekka Flak to Langanes Flak

The bank, Melrekka Flak, extends 30 miles northwestward from the peninsula of Melrakka Sljetta. It averages about fifteen miles in width.

Thistil Fjardar Dyb, between Melrekka Flak on the southwest and Kjölsen Banke on the east, trends northward and northwestward from Thistil Fjord. A greatest depth of 185 fathoms is shown at latitude 66 degrees 47.25 minutes N., longitude 14 degrees 7 minutes W. Most of the bottom, however, lies no deeper than 130 fathoms.

North-trending Kjölsen Banke lies, partially isolated, 25 miles north of the Langanes peninsula. It bears a least depth of 49 fathoms at latitude 66 degrees 42.5 minutes N., longitude 15 degrees 4.5 minutes W.

Langanes Dyb, between Kjölsen Banke on the west and Langanes Flak on the south, trends northeastward from a point about ten miles south-southeast of Kjölsen Banke. The greater part of its floor lies between 110 and 140 fathoms.

The bank, Langanes Flak, extends over thirty

miles northwestward from the Langanes peninsula. It averages about twenty miles wide throughout the greater part of its length. Soundings show a north-trending submarine valley, tributary to Langanes Dyb, cutting halfway across its width 15 miles northeast of Fontrinn.

Bottom sediments from Melrakka Flak to Langanes Flak

Sand is the predominant sediment covering the banks and deeps from Melrakka Flak to Langanes Flak. However, as mentioned before, the presence of discontinuous patches and areas of gravel on the banks, as on Ljósen Banks, and of mud in the deeps, as in Thistil Fjordur Dyb and Thistil Fjord, suggests that most of this sand is a relatively recent mantle covering an older sedimentation pattern similar to the one now existing west of Axar Fjordur Dyb.

Gravel covers the bottom of the northern and western sides of the Melrakka Sljetta peninsula and completely surrounds the Langanes peninsula for distances up to 15 miles out from shore. This gravel is no doubt derived locally from the basalt and tuff outcropping in cliffs at various points along the coast. The unusual width and continuity of the gravel zones suggests increased wave and current action over a wider area of outcrop during a former time of lowered sealevel. Also,

it is possible that pack ice in recent times has played a part in distributing the gravel, as relicts Siljette and Langanes both are frequently subjected to severe ice blockades in the spring of the year (24,p.270; 18,p.67).

In general, the gravel zones are somewhat shoaler than the adjacent sandy zones. In one place (Latitude 66 degrees 25.5 minutes N., Longitude 15 degrees 33 minutes W.) a slightly shoaler bar of gravel intrudes into and partially cuts off sand- and mud-filled Thistil Fjord. It would appear that the gravel was deposited later than the sand, thereby indicating that gravel movement may be going on at the present time, or, at least, quite recently.

Bathymetry off the Northeastern Coast of Iceland

The bathymetry off the northeastern coast of Iceland is characterized by alternating deeps and banks, much the same as those occurring off the northern coast, as shown on B.A.505, these deeps and banks, from northwest to southeast, are: Langanesdjúp (Langanes Dyb on B.A.2978), Langanesgrunn (Langanes Flak on B.A.2978), Bakkafjarðardjúp (Bakka Flói Dyb on B.A.2978), Vopnafjardargrunn (No name on B.A.2978), Héraðsdjúp (Hjeraðs Flói Dyb on B.A.2978), Glettinga nesgrunn (No name on B.A.2978), and Seydisfjarðardjúp (No name on B.A.2978).

The deeps were probably cut by subaerial erosion when the shelf was completely exposed at the end of the Miocene. As far as the author is aware, faulting has played no part in their formation. Some deepening may have been accomplished by glacial excavation during the Pleistocene epoch, however.

Bakka Flói Dyb and Vopna Fjord, Bathymetry and Bottom Sediments

Bakka Flói Dyb extends northeastward from the bay, Bakka Flói. Its greatest measured depth, 208 fathoms, falls outside H.D.297/3, on which chart most of the bottom lies between 110 and 150 fathoms. At its shoreward end the deep turns southward toward Vopna Fjord, while a smaller branch shown by the soundings continues southwestward and runs up into Bakka Flói.

Much of Bakka Flói Dyb is floored with mud, particularly the deeper central portions. It is not certain if this mud forms a continuous belt, as shown on the chart, since sediment notations are widely separated. Sand covers the slopes on the northwestern side of the deep, and the slopes and part of the bottom on the southeastern side.

The shoreward end of Bakka Flói Dyb is, to a great extent, surrounded by gravel. The boundary between gravel and mud on the eastern side of the southward extension of the deep, at about latitude 65 degrees 7 min-

utes N., Longitude 14 degrees 23 minutes W., has been placed along the bottom of a pronounced break in slope, where the bottom falls off to the west over 50 fathoms in 1 mile.

This gravel is probably continuous with the gravel surrounding Langanes Flak. It also extends to the south and east, covering most of the bank called Vopna-fjardargrunn on B.A.565.

The large areas of sand in Bakka Flói and in Vopna Fjord, 20 miles to the south-southeast, have very likely been deposited from the streams entering at their heads.

The bottom for 2 miles to seaward from the peninsula southeast of Bakka Flói is rocky. Likewise, rock bottom extends more than five miles outward from the peninsula between Vopna Fjord and Hjéreds Flói.

Hjéreds Flói and Hjéreds Flói Dyb, Bathymetry and Bottom Sediments

Hjéreds Flói, southeast of Vopna Fjord, and Hjéreds Flói Dyb are seaward extensions of two long, narrow valleys which commence in the interior and merge into one lowland just before reaching the sea. The Jökulsa and the Lager Fljot rivers, which flow through the valleys, both head in Vatna Jökull. Both valleys

are extensively alluviated (25), and the lower Fljot throughout much of its length forms a deep, narrow lake the bottom of which lies 84 meters below sea-level (24,p.210).

These valleys are partially-filled glacial troughs, and the common lowland at their lower end is presumably a coalescing delta of which the sandy area in Hjèrads Flòi represents the seaward extension. The outward edge of this advancing wedge of sand is marked approximately by the 100-fathom depth curve. In Hjèrads Flòi Dyb, outlined by the 100-fathom curve, mud is the predominant sediment.

Occurrence of Coral along the western half of the Northern Coast

Coral is shown on H.A.2978 in six separate localities. (1)Two patches occur about three miles offshore, west of the mouth of Ayja Fjord. (2)One patch occurs just offshore on the northeastern side of the Kjöğr peninsula, east of Ayja Fjord. (3)Two patches occur near the head of Thistil Fjord, and (4)one out in the middle of the embayment between the peninsulas of Melrakka Sljetta and Langanes at latitude 66 degrees 27 minutes N., longitude 15 degrees 6 minutes W. (5)One patch occurs on the south end of Kjölsen Banke, at lati-

tude 66 degrees 33.5 minutes N., Longitude 19 degrees 6 minutes W. (6) A number of patches and areas are distributed along the Langanes peninsula on both sides--some near shore and others up to eight miles offshore.

The extensive development of coral around Langanes is particularly worthy of note, since this peninsula, together with Melrakka Sljetta and North Cape, is subject to severe drift ice blockades more often than any other points along Iceland's coast.

B.A.2979 (Scale 1:254,000)

General Statement

This chart shows the waters off the eastern coast of Iceland, from Ljeredz Flói to the Vestrahorn peninsula. Overlap with B.A.2972 on the northwest consists of a strip measuring 34 miles east-west and 6 miles north-south. This common area includes only the southeastern edge of Ljeredz Flói, the remainder of the overlap falling on land.

Extra detail has been added from the following large-scale plans: B.A.3330 (1:36,580), covering Seydis fjord and Lodmundar Fjord; B.A.1535 (1:32,590), covering both branches of Ljósafi Fjord; B.A.1550 (approximately 1:40,650), covering Reydar Fjord and Fáskrud Fjord; and, B.A.1636 (approximately 1:30,000), covering Beru Fjord.

Character of the Western Coast

This section of Iceland's coast, like the northwestern peninsula and the western part of the northern coast, is mountainous and indented with numerous fjords. Many of these fjords are matched offshore by submarine valleys which extend outward across the shelf and form deeps, as off the northern coast.

However, unlike the northern coast, the land valleys at the heads of the fjords do not extend long distances inland. Here the drainage divide lies nearer

more than thirty-five miles in from the extremities of the intervening peninsulas (25), while it is often more than one hundred miles in from the extremities of the north-coast peninsulas.

The western fjords, and corresponding deeps, also differ from the northern fjords and deeps in that they owe their origin solely to subaerial erosion, which took place at the end of the Pliocene epoch. As far as is known, no faulting is involved in their depression.

Glacial excavation during the Pleistocene epoch has deepened many of the fjords, producing enclosed basins and well-developed thresholds. These basins, like the basins of the Northwestern Peninsula fjords, are the sites of accumulation of fine sediments. The muds are typical of the stinking, black fjord muds usually produced under conditions of stagnation (20,p.84).

The Shelf between Fjords Flói and Skjálfandi, Bathymetry And Bottom Sediments

Kjerads Flói and Kjerads Flói Dyb, enclosed by the 100-fathom depth curve, appear at the top of the chart. A belt of mud is shown lying in the deep and overlapping somewhat onto the bank south of it. This mud is continuous with the area of mud in Kjerads Flói Dyb shown on B.A.2978.

South of Kjerads Flói Dyb the bank called

Glettinganesgrunn (see p.a.,305), as outlined by the 100-fathom depth curve, reaches over forty miles eastward from the coast, narrowing from 20 miles in width at the shoreward end to a point at the outer end. South of it the deep, Seydisfjardardjúp, with the floor lying for the most part, between 110 and 120 fathoms, extends eastward from Seydisfjörður, or Seydis fjord. A long, narrow, unnamed bank extending eastward from the vicinity of Mjófi Fjord bounds Seydisfjardardjúp on the south.

From Hjereds Flói to Hendvik (latitude 65 degrees 5.5 minutes N., longitude 13 degrees 32 minutes W.) sand is the predominant sediment, covering deeps and banks alike. However, areas of gravel occur locally on the banks. One area, measuring 16 miles east-west by 10 miles north-south, occupies the west central portion of Glettinganesgrunn. Another area, measuring 7 miles east-west by 4 miles north-south, lies on the bank south of Seydisfjardardjúp. One small area of mud of unknown size lies in Seydisfjardardjúp.

The coast, both in the fjords and on the intervening peninsulas, is fringed by reefs, while isolated rocks and patches of rock bottom occur at various distances offshore. Gravel covers the bottom for 4 miles out from the peninsula between Seydis fjord and Mjóri Fjord.

Seydis fjord and Kjöfi fjord, bathymetry and bottom sediments

Two large fjords, Seydis fjord and Kjöfi fjord, indent this section of the coast. In Seydis fjord an enclosed basin reaching 50 fathoms in depth is separated from equivalent depths on the shelf by a threshold nearly twenty fathoms shoaler, located outside the fjord mouth.

Seydis fjord is floored with mud, except for a narrow strip of sand along the shore. This mud extends out into the open sea almost as far as the head of Seydisfjardardjúp.

Kjöfi fjord, likewise, is floored with mud except for a narrow strip of sand along the shore. This mud extends into the southern branch of Kjöfi fjord, called Nordfjordarflói on B.A.1933. Here it is flanked by sand on both sides, and the sand, in turn, by a continuous strip of rock bottom skirting the shore. The bottom sections on B.A.1933 show a continuous band of rock bottom across the mouth of Hellis fjord, middle one of three small fjords at the head of Nordfjordarflói. The soundings, however, show no particular evidence of a threshold ridge here.

Reydar fjord, bathymetry and bottom sediments

Between Lonavik and Reyd fjord (latitude 64 degrees 40 minutes N., longitude 14 degrees 15 minutes W.) the coast is indented by five fjords. From north-

east to southwest these are: Reydar Fjord, Reksud Fjord, Stöðvar Fjord, Breiddals Vik, and Beru Fjord.

Reydar Fjord is a flat-bottomed trough 2 miles wide and 15 miles long. It reaches its greatest depth, 196 fathoms (latitude 64 degrees 57.25 minutes N., longitude 13 degrees 36 minutes W.), at the outer end. East of this the bottom becomes shoaler, and a threshold separates the depths of the fjord from equivalent depth on the shelf outside. Soundings indicate that a submarine valley continues outward from the mouth of the fjord. As it crosses the shelf it increases in size and depth to form the deep, Reydarfjardardjúp (see B.A.1550), which indents the edge of the shelf.

The 80-fathom sounding 1½ miles south-southwest of the islet, Sorta Sker, marks the deepest point on the threshold. The gravel patch occurring at this point suggests the threshold may be covered in part with morainal material.

Halfway in toward the head of Reydar Fjord a smaller branch, called Leki Fjord, joins it from the northwest. Depths in Leki Fjord are no greater than 35 fathoms (shown on B.A.1550), as compared to depths of 62 to 77 fathoms in the adjacent part of Reydar Fjord. Leki Fjord is a "submerged hanging valley." Like Reydar Fjord, it contains an enclosed basin. This basin is

separated from the depths of Seyðis fjörður by a threshold which is 17 fathoms or more shoaler than the basin.

In the outer half of Seyðis fjörður sand and mud floor the deeper portions. The shallower portions on either side of this are covered with rocks, while much of the shoreline is rock-fringed.

The inner half of Seyðis fjörður is floored with mud, while narrow strips of sand probably skirt the shore. Seyðisá fjörður is floored largely with sand and mud.

Reyðarfjörður, bathymetry and bottom sediments

Reyðarfjörður, south of Seyðis fjörður, averages 1 mile in width and 7 miles in length. Like Seyðis fjörður, it contains an enclosed basin behind an outer threshold. The basin floor lies for the most part between 47 and 57 fathoms, the deepest part being near the outer end. The threshold lies at 41 fathoms.

Bottom notations on U.S.C.&G.S. 1550 show that a mile-wide band of rock bottom, coinciding with the threshold, extends completely across the mouth of Reyðarfjörður and to the headlands, Hólmur and Hólmanes, a few miles further east. A narrower band of rock bottom extends around the peninsula north of Reyðarfjörður, extending several miles into both Reyðarfjörður and Seyðis fjörður.

In some places in Reyðarfjörður rock bottom fringes the shoreline, while in others a narrow strip

of sand lies along the shore. Sand also covers the bottom of the enclosed basin for a distance of almost two miles west from the western edge of the rock threshold. However, by far the greater part of the bottom is covered with mud.

Stödvar fjord and breiddals Vik, Bathymetry and Bottom Sediments

Stödvar fjord and breiddals Vik, the two small indentations south of Reydar fjord, are comparatively shallow. Stödvar fjord reaches 30 fathoms at the deepest, while most of breiddals Vik lies above 25 fathoms. A submarine valley heading into Breiddals Vik contains a hole 44 fathoms deep; this, however, lies just outside the bay.

Both Stödvar fjord and Breiddals Vik have sand bottoms. In Breiddals Vik a row of rocks and rocky islets up to one mile wide skirts the entire southeastern shore, while separate reefs extend the same distance into the bay from the northern shore. The linear shape of these reefs suggests they may be submerged dikes, such as occur to the southeast in Seyd fjord.

Seyd fjord, Bathymetry and Bottom Sediments

Seyd fjord, the southernmost of the fjords in this section, averages 1½ miles in width and extends 11 miles inland. Unlike the fjords just described, Seyd fjord has no single enclosed basin within a pronounced

threshold. Throughout most of its length a series of small basins separated by narrow shoaler areas characterizes the bottom. The deepest parts of the basins are marked by: the 41-fathom sounding at latitude 64 degrees 44.75 minutes N., longitude 21 degrees 25.5 minutes W.; the 35-fathom sounding at latitude 64 degrees 43.4 minutes N., longitude 21 degrees 24 minutes W.; the 30-fathom sounding at latitude 64 degrees 42.25 minutes N., longitude 21 degrees 22.75 minutes W.; the 34-fathom at latitude 64 degrees 41.15 minutes N., longitude 21 degrees 19.25 minutes W.; the 33-fathom sounding at latitude 64 degrees 40.75 minutes N., longitude 21 degrees 16.5 minutes W.; and the 31-fathom sounding at latitude 64 degrees 40.4 minutes N., longitude 21 degrees 13.5 minutes W. The portions of basins between these are from 3 to 14 fathoms shoaler than the basins.

This bathymetric irregularity is believed to be due to the effect of numerous basalt dikes which traverse the [illegible] (Fig. 4a). These dikes are particularly [illegible] of the mouth of the fjord, here they form linear-shaped reefs and rocky islets extending from both shores out into the fjord. On H.A.1636 the landward portions, striking northeastward, are also seen. The linear-shaped reefs and islands between the end of the Ljusavogr peninsula, south of Hvammsfjord, and the

island of Papey, 4 miles to the southeast of the peninsula, are undoubtedly due to the effect of dikes also. The pattern of sediments in Lóns Fjord is the same as that in the other large fjords to the north. Mud covers the greater part of the fjord bottom, while strips of sand skirt much of the shore.

On the shelf outside the fjord lies an irregular-shaped area of mud, measuring 5½ miles east-west by 2½ miles north-south. This is separated from the mud in the fjord by 2 miles of sandy bottom.

As with the other fjords, a submarine valley continues outward from Lóns Fjord. It crosses the shelf, increasing in size to become the deep, Lónsfjordarall (see B.A.565).

The shelf between Langavik and Lónsa Fjord, bottom sediments

In the section north of Langavik the shelf was largely covered by sand, with only a few isolated areas of gravel. South of Langavik, however, gravel predominates over sand. Commencing about ten miles east-southeast from Langavik, a continuous belt of gravel 7 to 10 miles wide trends southeastward for about nine miles. It then turns sharply to the southwest and trends in this direction for about fifty miles, decreasing to 6 miles in width at the southwestern end. At a point 17 miles southwest of where it makes the sharp turn the width suddenly decreases

to 7½ miles and immediately increases again. Just before this point it is joined by another belt of gravel of equal width, approaching from the west and southwest. The author cannot account for this great amount of gravel except to suggest that it may have been formed by wave erosion on rocky terrain exposed on the shelf, or at least brought within wave base, when the sea level was lowered at the end of the Pliocene epoch.

Sand mantles the shelf east of this gravel for as far as the chart extends. A belt of sand 5 to 6 miles wide also intervenes between the gravel and the coast southwest of Reydar Fjord.

Two large areas in which the sediments, sand and gravel alike, contain shells occur on the shelf here. One of these, shaped roughly like an isosceles triangle with the east-west altitude measuring 12 miles and the north-south base, 7 miles, lies offshore just north of Reydar Fjord. The other, irregular-shaped, area, measuring 17 miles northwest-southeast by 12 miles east-west, commences at the rock threshold of Fáskrud Fjord and extends southward and southeastward almost to Berufjord. South of this a number of patches and small areas of shelly bottom are scattered over the shelf.

Numerous reefs and rocky shoals are found on the shelf at varying, and sometimes considerable, distances

Offshore. Examples of these are: Diesa Bodi (latitude 65 degrees 3.5 minutes N., Longitude 13 degrees 13.5 minutes W.), Nyibodi (Latitude 64 degrees 50.25 minutes N., Longitude 13 degrees 26 minutes W.), Sandgur (Latitude 64 degrees 47.25 minutes N., Longitude 13 degrees 25.5 minutes W.), Hvalsbekur (Latitude 64 degrees 36.25 minutes N., Longitude 13 degrees 17 minutes W.), Yztibodi (Latitude 64 degrees 35 minutes N., Longitude 14 degrees 3 minutes W.), and others.

The coincidence of most of these rocks with the belts of gravel previously described lends weight to the hypothesis that the gravel was obtained by wave erosion on rocky terrain when the sealevel was lowered. The rocks would therefore represent unreduced stacks and ledges.

The abnormal magnetic variation noted at Diesa Bodi and other places along the coast attests to the ferrous nature of the basic rocks underlying the shelf.

The Coastline between Hamars Fjord and Vestrahorn

In Hamars Fjord and Alfta Fjord, southwest of Beru Fjord, no information is available as to the nature of the bottom sediments. A sand bar 6 miles long has been built completely across the mouth of Alfta Fjord and partway across the mouth of Hamars Fjord. This is the first of a series of great offshore bars and storm beaches fringing the southeastern, southern, and southwestern

coasts of Iceland.

Just outside this bar lies an oval area of rock bottom, measuring 5 miles long parallel to the bay and 2½ miles wide. Another area of reefs and rock bottom extends 2½ miles to seaward from the point, Hvalsnes, a bout ten miles south of Alfta Fjord. According to Thoroddsen's geological map (25), the rock composing the point is liparite. Presumably, therefore, the rock composing the offshore reefs is likewise liparite.

Eleven and one half miles southwest of Hvalsnes lies another, smaller area of rock bottom off the northeastern side of the promontory, Vestrahorn. Thoroddsen's map (25) shows gabbro here.

From Hvalsnes an offshore bar extends southwestward to Vestrahorn. Two embayments are enclosed behind it. Lons Fjord (name shown on B.A.Y.S.) is apparently shut off completely, while Lops Fjord is nearly so. No information is available on the nature of the bottom sediments in these bays.

The shelf between Hamars Fjord and Vestrahorn, bottom sediments

With certain exceptions, to be given below, sand covers the greater portion of the shelf in this section. A number of patches and small areas of shelly bottom occur scattered throughout sand and gravel zones alike.

The long belt of gravel described on page 73 extends southwestward to a point 7 miles southeast of Hvalsnes. As previously mentioned, a belt of sand bottom intervenes between this gravel and the shore, except where rock bottom occurs. A small, linear-shaped area of gravel, 9 miles long by 2½ miles wide, lies offshore 30 miles east of Hvalsnes.

Commencing 7 miles southeast of the bar across Alfts Fjord, an S-shaped belt of mud and ooze trends southeastward, eastward, and again southeastward for almost twenty-five miles. It averages about three miles wide in the section nearest shore, swells to twice this width in the middle section, and tapers again to about three miles wide in the section farthest from shore. This last section lies in the trough of Berufjarðarall, marked by the 100-fathom and 108-fathom soundings at Latitude 64 degrees 15.5 minutes N., Longitude 13 degrees 29.5 minutes W. and Latitude 64 degrees 20.5 minutes N., Longitude 13 degrees 35.5 minutes W. respectively. The middle section occupies a gentle tributary submarine valley indicated by the 83-fathom and 73-fathom soundings at Latitude 64 degrees 19.5 minutes N., Longitude 13 degrees 44.75 minutes W. and Latitude 64 degrees 19.75 minutes N., Longitude 13 degrees 38.75 minutes W. respectively.

Two smaller areas of ooze lie several miles north of this belt, while a number of scattered areas of both

mud and ooze lie in the gravel zone still further north.

Another belt of mud and ooze, comparable in size to the belt southeast of [illegible] Fjord, commences 3½ miles southeast of [illegible], [illegible] belt trends southwestward past Vestrahorn, and is continued on [illegible].

It is not known whether the ooze is organic or simply a flocculent, watery mixture of inorganic material. Pertinent to this question, Kesseler (5, p. 97-102) mentions at least three cold-water forms of ostracods that occur off Iceland.

Occurrence of Coral Along the Eastern Coast

Coral is shown on this chart in single patches at eight localities. These are as follows: (1) 5 miles eastward from the southern cape of Fjarðar Flói; (2) 2 miles offshore, halfway between Fjarðar Flói and Seydisfjord; (3) close in to shore, halfway between the mouth of Héraðs Fjörður and the night of Loðmvik; (4) 3 miles south-southeast of Loðmvik; (5) 11 miles eastward from the mouth of Reyðar Fjord; (6) 17 miles east-southeastward from the mouth of Reyðar Fjord; (7) the northern tip of the mouth of Fáskrúð Fjord; (8) 3 miles east-northeast of the island, Papey, off the mouth of Berufjord.

It is not known if this is living or fossil coral.

B.A.2960 (approximate scale 1:260,000)

General Statement

This chart shows the waters off the southeastern and southern coasts of Iceland, from the Vestrahorn peninsula to the section of shoreline south of the volcano, Myjafjalla Jökull. The area portrayed includes the island shelf and the island slope out to depths of over eight hundred fathoms.

B.A.2979 overlaps into the northeastern corner, forming a rectangle measuring 15 miles east-west by 12 miles north-south. About nineteen miles of shoreline, including the Vestrahorn peninsula, are shown in this common area.

As previously mentioned, B.A.2960 and B.A.2733, to the west, have about twenty-two miles of shoreline in common. B.A.2960, however, extends 28 miles further south than B.A.2733.

Extra data have been added to Hornafjörd (latitude 64 degrees 15 minutes N., Longitude 15 degrees 12 minutes W.) from plan B.A.1533 (scale 1:14,870), and to the shelf between Reynis Dyb and the western edge of the sheet from chart B.A.2968 (scale 1:111,350).

Character of the Southeastern and Southern Coasts

In the southeastern and southern coastal region the mountains retreat and a coastal plain up to

fifteen miles in width, consisting of sandy and gravelly flats, takes their place. This is the Southeastern Lowland, mentioned on page 6. Great offshore bars, backed by marshes and lagoons, form the strandline. Lewis (12, p.436) describes them as follows:

> " ...more than 200 miles of the southern shores of Iceland consist of a great offshore bar. The mountains of the hinterland reach the shore at only two points-- Portland, south of Myrdalsjökull, and the Vestur horn. Elsewhere the great embankments of sand and shingle enclose wide areas of lagoon, marshland and gravel flats. Numerous rock outcrops are incorporated in the embankment, frequently forming nodal points from which the beaches recede in sweeping curves both to the east and west."

Bathymetry off the southeastern and southern coast

From the bank, Breiddals Grunn (see F.A.565), opposite Berufjörður, or Bero fjord, southward to the western side of the submarine ridge, Reynis Djúp, or Reynis Dyb, the shelf narrows from over forty miles in width to less than ten. It is indented by six large submarine valleys which, in each case, cause the 100-fathom depth curve to trim in halfway or more across the shelf. From northeast to southwest these are Berufjarðarhall, Lónsdjúp, Hornafjarðar Djúp, Skeiðarárdjúp, Skeiðarar Djúp, and Reynis Djúp.

These submarine valleys run up toward fjords, or toward portions of the coast where fjords or embayments

previously existed and have since been filled in.

Like the east-coast deeps, they are believed to have been eroded subaerially by streams crossing the shelf when the shelf was bared at the end of the Miocene epoch. As far is known, faulting is not responsible for their existence.

A smoothly curved zone may be outlined connecting the outer edges of the banks between the valleys, from the southern tip of Breiddals Grunn to Reynis Djúp. On this zone the bottom drops off rapidly toward the southeast and south to sub-oceanic depths: 70 fathoms to 432 fathoms in 5 miles at Latitude 63 degrees 58 minutes N., Longitude 13 degrees 45 minutes W.; 115 fathoms to 575 fathoms in 5 miles at Latitude 63 degrees 45 minutes N., Longitude 16 degrees 5 minutes W.; 60 fathoms to 360 fathoms in 5 miles at Latitude 63 degrees 17 minutes N., Longitude 17 degrees 20 minutes W.

This curved zone is sub-parallel to the curved zone of faulting which cuts across Iceland from north to southwest. The two zones converge gradually toward the southwest, coming together at the Vestmannaeyjar Islands. Can the shelf off southeastern Iceland be bounded by a zone of faulting?

The smoothness of the curves connecting the outer facets of the banks, plus the fact that the bottom

drops off over four hundred feet per mile, leads weight to the possibility of faulting, or at least downwarping, here. Such subsidence fits in with the process believed to have submerged the Thulean Plateau and converted Iceland into an island (see page 7).

Source of Sediments Off the Southeastern and Southern Coasts

(1) Glacial outwash. The mountains at the inner edge of the coastal plain bear extensive ice fields, which send lobes down every available valley. Streams flowing from these lobes carry tremendous quantities of mud, sand, and gravel across the coastal plain to the sea. It has been estimated (28, p.74) that the sediment carried out by a single sub-glacial stream on the coast of Greenland, which is comparable to the southern Icelandic coast, amounts to over 15,000 tons per day. The quantity of sediment delivered to the sea by the stream in one year would thus total 5½ million tons!

Thoroddsen describes this sedimentation in the following passages(24, p.206):

> " Almost all Icelandic glaciers rest on soft rocks (tuff and breccia) upon which erosive action is very active; therefore, the Icelandic glacier-rivers carry down an immense amount of rock in the form of mud, sand, gravel, and blocks of stone; for this reason they are hardly ever found entering fjords or deep bays, these having become filled up in cases where they formerly so entered."

(2) Glacier bursts. In addition to normal deposition from glacial streams, catastrophic deposition from "glacier-bursts" or "glacier torrents" periodically adds to the shoreline and offshore sediments.

The great ice fields rest on active volcanoes. When an eruption occurs floods of water bearing volcanic debris and ice sweep down over the coastal lowland to the sea. Skeidararsandr and Myrdalssandr are particularly subject to these floods although they occur elsewhere along this section of the coast.

Thoroddsen describes these floods as follows (24,p.201):

> " Peculiar to Iceland are the so-called 'glacier-torrents' (Jökull-hlaup). When the glaciers by the eruption of volcanoes hidden under the ice,are broken to pieces and melt, the large stretches of land beneath them are inundated by a roaring sea of dirty water with swirling icebergs. Such catastrophes may cause great changes in the surface features of the surrounding country, as the waterfloods often carry along with them an incredible quantity of gravel and rocky blocks. In this way the volcano of Katla especially has caused considerable changes--the course of rivers are constantly changed, the smaller fjords have been filled up even within historic times, and several large parishes and districts have been destroyed...minor glacier-bursts are also occasionally due to lakes and rivers , which have been dammed by glaciers, suddenly breaking through their barriers and inundating the district."

also, Thoroddsen cites three instances when deposition from glacier bursts formed dry land where previously over fifteen fathoms of water existed (22,pp.503,505, 510).

According to witnesses, when an eruption under Vatna Jökull sent a glacier burst down the Skeidara River (east of longitude 17 degrees W.) in 1934 the river increased to ten times the volume of its summer flow within one week (2,p.16). Two days afterward the burst reached its maximum; huge icebergs sailed downstream and out to sea, while tremendous crashing noises were heard from the glacier.

According to the Sailing Directions (18, p.498), in 1918 the eruption of Kötlutangi, above Myrdalssandur, resulted in a 4-mile stretch of coast at the hill, Hjörleifshöfdi, being advanced seaward a distance of 1 mile.

(3) Windblown sand. The shelf off the southwestern and southern coasts of Iceland is subject to a third type of deposition from the adjacent land. Windblown dust and sand from the clayey, sandy flats of the coastal lowland, from weathered tuff formations in the mountains, and from volcanic eruptions are spread probably in no small amounts over the seabottom. Volcanic dust from eruptions of Icelandic volcanoes sometimes is carried

by winds considerably across the Atlantic ocean to Europe (24,p.223), while dust whipped up by windstorms on the land has been known to fall on vessels in mid-Atlantic (24,p.243).

Therefore, if noticeable amounts of this dust are carried such great distances, much larger amounts, containing coarser constituents, must be deposited over the nearby shelf. Accordingly, the boiling directions reports fine sand in Skeidara hyb, or Skeidara sjúp, which has been blown out from Skeiðarársandur (15, p.493).

(4) Pumice. Large amounts of pumice are delivered to the sea by streams flowing through areas of volcanic activity, by glacier bursts, and directly by submarine eruptions. This occurs off other coasts as well as off the southern and southeastern.

According to Thoroddsen (22,pp.502,505), eruptions of Hekla (western side of [illegible], on latitude 64 degrees N.) have produced pumice in amounts great enough to be transported by currents to the Faeroe Islands. As previously mentioned, in 1717 large quantities of pumice from a volcano in the interior was carried to Axar Fjord on the northern coast by the Jökulsa river (22,p.[illegible]). In 1783 pumice from a submarine eruption off Reykjanes covered the sea for a distance of 150 to 225 kilometers (22,p.504).

Although no specific examples are known of by the author, it is to be expected that agitation by ocean waves would scatter the glassy coils of much of this pumice, causing it to sink to the bottom as fine to coarse sand.

(5) Volcanic bombs. It is likely also that volcanic bombs and other, larger fragments of ejecta are frequently contributed to the sediments on the shelf. These fragments have been known to be blown far from the point of eruption. In 1510 a bomb ejected from Hekla killed a man 45 kilometers away (24, p.233); in 1766, from the same volcano a bomb the size of a man's fist was hurled entirely across Iceland to the northern coast, 165 kilometers away!

Bottom Sediments Off the Southeastern Coast

East of Longitude 15 degrees 8 minutes W. sand is by far the most abundant sediment. It mantles much of the shelf from shore to outer edge, covering submarine valleys as well as banks.

This sand originates mostly from the numerous rivers which here deposit tremendous amounts of sediment derived normally from glacial erosion or catastrophically from glacier bursts. The presence of windblown sand in Skeidara Dyb has already been mentioned. Some sand also may be derived from pumice, as previously described.

Sand evidently has also been transported down the island slope to mingle with deep-sea sediments. Its exact extent, however, is uncertain. The sediment distribution chart of the "Ingolf" expedition (9, part 3, plate 1) shows deep-sea clay in the vicinity of the 747-fathom sounding south of Skeidara Dyb, at latitude 62 degrees 59.5 minutes N., longitude 17 degrees 6 minutes W. (on B.A.2980). However, the numerous notations of fine sand mixed with clay or ooze southwest of Skeidara Dyb indicate that here much sand from the shelf must have moved into this deeper region.

On this section of the shelf, after sand gravel is the next most abundant sediment. Large areas of gravel occupy the central and outer portions of each of the banks between submarine valleys, and in Jökulsa Dyb and Hornafjarðar Dyb they even lap down into the valleys themselves. A large area of gravel extends 15 miles out from shore on Lyre Bugt, the inner portion of the bank between Jökulsa Dyb and Hornafjarðar Dyb. Another small area lies across the head of Hornafjarðar Dyb, and numerous patches are scattered over the shelf from shore to outer edge.

It is believed most of this gravel is residual from a former period of lowered sea-level. Some patches, especially those near shore, may be the result of deposition

from glacier bursts.

Mud and ooze are present in several places on the shelf. From the southwestern corner of H.A.2979 the area of mud and ooze described on page 79 extends onto this chart to a position 5 miles off Vestrahorn. At that position it is 6 miles wide. Another belt 10 miles long and from 1½ to 2-3/4 miles wide lies completely across the shoreward extension of Hökulsø Dyb. A number of patches of these finer sediments are scattered over the inner half of the shelf. As previously stated, it is not known whether this ooze noted off the eastern and southeastern coasts is organic in nature or merely a hydrographer's term for watery mud.

Rock bottom is found infrequently off this section of the coast. What there is occurs mostly as small shore reefs or small, isolated rocks not far from shore. In addition, rock outcrops sometimes are incorporated into the barrier beach.

Reefs and patches of rock bottom are found off Vestrahorn; off the mouth of Hornafjördr, west of Vestrahorn; at several places off the coast between Hornafjördr and Ingolfshöfdi, 4.7 miles to the southwest; and, off Ingólfshöfdi. Between Ingolfshöfdi and Dyrdalsvik, 67 miles to the west-southwest, no rock is shown on the chart. This stretch of shore bounds a series of extensive sandy lowland tracts: Skeidarársandr, Brunasandr, Medalland-

sandr, and Myrdalssandr. A number of large, glacial rivers empty into the sea here, depositing enough sand apparently to bury any pre-existing rocky prominences.

The 79-fathom shoal in Skeidara Dyb may have bare rock exposed in it, although none is shown on the chart. Also, the two shoal areas of 65 fathoms each just east of the mouth of the same deep may be marked in places by rock.

Occurrence of Coral off the Southeastern Coast

Only one sediment notation showing the presence of coral is found on this chart. It lies at latitude 64 degrees 4.75 minutes N., longitude 14 degrees 39 minutes W., southeast of Vestrahorn. As the notation indicates, enough mud was present with the coral to warrant mention by the hydrographer.

Sediments Off the Southern Coast

The shoreline and shelf west of the bight of Myrdalsvik is shown on H.S.#733 and has been described in pages 13 and 14 of this report. The following description of the shoreline and shelf in this area supplements the previous description.

West of Longitude 18 degrees 8 minutes W. the shelf is largely covered with gravel. A continuous belt extends from that meridian westward to the edge of the chart, occupying the outer two-thirds of the shelf.

the only interruption to this belt occurs at Skapte Nyb, where a small elliptical area of fine gravel, measuring 7 miles northeast-southwest by 4 miles east-west, occupies the floor of the valley. Although the chart does not show it, this sand may very well be continuous with the coastal sand.

At latitude 63 degrees 25.8 minutes N., longitude 19 degrees 34 minutes W., within the overlay zone with H.A.2733, a 19-fathom sounding bearing a gravel notation appears on this chart but fails to appear on either H.A.2733 or H.A.2968. Surrounding depths, as shown on H.A.2967, range from 39 to 40 fathoms. This sounding, if correct, represents a sudden, local rise in the bottom of over twenty fathoms. Speculation on its origin suggests either an isolated rock hill, disregarding the gravel notation, or possibly a glacial feature, such as a kame deposit.

A belt of sand bottom 2 to 5 miles wide lies between the above gravel belt and the strand line. From Skapte Nyb westward this sand, and probably the gravel also, is mixed with shells. It has been seen that this admixture of shells characterizes most of the shelf sediments off the southern and western coasts, in contrast to the shelf sediments off the northern and eastern coasts.

The mud line from Skapte Nyb westward to the

edge of the chart has been placed at the 100-fathom depth curve, on the basis of the sharp dropoff south of it. The narrow tongue of mud shown entering the southwestern corner of Reynis Dyb follows a narrow trough between the 97-fathom shoal and the western side of the valley.

In this stretch of coast rock bottom is definitely known only at Portland and at Reynisdrangur, just east of Kyrdalsvik. At both of these points rocky reefs extend one-half mile or more from shore, representing the truncated base of rock hills fronting the coast.

U.S.C.&G.S. 1909 shows a sand notation at the 23-fathom sounding southeast of Reynis Dyb. However, it is believed the shoal represented here, as well as the 97-fathom shoal in the southwestern corner of Reynis Dyb, may have rock exposed in it.

SECTION III. CONCLUSIONS

From the data presented in the preceding pages a number of conclusions may be drawn concerning the bathymetry and bottom sediments immediately surrounding Iceland.

1. Quantitatively sand is the most important bottom sediment on the shelf. It predominates over other sediments off the western, southern, eastern, and eastern half of the northern coasts.

Mineralogically it is entirely volcanic in content, and has been derived from glacial, stream, and wind erosion of volcanic rocks or else directly from volcanic eruptions. Quartz sand is not known in Iceland.

2. Gravel is the next most important bottom sediment after sand, covering large areas off all coasts from the shore to the outer edge of the shelf. Its probable sources, in order of importance, are: (1) residual from a period of lowered sealevel, with resultent wave erosion and probable stream erosion on rock exposed on the shelf; (2) wave erosion on the present rocky coast; (3) submarine vulcanism; and (4) Pleistocene glaciation on the shelf.

3. Off the western half of the northern coast sedimentation is controlled by a series of north-trending deeps and banks, with mud flooring the deeps and gravel,

flanked symmetrically by belts of sand, covering the banks.

4. Shells in the sediments are most abundant off the western coast and off the western half of the southern coast. Apparently the shelf off the northern coast is almost devoid of shells. This variation may be due to the effect of the Irminger Current, a branch of the Gulf Stream which circles Iceland in a clockwise direction.

5. Several belts of fine sediment termed "ooze" on the charts lie on the shelf off the southeastern coast. It is not known if this is organic or inorganic.

6. Bottom notations indicate the presence of coral along all coasts except the southern coast and the southern half of the western coast. It occurs inside the fjords, on the open coast close in to shore, and at considerable distances offshore, out on the shelf.

It is not definitely known whether this is living or fossil coral. Despite the cold-water environment, it may very well be living, since living colonial forms have been found in cold waters in other parts of the world.

7. The shelf off all coasts is trenched by wide, deep submarine valleys which continue outward from the fjords and bays indenting the coasts. These valleys,

at least off the eastern and southern coasts, are the result of subaerial erosion at the end of the Pliocene epoch, when the shelf was bared out to what is now the 150-fathom depth curve. Off the northern and western coasts Tertiary and Quaternary faulting have undoubtedly been responsible for some of the depth of the valleys.

8. The island shelf off the southeastern and southern coasts is probably bounded along the outer edge by a zone of faulting or downwarping.

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