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The Mechanical Composition of Wind Deposits

BY

JOHAN AUGUST UDDEN.

PUBLISHED BY THE AUTHORITY OF THE BOARD OF DIRECTORS OF
AUGUSTANA COLLEGE AND THEOLOGICAL SEMINARY,
ROCK ISLAND, ILL.

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GENERAL STATEMENT.

The great lightness of the air, when compared with water, and the comparatively high velocity of its currents will necessarily render any materials it may carry and deposit somewhat different in composition and structure from those which are laid down in water. They are as a rule finer, they exhibit a different bedding and are more capriciously placed. These characteristics are familiar in a general way. It is here desired to present more exact information on this subject, particularly as to the mechanical composition of these deposits; and to show how this changes under varying circumstances of deposition. It is hoped that this may lead to a more certain identification of wind sediments, wherever they may be found. The inquiry seems to be of special importance in connection with the study of superficial deposits.

Samples of different kinds of materials moved by the wind have been collected from different places of deposition and from the atmosphere directly for this study. Each of these has been separated into grades of different coarseness and the per cent of the weight for each grade *)

*) The particles ranging between two successive separations will here be referred to as a *grade*. In the analyses these separations were made in a uniformly decreasing series of diametrical dimensions, the diameter of the largest particles in one grade having twice the length of the diameter of the coarsest particles in the next finer grade. The coarsest grade consists of rock fragments with diameters ranging from 16 to 8 millimeters, the next from 8 to 4 mm., and so on, down to particles measuring from $\frac{1}{128}$ to $\frac{1}{256}$ mm. Below this size no separations have

in each sample has been determined. It appears that all of these samples and presumably the greater part of such materials as owe their present position and arrangement to the action of the atmosphere may be referred to some one of four categories. These may be characterized as 1) lag gravels, or coarse residual deposits in the rear of

been made, particles so minute constituting only a very small proportion of even the finest atmospheric sediments. In general, when the finest grades have been found in a quantity amounting to only a small fraction of a per cent of any sample, they have been neglected. For the sake of convenience the following designations of the different grades will be used in this paper:

<i>Coarse gravel</i>	diameter from 8	to 4	millimeters.
<i>Gravel</i>	“	“ 4	“ 2 “
<i>Fine gravel</i>	“	“ 2	“ 1 “
<i>Coarse sand</i>	“	“ 1	“ $\frac{1}{2}$ “
<i>Medium sand</i>	“	“ $\frac{1}{2}$	“ $\frac{1}{4}$ “
<i>Fine sand</i>	“	“ $\frac{1}{4}$	“ $\frac{1}{8}$ “
<i>Very fine sand</i>	“	“ $\frac{1}{8}$	“ $\frac{1}{16}$ “
<i>Coarse dust</i>	“	“ $\frac{1}{16}$	“ $\frac{1}{32}$ “
<i>Medium dust</i>	“	“ $\frac{1}{32}$	“ $\frac{1}{64}$ “
<i>Fine dust</i>	“	“ $\frac{1}{64}$	“ $\frac{1}{128}$ “
<i>Very fine dust</i>	“	“ $\frac{1}{128}$	“ $\frac{1}{256}$ “

Down to the particles measuring $\frac{1}{8}$ of a millimeter all the separations were made by sieves, and below this the per cent of the weight of each grade was determined by microscopic measurements and by calculation from the number of grains counted in each grade. In nearly all samples which have been examined, there is a medium grade, which is present in greatest quantity, while the other grades diminish in bulk the more the size of their particles differ from the medium grade. The latter will here be called the *chief ingredient*, or the *maximum*, and the two decreasing series on either side will be referred to as the *coarse* and the *fine* admixtures.

In this connection I desire to state that I am under great obligations to Professor Milton Whitney, of the United States Department of Agriculture, from whom I received much valuable information regarding the mechanical analysis of superficial deposits, in examining a series of Illinois soils some years ago. Down to medium sand, the grades here adopted correspond to the coarser grades in the scale which he has adopted for soil analysis. Below this size I have found it necessary to make use of another scale. In the analysis of soils it is of particular importance to determine the quantity of “clay” consisting of particles below the size of $\frac{1}{256}$ mm., while in an investigation of the nature of the sorting effected by different mechanical forces, all the grades present in any considerable quantity are of equal significance. In the separations here made the sizes of the fragments in the successive grades increase uniformly in a geometric ratio.

sand dunes; 2) drifting sand, constituting the familiar dunes in dry and sandy regions; 3) fine sand, which is soon dropped by the wind in the lee of drifting dunes; 4) and dust, which only slowly settles out of the air far away from the place where it was raised.

Numerous observations on known eolian deposits in the field and on the mode of action of the wind have also been made to supplement this special study of the mechanical composition of wind sediments, and these will be drawn upon in the discussion of the other data.

LAG GRAVELS.

In many places where atmospheric erosion is going on, streaks of gravel are to be seen, partly covering the ground. Most often this gravel forms a thin veneer which partly protects the ground from further erosion. Though the present position of this material is due to the action of the wind, it is quite evident that it has not been transported very far. The deposits from which it has been derived may lie close by, and they are never far off. Commonly it is a bank of sand, part of which has been removed. The finer grades have been blown away, exposing these larger fragments to the force of the wind, which apparently moves them by undermining and rolling. They sometimes occupy the hollows on the eroded ground. It is evident that the coarseness of this gravel renders it much less subject to the action of the winds than the finer materials. Occasionally it may be found partly or wholly covered by finer materials, but on the

whole it is continually left in the rear of these, which follow the winds with greater promptness. Only ten samples have been examined. These were collected at eight different localities in the central part of the United States, as given in the table of analyses (Tab. I). It is not likely that these few samples adequately represent the composition of similarly formed deposits in other localities. The largest rock fragment in the lot measured only a little over eight millimeters in its longest diameter. It was part of a sample consisting of flat chips of a hard shale. Pebbles over four millimeters in diameter were present in four of the samples. All the other, with one exception, had pebbles over two millimeters in diameter. The different grades are rather indiscriminately mingled, in a manner determined by the caprices of the wind. Five of the samples have two maxima each. The chief ingredients vary from fine gravel through coarse and medium sand to fine sand. In three of the samples ninety per cent of the weight is distributed among five different grades; in six, among four grades; and in one, among three. In an average of all ten samples ninety per cent of the weight is distributed among five grades. The highest maximum in any grade is sixty-eight per cent and the lowest is twenty-five. The average height of the highest maxima is forty per cent.

The lag gravels are the most heterogenous of all the wind deposits. They are generally distinctly stratified. The fine admixtures are sometimes present as an original constituent of the eroded ground, but they may sometimes also be deposited with the gravels by the lighter winds. Compared with water-bedded materials of the

same coarseness, the layers are more irregular and thinner. Pebbly layers as much as an inch in thickness are extremely uncommon. On the whole gravels of this kind form very insignificant deposits, where they have been seen. This circumstance does not render it unlikely that lag gravels may have a greater development in regions long exposed to the actions of the stronger winds.

DRIFTING SAND.

Lag gravels graduate imperceptibly into coarse drifting sand, which in the field always lies in front of the gravels, following the direction of the prevailing winds. Farther in this direction the coarse sand becomes in turn finer and finer, until the main deposit is reached, where it always consists of grains of a more uniform size. In fact the main bulk of all sand drifts, large enough to be called dunes, have been found to contain only subordinate proportions of sand grains measuring more than one fourth or less than one eighth of a millimeter in diameter.

Sand coarser than this is present as a maximum ingredient only in superficial layers of no very great thickness, which lie on the rear slopes of dunes. It forms an intermediate series between typical dune sand and lag gravels, and it is capable of being rolled rather than lifted by the winds. This is indicated by the circumstance that it is often the main ingredient on the crests of wind ripples, being heavy enough to remain resting in this exposed position, while the finer dune sand is lifted to the upward slope of the next ripple. It differs from the lag

Table I. Mechanical Composition

Length of diameter in mm.	1	2	3	4	5
	Chips of shale from Edgemont, S. Dak.	From a "blow-out," Hoopole, Ills	From a "blow-out," Hoopole, Ills.	From north of Mineral, Ills.	From rear of dune, Michigan City, Ind.
16-8	5.7	.....	.....	.....	.....
8-4	14.4	.6	.3	.8	.....
4-2	33.1	14.5	10.1	27.4	29.5
2-1	35.1	18.6	35.0	34.5	43.4
1- $\frac{1}{2}$	10.3	16.6	23.9	4.2	7.2
$\frac{1}{2}$ - $\frac{1}{4}$	1.0	25.7	20.4	10.8	4.3
$\frac{1}{4}$ - $\frac{1}{8}$	.4	20.5	8.8	16.2	14.7
$\frac{1}{8}$ - $\frac{1}{16}$	.....	3.3	.4	5.3	.1
$\frac{1}{16}$ - $\frac{1}{32}$	.....	.....	.....	.2	.....
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.....	.....	.....	.....
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....	.....

Table II. Mechanical Composition

Length of diameter in mm.	11	12	13	14	15
	Rear slope of a dune, Alliance, Neb.	Rear slope of a dune, Tampico, Ills.	Rear slope of a dune, New Boston, Ills.	Rear slope of a dune, Alliance, Neb.	Rear slope of a dune, Alliance, Neb.
16-8	.....	.....	.....	.....	.....
8-4	.....	.....	.....	.....	.....
4-2	.....	.....	.2	.....	.....
2-1	9.0	3.9	1.8	.2	.1
1- $\frac{1}{2}$	80.0	43.8	22.0	37.1	33.7
$\frac{1}{2}$ - $\frac{1}{4}$	6.6	28.6	46.2	50.9	49.4
$\frac{1}{4}$ - $\frac{1}{8}$	5.0	22.0	26.2	18.9	15.0
$\frac{1}{8}$ - $\frac{1}{16}$	.1	1.7	2.8	1.7	.1
$\frac{1}{16}$ - $\frac{1}{32}$	.....	.....	.2	.....	.....
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.....	.....	.....	.....
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....	.....

of Lag Gravels.

6	7	8	9	10	Average.
Bottom of a "blow-out," Alliance, Neb.	From rear of dune, Michigan City, Ind.	From wind-eroded ground, Ardmore, S. Dak	From rear of a dune, New Boston, Ills	From a "blow-out", Alliance, Neb.	
.....	.....	.....	.....	.....	.5
.....	.....	.....	.....	.....	1.6
5.9	4.2	1.2	.1	.....	12.6
1.4	28.0	4.1	26.1	11.5	23.8
23.5	19.9	15.0	62.6	68.5	25.1
30.7	15.2	33.5	19.3	8.5	16.9
34.6	31.5	24.9	1.4	8.5	16.1
4.2	.4	19.6	.....	2.0	3.5
.3	.....	1.9	.....	.....	.2
.....
.....
.....

of Rolling Drift Sand.

16	17	18	19	20	Average.
Rear slope of a dune, Hooppole, Ills.	Rear slope of a dune, Hooppole, Ills.	Rear slope of a dune, Hooppole, Ills.	Sand Drift, Griggs co., N. Dak.	Sand drift, Griggs co., N. Dak.	
.....
.....
.....	.....	.....	.....	.....	tr.
.....	.2	.....	.....	.3	.5
12.4	9.7	6.2	19.3	14.0	27.8
34.6	44.4	39.2	45.2	42.9	33.5
33.0	40.7	29.4	30.7	37.9	25.3
17.2	4.0	23.4	2.4	2.5	5.5
2.0	.3	1.2	.4	1.8	.5
.....	.....	.....	tr.	.3	tr.
.....
.....

gravels in being light enough to be rolled up a gentle slope, and to be moved without any undermining taking place. Eleven samples of such rolling drift sand, as it may be called, have been collected and examined (Tab. II). Its composition is much more uniform and regular than that of lag gravels. The proportions of the different grades arrange themselves in all the samples in two decreasing series on either side of a maximum, which in three cases consists of coarse sand and in eight cases of medium sand. In one sample the maximum grade constitutes eighty-five per cent of the whole sample. The smallest maximum is thirty-four per cent. All the maxima average fifty per cent in the eleven samples. Ninety per cent of each sample is distributed among only three grades in nine of the samples and among four grades in the other two. By different sampling, no doubt somewhat different results might be obtained. But these analyses indicate that there is a rapid increase in the power of the winds to roll quartz grains, when these begin to be less than one millimeter in diameter. The same is also indicated by the sudden decrease in several of the analyses of lag gravels in the percentages of the grades, when this limit of size is passed. (See analyses no. 1, 2, 3, 4, 5, and 7). The rock fragments which exceed one millimeter in diameter, are too large to be rolled up the rear slope of a dune and are left in the "blow-outs" as a characteristic ingredient in the lag gravels, but they are, as may be seen in the analyses, only very sparsely mingled in the sand which is rolled up the rear slope of a sand drift.

The sand which constitutes the main body of dunes has been found remarkably uniform in its mechanical

composition. Thirty-eight samples have been analyzed, coming from eleven different localities. These it will be well to briefly describe, together with the sand from each place.

On the north side of the Mississippi river at New Boston in Illinois an ancient terrace is blown up into a sand ridge about a mile in length. From all appearances the

Table III. Mechanical Composition of Dune Sand from New Boston, Ills.

Length of diameter in mm.	21	22	23	24	Average.
	Rear slope of ripples in dune sand.	Dune sand.	Top of ripple in dune sand.	Front slope of dune.	
16-8	.....	.....	.....	.....	.....
8-4	.6	.....	.....	.....	.1
4-2	2.8	.....	.....	.....	.7
2-1	2.0	.1	.....	.....	.5
1- $\frac{1}{2}$	9.9	2.6	29.6	3.6	11.4
$\frac{1}{2}$ - $\frac{1}{4}$	30.4	31.8	56.0	30.8	37.2
$\frac{1}{4}$ - $\frac{1}{8}$	47.8	64.4	13.6	63.6	47.3
$\frac{1}{8}$ - $\frac{1}{16}$	5.0	.6	.2	2.0	1.9
$\frac{1}{16}$ - $\frac{1}{32}$	.4	.....	.....	1.0	.3
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.....	.....	.....	.....
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....	.....

sand in these dunes has not yet travelled a half mile. The materials in the original terrace are quite heterogenous in composition (Tab. I). The coarse grades have not yet had time to be quite left behind but appear in a small quantity in some of the dune sand (no. 21). One of the samples (no. 23) was taken by skimming the surface on the crest of a ripple. This is unique among all the analyses of typical dune sand in having medium sand as its

Table IV. Mechanical Composition of Dune Sand from the Shore of Lake Michigan, Michigan City, Ind.

Length of diameter in mm.	25	26	27	28	29
	Upper rear slope of dune	Dune sand.	Typical dune sand.	Near the crest of a dune.	From the crest of a dune.
16—8	.....	.....	.....	.....	.....
8—4	.2	.....	.....	.....	.....
4—2	4.1	.1	.....	.....	.....
2—1	7.4	1.1	.....	12.4	.....
1— $\frac{1}{2}$	14.1	8.2	.9	6.4	.4
$\frac{1}{2}$ — $\frac{1}{4}$	26.7	25.1	20.7	13.8	6.0
$\frac{1}{4}$ — $\frac{1}{8}$	45.3	64.0	76.8	65.2	92.6
$\frac{1}{8}$ — $\frac{1}{16}$	.5	1.2	1.0	1.8	.6
$\frac{1}{16}$ — $\frac{1}{32}$	.....	.2	.....	.....	.....
$\frac{1}{32}$ — $\frac{1}{64}$	.....	.....	.....	.....	.....
$\frac{1}{64}$ — $\frac{1}{128}$	.....	.....	.....	.....	.....
$\frac{1}{128}$ — $\frac{1}{256}$	.....	.....	.....	.....	.....

Table IV. (Continued.)

30	Average.
From the top of a dune.	
.....
.....	tr.
.....	.7
.....	3.4
3.4	5.5
12.9	17.5
73.1	69.5
8.7	2.3
.....	tr.
.....
.....
.....

Table 5. Mechanical Composition of Drifting Sand from the River Bluffs east of Cordova, Ill.

Length of diameter in mm.	31
	16—8
8—4	.....
4—2	.4
2—1	10.5
1— $\frac{1}{2}$	14.0
$\frac{1}{2}$ — $\frac{1}{4}$	25.9
$\frac{1}{4}$ — $\frac{1}{8}$	52.2
$\frac{1}{8}$ — $\frac{1}{16}$	6.0
$\frac{1}{16}$ — $\frac{1}{32}$	.....
$\frac{1}{32}$ — $\frac{1}{64}$	.....
$\frac{1}{64}$ — $\frac{1}{128}$	.....
$\frac{1}{128}$ — $\frac{1}{256}$	.....

maximum ingredient. Had it been taken a little deeper, it would have been more like the rest, for the coarser grains are least easily dislodged from this exposed position and remain, while the finer sand is blown away. Some coarse dust is still mixed in the sand at this place in one instance (no. 24). All taken together and compared with sand from other places, these samples may be said to be imperfectly sorted, owing no doubt to the recency of the inception of the wind action in this locality.

The dunes on the south-east shore of Lake Michigan have furnished the materials for six analyses (Tab. IV). These sand hills have been recently formed and are largely made up of sand that is freshly supplied by present wave action on the shore of the lake. In this place also the coarse grades occur with the typical dune sand in small quantities on the very top and front slope of the hills (see nos. 25, 26, and 28). But there is practically no coarse dust to be seen, presumably because no such fine material is present in the beach sand. This locality and the previous are the only ones that furnish instances of dune sand having a second maximum in the coarser grades (no. 21 and 28).

The bluffs facing the bottom lands of the Mississippi, east of Cordova in Illinois, are here and there being eroded by the northwest winds. Some sand taken from a small drift only a foot in height exhibits imperfect sorting like that observed in the sand from New Boston and Michigan City (Tab. V).

In Rice county in the central part of Kansas there is a tract of sand hills extending many miles along the little Arkansas river. These are derived from underlying late

tertiary beds. Their extensive development shows that the wind has been at work here for some considerable time. The sand is correspondingly uniform, and rock fragments of either extreme size are absent (Tab. VI). One of the analyses exhibits the mechanical composition of a single thin lamina in the dune (no. 34), evidently laid down under a uniform wind velocity. It is interesting as

Table VI. Mechanical Composition of Dune Sand from Rice County, Kans.

Length of Diameter in mm.	32	33	34	Average.
	From the front slope of a dune.	From the rear slope of a dune.	From the front slope of a dune (a single seam)	
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.2	.....	.....	tr.
2-1	.0	.....	.....	.....
1- $\frac{1}{2}$	6.2	6.6	1.5	4.7
$\frac{1}{2}$ - $\frac{1}{4}$	34.8	28.2	10.0	24.3
$\frac{1}{4}$ - $\frac{1}{8}$	57.8	61.2	83.0	67.3
$\frac{1}{8}$ - $\frac{1}{16}$	.6	2.7	4.5	2.6
$\frac{1}{16}$ - $\frac{1}{32}$	.....	.1	.....	tr.
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.....	.....	.....
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....

indicating, when compared with the other analyses, the range of variation in the coarseness of the sand due to differences in the velocity of the wind. Evidently this is not very great.

At Folly's Cove in Massachusetts some beach sand is driven inland by the winds. The absence of fine particles in this sand is no doubt partly due to washing on the beach (Tab. VII).

Some sand has been collected from small and freshly formed drifts on plowed fields and on the open prairie in the eastern part of North Dakota. Two samples of this have been placed arbitrarily with the rolling sand, but these differ only slightly from those given here. The rather large amount of dust in all of these analyses is evidently due to the fact that the wind has just begun its work on

Table VII. Mechanical Composition of Dune Sand from Folly's Cove, Mass.

Length of diameter in mm.	35	36	Average.
	Dune sand.	Dune sand.	
16-8	.....	.....	.....
8-4	.....	.....	.....
4-2	.....	.....	.....
2-1	.....	.1	tr.
1- $\frac{1}{2}$	6.8	4.3	5.5
$\frac{1}{2}$ - $\frac{1}{4}$	27.8	19.0	23.4
$\frac{1}{4}$ - $\frac{1}{8}$	63.8	71.4	67.6
$\frac{1}{8}$ - $\frac{1}{16}$	.7	4.0	2.4
$\frac{1}{16}$ - $\frac{1}{32}$	.....	.1	tr.
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.....	.....
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....

surface deposits, which contain fine materials in some abundance (Tab. VIII).

Scattered dunes occur in the basin of the Green river in Illinois. Though the superficial deposits here are but little affected by the action of the atmosphere now, the topography of several sandy belts in this valley indicates earlier deflation by the atmosphere. The sand is moderately well sorted (Tab. IX).

Table VIII. Mechanical Composition of Drifting Sand from

Length of diameter in mm.	37	38	39	40	41
	Field drift in Barnes county.	Field drift, Cooperstown, Griggs county.	Field drift, Steele county.	Drifting sand, Steele county.	Drifting sand, Griggs county.
16—8	.....	.....	.....	.....	.....
8—4	.....	.....	.....	.....	.....
4—2	.....	.....	.....	.....	.....
2—1	.2	.....	.....	.....	.1
1— $\frac{1}{2}$	14.5	13.1	6.7	6.4	5.4
$\frac{1}{2}$ — $\frac{1}{4}$	28.7	22.7	19.4	14.2	16.8
$\frac{1}{4}$ — $\frac{1}{8}$	50.4	55.8	62.3	62.4	63.6
$\frac{1}{8}$ — $\frac{1}{16}$	6.1	6.4	9.4	15.6	12.0
$\frac{1}{16}$ — $\frac{1}{32}$	1.5	1.3	1.3	1.1	1.2
$\frac{1}{32}$ — $\frac{1}{64}$	.3	.2	.3	.2	.3
$\frac{1}{64}$ — $\frac{1}{128}$	.....	.....	.....	.....	.....
$\frac{1}{128}$ — $\frac{1}{256}$	.....	.....	.....	.....	.....

Some years ago a drift of sand was blown up in a field near the city of Lindsborg in the central part of Kansas. The soil in this place was composed of a sandy alluvium, which held very little fine material. No specially noteworthy feature appears in the mechanical composition of this sand (Tab. X).

The most extensive sand-hill region in the United States is probably found in the western part of Nebraska. Here the winds have been at work for a long time rearranging, shifting, and sifting extensive beds, which were formed in Pliocene and early Pleistocene time. Entire counties are covered by extensive ranges of sand hills sometimes exceeding three hundred feet in height. The bulk of the blown sand in this region largely exceeds that of any other locality from which any material has been collected. The lag gravels are conspicuously absent in the samples

North Dakota.

Table IX. Mechanical Composition of Drifting Sand from Green River Valley, Ills.

Average.	Length of diameter in mm.	42	43	Average.
		Dune sand from Tampico.	Dune sand from Hooppole.	
.....	16—8	.....	.....	.....
.....	8—4	.....	.....	.....
.....	4—2	.....	.....	.....
tr.	2—1	.1	.....	tr.
9.2	1— $\frac{1}{2}$	11.4	2.5	6.9
20.3	$\frac{1}{2}$ — $\frac{1}{4}$	32.7	22.1	27.4
58.9	$\frac{1}{4}$ — $\frac{1}{8}$	51.4	61.7	56.5
9.9	$\frac{1}{8}$ — $\frac{1}{16}$	3.9	14.0	8.9
1.3	$\frac{1}{16}$ — $\frac{1}{32}$	.....	1.0	.5
.3	$\frac{1}{32}$ — $\frac{1}{64}$	.....	.....	.....
.....	$\frac{1}{64}$ — $\frac{1}{128}$	.....	.....	.....
.....	$\frac{1}{128}$ — $\frac{1}{256}$	.....	.....	.....

examined, nor do these contain more than a trifle of dust. It may be said to be the most uniformly sorted of all the sands described (Tab. XI). Two of the samples (nos. 47 and 48) were selected to represent the extremes of variation among a series of layers which were seen in an exposure with well defined bedding. One was taken from the coarsest seam which could be seen and the other from the finest. The difference in texture was quite apparent to the eye, as the seams appeared

Table X. Mechanical Composition of Drifting Sand from Lindsborg, Kans.

Length of diameter in mm.	44
	Drifting sand.
16—8	.....
8—4	.....
4—2	.....
2—1	.....
1— $\frac{1}{2}$	3.1
$\frac{1}{2}$ — $\frac{1}{4}$	23.3
$\frac{1}{4}$ — $\frac{1}{8}$	69.1
$\frac{1}{8}$ — $\frac{1}{16}$	3.9
$\frac{1}{16}$ — $\frac{1}{32}$	.4
$\frac{1}{32}$ — $\frac{1}{64}$	.....
$\frac{1}{64}$ — $\frac{1}{128}$	.....
$\frac{1}{128}$ — $\frac{1}{256}$	.....

in the natural exposure, but it seems rather insignificant in the analyses.

South of the city of Moline in Illinois there are some drifts of sand in a remnant of an old terrace. It rises like an island in the bottom lands of Rock river. The bulk of the assorted material in this elevated land is quite free from coarse ingredients but there is a considerable admix-

Table XI. Mechanical Composition of Dune Sand from Western Nebraska.

Length of diameter in mm.	45	46	47	48	Average.
	Dune sand, Alliance.	Front slope of dune, Alliance.	Coarse seam in dune sand, Hyannis.	Fine seam in dune sand, Hyannis.	
16-8	.....	.....	.....	.....	.....
8-4	.....	.....	.....	.....	.....
4-2	.....	.....	.....	.....	.....
2-1	.....	.....	.....	.....	.....
1- $\frac{1}{2}$	2.5	1.1	2.8	1.9	4.1
$\frac{1}{2}$ - $\frac{1}{4}$	17.2	16.2	10.2	6.6	12.5
$\frac{1}{4}$ - $\frac{1}{8}$	70.5	80.3	71.3	78.4	75.1
$\frac{1}{8}$ - $\frac{1}{16}$	9.7	1.9	15.3	12.8	9.9
$\frac{1}{16}$ - $\frac{1}{32}$	.1	.....	.....	.....	tr.
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.....	.....	.....	.....
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....	.....

ture of fine fragments. Some of these are yet retained, it seems, in the drifting sand, which has not been carried farther than two or three hundred yards (Tab. XII).

In the southern part of Henderson county in Illinois there is a range of sand hills which follow the bluffs of the Mississippi river. In their topographic features these hills resemble sand dunes, but the activity of the winds seems to have come to a standstill at present, except in a

Table XII. Mechanical Composition of Sand from a small Dune, south of Moline, Ills.

Length of diameter in mm.	49	50	51	52
	From the rear slope of the dune.	From the top of the dune.	From the top of the dune.	Lower front slope of the dune.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1- $\frac{1}{2}$	2.6	3.2	3.7	2.2
$\frac{1}{2}$ - $\frac{1}{4}$	24.3	15.6	15.9	14.7
$\frac{1}{4}$ - $\frac{1}{8}$	68.1	72.0	65.7	66.9
$\frac{1}{8}$ - $\frac{1}{16}$	10.7	7.2	12.0	12.8
$\frac{1}{16}$ - $\frac{1}{32}$	2.7	3.0	2.0	2.4
$\frac{1}{32}$ - $\frac{1}{64}$	.2	.....	.3	.3
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....

Table XII. (Continued.)

53	54	55	56	Average.
Top of the dune.	Upper front slope of the dune.	Top of the dune.	Lower front slope of the dune.	
.....
.....
.....
.....
.7	1.2	2.1	.9	2.1
12.9	11.0	10.7	10.0	14.0
74.6	73.9	71.9	66.0	69.9
10.6	12.4	12.5	23.7	12.7
.6	.6	3.1	.5	1.5
.....	.....	.2	.....	.1
.....
.....

few places on the summits of the ridges (Tab. XIII). Two samples from this locality show a remarkably perfect sorting, though one of them (no. 58), which was taken from a drifting cultivated field, carries the usual quantity of fine grades present in drifting soils.

It will be noticed that in all these samples of dune sand, excepting the one collected by skimming the ridge

Table XIII. Mechanical Composition of Blown Sand from Henderson County, Ills.

Length of diameter in mm.	57		58		Average.
	From a dune on the bluff east of Carman.		From a field near Decorra.		
16—8	.....	.....	.....	.....	.....
8—4	.....	.....	.....	.....	.....
4—2	.....	.....	.....	.....	.....
2—1	.....	.....	.....	.....	.....
1— $\frac{1}{2}$	1.2		.2		.7
$\frac{3}{2}$ — $\frac{1}{4}$	5.4		1.7		3.5
$\frac{1}{4}$ — $\frac{1}{5}$	84.6		81.4		83.0
$\frac{1}{8}$ — $\frac{1}{16}$	8.6		8.0		8.3
$\frac{1}{16}$ — $\frac{1}{32}$	.2		5.0		2.6
$\frac{1}{32}$ — $\frac{1}{64}$	.....		2.0		1.0
$\frac{1}{64}$ — $\frac{1}{128}$	.....		.....		.....
$\frac{1}{128}$ — $\frac{1}{256}$	.....		.....		.....

of a ripple, the maximum ingredient is fine sand. In one instance ninety-two per cent consists of this grade, while in three cases it forms over eighty per cent of the bulk. Where lowest it forms forty-five per cent, and it averages sixty-five per cent in all the sand examined (Tab. XIV). In three of the samples ninety per cent is distributed among four grades; in twenty-two, among three grades; and in thirteen, between only two. Here also the admix-

tures arrange themselves in two series decreasing on either side of the maximum. The coarse admixtures form a less rapidly decreasing series than the fine, the former extending over five grades in the general average and the latter over only three grades. The extension of either is diminished by prolonged wind action, which results in more perfect elimination of grains near either extreme.

The occurrence of the maximum at the same or nearly the same point in nearly all the dune sand taken at many different localities, challenges our special notice. The size of a particle capable of being transported by the current of a fluid varies as the sixth power of the velocity of the current. The diameter of the particles, therefore, varies as the square of the velocity. If the velocity is doubled, the diameter of particles transported may be increased four times. The range of velocities of dune-making winds, as usually measured, certainly exceed a doubling of their

Table XIV. General Average of the Composition of Dune Sand (based on the averages for each locality where samples have been taken).

Length of diameter in mm.	Average.
16—8	.....
8—4	tr.
4—2	.2
2—1	1.3
1— $\frac{1}{2}$	5.9
$\frac{1}{2}$ — $\frac{1}{4}$	20.8
$\frac{1}{4}$ — $\frac{1}{8}$	65.1
$\frac{1}{8}$ — $\frac{1}{16}$	6.2
$\frac{1}{16}$ — $\frac{1}{32}$	.6
$\frac{1}{32}$ — $\frac{1}{64}$	.1
$\frac{1}{64}$ — $\frac{1}{128}$	.....
$\frac{1}{128}$ — $\frac{1}{256}$	.....

speed, and it might be expected that the bulk of the sand, in some place at least, should consist of grains many times as large as in others. It may be that sometimes there is a scarcity of such sand for the wind to work on, but this will not alone account for the uniform composition of the dune sand. Wind velocities are usually measured some

distance above the ground, but the dune sand is moved only by the very lowest layer in the atmosphere. Now it is known that the velocity of the current in this lowermost layer is increased at a very slow rate with an increase in the speed of the layers next above it. The velocity in the layer next to the surface of the ground probably never reaches three miles per hour. It is this comparatively inert layer, which alone comes in contact with the resting sand and first causes it to stir. As velocities much lower than this will not move sand at all, the range of variation of the velocity of the currents which impel dune sand, is most likely quite limited. Another circumstance aids in bringing about the same result. Any load which is picked up, has the effect of retarding the current in which it is carried and the greater the particle which is moved, the greater the retardation will be. In an element of such lightness as the air this retardation must be considerable.

Another significant feature in the analyses of the dune sand is the more rapid decrease in the percentages of the finer grades than in the percentages of the coarser grades, in the opposite direction. Evidently the law which governs the separation of the fine admixtures from the dune sand is different from the law which determines the separation of the latter from the coarse admixtures. A little reflection makes this clear. Materials finer than dune sand are wholly lifted up into swifter currents, which promptly remove them. The dune sand itself, on the other hand, is partly lifted and also partly rolled, just as the grains of the nearest larger sizes. Working in this last manner the transporting power of the wind varies

more nearly in approximation to its erosive force than to its lifting force. With changes in velocities the latter varies as the sixth power, while the erosive force varies as the square. It is therefore much easier for the coarser ingredients to be rolled along with the dune sand than it is for the dune sand to be picked up and carried away with the finer ingredients. The wind much more rapidly

Table XV. Mechanical Composition of Sand heaped up by Incipient Drifting.

Length of diameter in mm.	59	60	61	62	63
	From a drifting field, Kansas.	On a snow drift in Maryland.	From a gutter in Baltimore, Md.	Beach, St. Augustine, Fla.	Road-bed, Carman, Ills.
16—8	.....	.....	.....	.....	.....
8—4	.....	.....	.....	.....	.....
4—2	.....	.....	.....	.....	.....
2—1	.....	.1	.....	.....	.....
1— $\frac{1}{2}$	.3	5.7	.6	tr.	16.8
$\frac{1}{2}$ — $\frac{1}{4}$	5.7	36.3	2.6	.3	29.6
$\frac{1}{4}$ — $\frac{1}{8}$	60.3	53.5	50.2	97.0	51.4
$\frac{1}{8}$ — $\frac{1}{16}$	29.9	2.6	44.6	2.9	.8
$\frac{1}{16}$ — $\frac{1}{32}$	2.8	1.0	1.4	.....	tr.
$\frac{1}{32}$ — $\frac{1}{64}$	.5	.....	.5	.....	.....
$\frac{1}{64}$ — $\frac{1}{128}$	.....	.....	tr.	.....	.....
$\frac{1}{128}$ — $\frac{1}{256}$	.....	.....	.....	.....	.....

ceases to lift sand grains exceeding one eighth of a millimeter in diameter than it ceases to roll grains which become larger than one fourth of a millimeter. The operation of this principle is more or less evident in all the samples, but it is best seen in such as have been taken from the surface of the highest ridge and the rear slope of a dune. It is most conspicuous in the general average of the averages of the sands from each locality.

Though it is not supposed that all dune sand is as uniform in composition as are the specimens described here, it seems probable that the wind forms drifts mainly of grains which measure from one half to one eighth of a millimeter in diameter. How promptly it selects just these sizes for drift-building, may be seen in the composition of some specimens of sand collected from widely distant places, where it has just begun to work on materials of quite diversified composition (Tab. XV). In the following table one sample (no. 59) was collected in Kansas in a bottle placed about a foot above the ground in a drifting cultivated field, where the soil held gravel as well as clay; one (no. 60) was taken from the surface of a snow-drift in Maryland, where the deposit had blown from an exposure of Potomac sand of somewhat heterogenous composition; one (no. 61) is from a gutter in the city of Baltimore and was sifted out by the wind from the dust on a paved street; one (no. 62) is from the beach at St. Augustine in Florida where such sand is reported to be tossed about by the sporting wind with particular ease, owing to the fact that the water has already affected a most favorable sorting; and one (no. 63) was collected in a small receptacle placed on a drifting railroad bed in the western part of Illinois. The chief ingredient in these sands is alike in all and is of the same grade as that found in dune sand.

LEE SAND.

We have now to see what becomes of the rock fragments that are finer than the maximum grade of the dune sand, a small part of which only are retained in the drifts. Right in the front of the dune drift, and confluent with it, there is generally a smaller rippleless drift or bench of

Table XVI. Mechanical Composition of Sand taken in the Lee of Sand Dunes in Rice co., Kansas.

Length of diameter in mm.	Average of the dune sand.	64	65	66	67
		Lee drift sand.	From six feet in front of the lee drift.	From 15 feet in front of the lee drift.	From 24 feet in front of the lee drift
16-8	.....	.....	.....	.....	.....
8-4	.....	.....	.....	.....	.....
4-2	.....	.....	.....	.....	.....
2-1	.....	.....	.....	.....	.....
1- $\frac{1}{2}$	4.7	2.1	.2	.3	.....
$\frac{1}{2}$ - $\frac{1}{4}$	24.3	16.5	4.6	1.5	1.1
$\frac{1}{4}$ - $\frac{1}{8}$	67.3	72.0	60.0	72.3	62.0
$\frac{1}{8}$ - $\frac{1}{16}$	2.6	7.5	31.0	23.8	32.1
$\frac{1}{16}$ - $\frac{1}{32}$	tr.	.....	.7	2.1	3.4
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.....	.....	.....	.6
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....	.....

sand, which has settled in the eddy in the lee of the larger drift. *) The sand in the lee drift, as it may be called, is found to be a little finer than the dune sand proper. Its grains have been lifted a little higher, and that is the reason why they have been carried a little farther. But the difference is very slight and consists merely in a

*) See Die Denudation in der Wüste etc., Johannes Walther, p. 172, fig. 89.

change in the proportions of the percentages on either side of the maximum.

It is evident that the finer grains, which may have been present originally or which may have been produced by trituration afterwards, are carried still farther away. Just how far each different grade may be carried from the place where it is first taken up in the wind, has not been made out satisfactorily, but there can be no doubt that the different grades in the fine material are let down at successively greater distances according to their coarseness. Some inferences with regard to these distances may however be drawn from the examination of some sediments, which the writer has taken occasion to collect somewhat promiscuously.

Four series of wind sediments have been taken from successively more distant points in front of dunes and sand drifts in Kansas, Illinois and North Dakota. The analyses of these series show that the grains which approximate nearest to the dune sand in size are not carried very far. The samples from Rice county in Kansas and those taken near Moline in Illinois exhibit merely a decrease of the coarse admixtures and a corresponding increase in the fine for increasing distances within a range of two hundred feet (Tab. XVI and XVII).

The maximum ingredient still consists of fine sand. While this rate of change is not very rapid, it is such as to indicate that the maximum ingredient in the drift sediments in this direction would change to very fine sand a few hundred feet farther out.

In distances less than two hundred feet the percentage of the fine ingredients increases from eight in the dune

Table XVII. Mechanical Composition of Sand taken in the Lee of Drifting Sand south of Moline, Ills.

Length of diameter in mm.	Average of the dune sand.	71	72	73
		10 feet in front of the dune.	100 feet in front of the dune.	160 feet in front of the dune.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1- $\frac{1}{2}$	2.1	.....	.....	.....
$\frac{1}{2}$ - $\frac{1}{4}$	14.0	4.2	2.6	1.9
$\frac{1}{4}$ - $\frac{1}{8}$	69.9	55.6	58.5	51.8
$\frac{1}{8}$ - $\frac{1}{16}$	12.7	34.0	28.8	32.0
$\frac{1}{16}$ - $\frac{1}{32}$	1.5	5.6	9.0	13.7
$\frac{1}{32}$ - $\frac{1}{64}$	.1	.3	.4	.3
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....

Table XVIII. Mechanical Composition of Sand taken in the Lee of Drifting Fields in North Dakota.

Length of diameter in mm.	Average of drift sand.	74	75
		Dust in a house 4 mi. from a drifting field.	Dust in a school-house, 4 mi. from a drifting field.
16-8	.....	.....	.....
8-4	.....	.....	.....
4-2	.....	.....	.....
2-1	tr.	.....	.1
1- $\frac{1}{2}$	9.2	.5	.4
$\frac{1}{2}$ - $\frac{1}{4}$	20.3	1.0	.3
$\frac{1}{4}$ - $\frac{1}{8}$	58.9	5.0	4.6
$\frac{1}{8}$ - $\frac{1}{16}$	9.9	19.8	22.8
$\frac{1}{16}$ - $\frac{1}{32}$	1.3	58.9	60.9
$\frac{1}{32}$ - $\frac{1}{64}$	.3	12.7	9.4
$\frac{1}{64}$ - $\frac{1}{128}$	.....	1.3	.7
$\frac{1}{128}$ - $\frac{1}{256}$	.....	tr.	tr.

sand to forty-one in the lee-sand. The series taken in front of the sand drift at Lindsborg changes more rapidly, so that only fifty feet away sixty-five parts in a hundred consist of very fine sand (Tab. XIX).

The dune at this place was much lower than the other, and this partly accounts for the more rapid settling of the fine sand, which here had a much shorter distance to

Fig. XIX. Mechanical Composition of some Sand taken in the Lee of Drifting Sand near Lindsborg, Kans.

Length of diameter in mm.	Dune sand.	68	69	70
		Lee drift sand.	Sand from 16 feet in front of lee drift.	Sand from 50 feet in front of lee drift.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1- $\frac{1}{2}$	3.1	3.2	.6	.7
$\frac{1}{2}$ - $\frac{1}{4}$	23.3	18.7	3.3	1.3
$\frac{1}{4}$ - $\frac{1}{8}$	69.1	71.2	69.3	14.4
$\frac{1}{8}$ - $\frac{1}{16}$	3.9	5.0	20.5	65.2
$\frac{1}{16}$ - $\frac{1}{32}$	.4	3.9	5.9	16.3
$\frac{1}{32}$ - $\frac{1}{64}$	.....	.1	.3	.8
$\frac{1}{64}$ - $\frac{1}{128}$	.....	.....	.....	.....
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.....	.....	.....

fall. The samples from North Dakota were taken in buildings and are not strictly comparable to the other, but the small amount of fine sand and even of very fine sand which they contain, indicates that most of the former grade, at any rate, had already settled (Tab. XVIII).

As the houses were about four miles away from the place of active drifting, it seems safe to infer that this

distance exceeds that over which fine sand is generally lifted in single leaps. And this quite likely also applies to the transportation of the next finer grade. It should also be noticed here that only a very subordinate percentage of particles smaller than one thirty-second of a millimeter in diameter settles within the distance observed.

We may infer that the grades of rock fragments which range in diameter from one eighth to one sixteenth of a millimeter in diameter are mainly deposited, together with some coarser and some finer ones, in front of drifting tracts as a thin apron, which becomes finer in composition with increasing distance to the leeward. There is little doubt that the change in the texture of this apron deposit is most rapid at first and more slow farther out. Its deposition results from temporary lulls in the wind, which allow the coarser grains to fall to the ground. Going down the scale of diminishing particles a size will at last be found, which is capable of almost indefinite suspension in the changeable currents of the atmosphere. Material of this kind is scattered over wide distances and the change in the texture of the deposits formed from this dust progresses with extreme slowness from one place to another.

ATMOSPHERIC DUST.

To determine the size of the particles that may readily be transported such long distances by ordinary winds, it is only needed to examine the nature of the loads which these winds generally carry. I have collected a number of samples of such dust by different methods, under dif-

Table XX. Mechanical Composition of some Dust collected in Running Railroad Coaches.

Length of diameter in mm.	76	77	78	79
	Sandstorm in Arizona.	From southern Minnesota.	From Nebraska and Kansas.	From New England.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1-1/2	.3	.....	tr.	.2
1/2-1/4	.6	1.0	.5	1.3
1/4-1/8	17.0	14.0	12.0	12.0
1/8-1/16	44.5	32.8	17.2	32.0
1/16-1/32	29.2	41.0	52.6	49.0
1/32-1/64	5.5	9.8	12.5	4.0
1/64-1/128	.6	1.2	1.3	.5
1/128-1/256	.....	.....	.....	.....

Table XX. (Continued).

80	81	82	83	84
From N. Dakota and Montana.	From Rocky Mts. and Cascade Mts.	From Utah. Speed 30 mi. pr h.	From N. Dakota after a storm.	From N. Dakota.
.....
.....
.....
.....
.....
1.0	.....	tr.	tr.	tr.
4.0	3.4	11.0	3.5	3.6
15.8	19.0	67.2	49.1	35.5
29.7	34.0	19.7	39.7	56.8
38.1	29.0	1.7	7.0	3.9
11.9	9.1	tr.	.9	tr.
1.4	2.0	.....	.....	.....

ferent conditions of deposition, and from different localities.

Before discussing the composition of these samples it may, however, be well to note the nature of some wind-borne sediments which have been carried by the atmosphere under more than ordinarily favorable circumstances, and in currents of more than ordinary strength.

Such is the sand and dust stirred up from the roadbeds by running railroad trains. Quartz particles considerably larger than fine sand are here moved nearest the ground. But the material which is lifted high enough (five or six feet) to come in through the windows and doors of passenger coaches is much finer.

Among thirteen samples of such material collected in coaches in different parts of the United States only one

Table XX. (Continued).

85	86	87	88	Average.
From Western Minnesota.	From Eastern Colorado.	From Kansas.	From Idaho and Washington.	
.....
.....
.....
.....
.....	.....	.....	.....	tr.
.....	.....	.1	.....	.3
2.0	1.0	.6	.3	6.4
49.0	22.8	36.8	54.8	36.6
43.1	65.2	57.0	41.6	42.9
4.9	10.2	4.6	3.3	10.3
.5	.5	.5	.1	2.9
.....	.....	.....	.....	.2

had as much as seventeen per cent of fine sand, and one had less than one per cent (Tab. XX). In five of these samples the maximum occurs in the grade of very fine sand, which is next in fineness to the maximum grade of the dune sand; in seven of the samples it occurs in the coarse dust; and in one it is in the next finer grade. The small percentages of the coarser grains is no doubt in

Table XXI. Mechanical Composition of some Dust taken from a Window Sill in a House in Yuma, Arizona.

Length of diameter in mm.	89
16-8	.....
8-4	.....
4-2	.....
2-1	.....
1- $\frac{1}{2}$	.3
$\frac{1}{2}$ - $\frac{1}{4}$	.6
$\frac{1}{4}$ - $\frac{1}{8}$	7.3
$\frac{1}{8}$ - $\frac{1}{16}$	46.5
$\frac{1}{16}$ - $\frac{1}{32}$	36.4
$\frac{1}{32}$ - $\frac{1}{64}$	7.0
$\frac{1}{64}$ - $\frac{1}{128}$	.8
$\frac{1}{128}$ - $\frac{1}{256}$	tr.

part due to the reduced velocities of the currents entering the coaches. Analogous causes may have affected the perfection of the sorting in these samples, which varies considerably, ninety parts in a hundred being distributed among four grades in some instances and between only two in some. But the differences in the speed of the trains and the differences in the mechanical composition of the surface deposits along the railroads must also be taken into account. Nor was the sampling uniform. In some instances the dust was taken after

heavy winds and in others during calm weather, sometimes it was gathered up from the window sills and sometimes from the seats in the coaches. Some of it was brushed from the wearing apparel of a passenger. Taking all these modifying circumstances into due consideration and remembering that the currents of wind which follow a running railroad train are quite as powerful as the cur-

rents next to the ground in the heaviest wind storm, the composition of this dust may be said to indicate that fine sand is too heavy to be effectively kept from settling in such winds, that very fine sand and coarse dust are just on the limits of the size which is subject to effective suspension, and that particles which have a diameter less than one thirty-second of a millimeter will not readily settle from the atmosphere in a strong wind. It may be inferred also that dust of the kind taken in railway coaches must be capable of being lifted up into the atmosphere by moderately strong winds. This is also indicated by the composition of some dust gathered on a window sill three feet above the ground in a building at Yuma in Arizona (Tab. XXI).

Volcanic dust forms another class of atmospheric sediments which are transported under unusually favorable conditions. It is launched from great heights, to which it never could have been raised by the convection currents of the lower part of the atmosphere, and it is carried by the upper currents, where transportation is much more swift than below. Nearest the volcanic outburst there is no maximum limit to the size of volcanic fragments which may fall, but beyond the distance of the influence of the projectile force, which seldom, perhaps, exceeds a dozen miles, their size is determined by the sorting action of atmospheric currents and hence will be a true exponent of the nature of this action.

Seven samples of such volcanic dust have been examined (Tab. XXII). Five of these are from quaternary deposits on the western plains, one is from the Lahontan sediments in Nevada, and one is from a recent shower on

Table XXII. Mechanical Composition of Volcanic Dust.

Length of diameter in mm.	90	91	92	93
	From a coarse layer, McPherson co., Kans.	From McPherson co., Kans.	From Golden, Colo.	From snow in Norway.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1- $\frac{1}{2}$	tr.	.....	.5	.....
$\frac{1}{2}$ - $\frac{1}{4}$	.5	.2	.8	tr.
$\frac{1}{4}$ - $\frac{1}{8}$	46.0	28.8	37.4	10.0
$\frac{1}{8}$ - $\frac{1}{16}$	52.0	24.8	36.4	42.0
$\frac{1}{16}$ - $\frac{1}{32}$	1.0	33.4	21.7	42.0
$\frac{1}{32}$ - $\frac{1}{64}$	.....	11.1	1.6	5.2
$\frac{1}{64}$ - $\frac{1}{128}$	.....	1.2	.2	.7
$\frac{1}{128}$ - $\frac{1}{256}$	.....	.2	.....	.....

Table XXII. (Continued.)

94	95	96	Average.
From Furnas co., Nebr.	From Nevada.	From Orleans, Nebr.	
.....
.....
.....
.....
.2	tr.	.....	.1
.1	tr.	.....	.1
7.0	2.4	.2	18.8
51.0	32.4	19.4	36.8
37.2	40.1	51.0	32.3
3.4	20.2	23.4	9.2
.2	5.4	5.2	1.8
.....	.6	.2	.1

the coast of Norway, following an eruption in Iceland. The coarsest one forms the bottom layer in a deposit in Kansas, where the material settled in water. It contains only the coarsest fragments, which first settled on the bottom under the water. The other sample from the same place represents more nearly the average of the same shower at that place. The dust from Golden in Colorado is the second in coarseness. It fell nearer the place of the eruption, which probably was somewhere in Colorado. The Norway dust which was carried a distance of eight hundred miles, is of about average fineness, compared with the other samples. The materials from Nebraska and Nevada are finer. The variation in composition is quite remarkable in these samples, but it is largely due to secondary sorting in water.

On comparing the average of these analyses with that of sand and dust taken in coaches, the latter are seen to be slightly finer. This appears hardly possible, when we think of the great distances the volcanic dust has been carried, but there are three circumstances which combine to keep the volcanic dust in suspension longer than any other atmospheric sediments. Most of its particles are in the form of flakes, tubes, or hollow bubbles. The flakes may be twenty times as long and as wide, as thick. Such material floats easily in the air. Besides, other sediments have first to be raised by the lower and weaker currents of the air, as already pointed out, while the volcanic dust is thrown up to great heights by an explosion. And then the dust itself is about one fifth lighter than ordinary quarts. We must hence infer that ordinary dust, which is capable of being transported several hundred miles by

the atmosphere, is finer than volcanic dust, most of which consists of particles ranging from one eighth to one thirty-second of a millimeter in diameter.

Somewhat similar inferences may also be made from the nature of some dust taken close to wagon roads, where it was raised by passing vehicles and sifted as it fell by gentle winds. In some dust of this kind, which fell

Table XXIII. Mechanical Composition of Dust collected close to a travelled Wagon Road.

Length of diameter in mm.	97	98	99	100	Average.
	Dust taken 5 ft. from a road near Baltimore, Md.	Dust taken 15 ft. from a road near Baltimore, Md.	Dust taken 25 ft. from a road near Rock Island, Ills.	Dust taken 25 ft. from a road near Baltimore, Md.	
16-8	.....	.....	.....	.....	.....
8-4	.....	.....	.....	.....	.....
4-2	.....	.....	.....	.....	.....
2-1	.4	.....	.....	.....	.1
1- $\frac{1}{2}$	4.0	.2	.....	.7	1.2
$\frac{1}{2}$ - $\frac{1}{4}$	6.7	.8	tr.	.7	2.0
$\frac{1}{4}$ - $\frac{1}{8}$	23.7	3.5	1.4	3.0	7.9
$\frac{1}{8}$ - $\frac{1}{16}$	26.1	31.3	29.2	9.6	24.0
$\frac{1}{16}$ - $\frac{1}{32}$	25.0	48.6	45.1	58.0	44.2
$\frac{1}{32}$ - $\frac{1}{64}$	9.2	14.8	23.1	21.7	17.2
$\frac{1}{64}$ - $\frac{1}{128}$	4.3	.7	.5	4.2	2.4
$\frac{1}{128}$ - $\frac{1}{256}$	.6	.1	.....	.6	.3

five feet from the road, twenty-three per cent was fine sand and eleven per cent was composed of still coarser grains (Tab. XXIII). In some other dust, which fell ten feet farther away, there was only a little over four per cent of the coarse grades. In this sample very fine sand forms thirty-one per cent. Ten feet still farther out this grade is represented by less than ten per cent. These grades evidently easily settle out of gentle atmospheric currents.

Of particles which are less than one sixty-fourth of a millimeter in diameter, there are only small quantities, presumably because such particles tardily settle even in ordinary low winds.

Some dust which was swept by the wind from the banks and the bottom lands of the Minnesota river and lodged on the ice in its channel close by, shows about the same composition as the average of the last samples (Tab. XXIV).

The dust from the railroad coaches, the volcanic dust, the dust from the wagon roads, and this last sample from the ice of the Minnesota river may be said to indicate that particles, which are capable of suspension in strong winds, must have a diameter less than one sixteenth of a millimeter in length, and that particles with a diameter of less than one fourth of this length are hindered from promptly settling out of such winds. The latter part of this statement must

Table XXIV. Mechanical Composition of Dust taken on the Ice in the Minnesota River.

Length of diameter in mm.	101
16—8	.....
8—4	.....
4—2	.....
2—1	.....
1— $\frac{1}{2}$	tr.
$\frac{1}{2}$ — $\frac{1}{4}$	.6
$\frac{1}{4}$ — $\frac{1}{8}$	6.1
$\frac{1}{8}$ — $\frac{1}{16}$	16.6
$\frac{1}{16}$ — $\frac{1}{32}$	53.4
$\frac{1}{32}$ — $\frac{1}{64}$	20.7
$\frac{1}{64}$ — $\frac{1}{128}$	1.0
$\frac{1}{128}$ — $\frac{1}{256}$	.....

however be made with a limitation as to the quantity of the load which is carried. Should this be increased beyond a certain limit, flocculation will take place, and then even finer dust will soon be brought down.

Fifty-six samples of dust capable of prolonged suspension in the atmosphere have been studied, and will here be described under three divisions: 1) dust collected

directly from the atmosphere by means of some apparatus; 2) dust which has settled out of the atmosphere on surfaces more or less elevated above the ground, as from leaves of trees and from house-roofs, and 3) dust which has settled out of the atmosphere on snow, on ice, or on other surfaces nearly on a level with the ground.

DUST COLLECTED DIRECTLY FROM THE ATMOSPHERE.

One of the devices used in collecting dust directly from the atmosphere consisted of some whisks of broom-corn, smeared with glycerine, and suspended from a pole ninety feet above the ground. The observations were made on a bluff overlooking the Mississippi river at Rock Island

Table XXV. Mechanical Composition of Dust collected directly from the Atmosphere by means of Whisks of Broom-corn smeared with Glycerine, March, 1895. *)

Length of diameter in mm.	102	103	104	105
	Maximum hourly velocity, 12 miles.	Maximum hourly velocity, 17 miles.	Maximum hourly velocity, 22 miles.	Maximum hourly velocity, 28 miles.
16—8	.....	.....	.....	.....
8—4	.....	.....	.....	.....
4—2	.....	.....	.....	.....
2—1	.....	.....	.....	.....
1— $\frac{1}{2}$	.....	.....	.....	.....
$\frac{1}{2}$ — $\frac{1}{4}$	.....	.....	.....	.....
$\frac{1}{4}$ —1	.....	.....	.....	.....
$\frac{1}{8}$ — $\frac{1}{16}$	16.9	3.0	14.8	12.0
$\frac{1}{16}$ — $\frac{1}{32}$	22.5	16.2	18.5	15.0
$\frac{1}{32}$ — $\frac{1}{64}$	38.3	43.3	37.1	49.5
$\frac{1}{64}$ — $\frac{1}{128}$	19.7	34.7	25.9	21.0
$\frac{1}{128}$ — $\frac{1}{256}$	2.2	2.6	3.3	2.2

*) The method used in making the analyses given in this table was somewhat imperfect and the proportions of particles ranging in size from a diam. of $\frac{1}{8}$ to $\frac{1}{16}$ of a millimeter is too large.

in Illinois. The whisks were taken down once a day and washed in water which was allowed to stand until the dust had settled. This was then removed, dried, and ignited. One series of such samples was secured during the month of March in 1895. These were taken daily and mixed into five larger samples, each of which represented days with maximum hourly wind velocities ranging between certain limits as indicated in the table of analyses. The range of these velocities during the month was from twelve to thirty-three miles per hour, and the quantities of dust taken were quite proportionate to the sixth power of these velocities, ranging from one tenth of a gram to fifty grams. The analyses do not indicate that there was any decided increase in the size of the particles transported during the days having the strongest

wind, as might have been expected (Tab. XXV). The maximum in each of the samples occurs in the medium dust and the samples taken on the calmest days appear to contain the largest proportion of coarse admixtures. There is, however, a small decrease of the fine admixtures in the dust taken during the most windy day, when the highest hourly velocity was thirty-three miles.

In June the same year material was collected in the same way and at the same place, daily, for one week, and a separate analysis

Table XXV. (Continued).

106	
Maximum hourly velocity, 33 miles.	Average.
.....
.....
.....
.....
.....
.....
.....
tr.	tr.
14.2	12.2
21.3	18.7
50.5	43.7
12.4	22.7
1.0	2.2

Table XXVI. Mechanical Composition of Dust collected directly from the Atmosphere by means of Whisks of Broom-corn smeared with Glycerine, June 16—22, 1895.

Length of diameter in mm.	107	108	109	110
	Maximum hourly velocity, 9 miles.	Maximum hourly velocity 9 miles.	Maximum hourly velocity, 12 miles.	Maximum hourly velocity, 13 miles.
16—8	.....	.....	.....	.....
8—4	.....	.....	.....	.....
4—2	.....	.....	.....	.....
2—1	.....	.....	.....	.....
1— $\frac{1}{2}$	.....	.....	.....	.....
$\frac{1}{2}$ — $\frac{1}{4}$	.....	.....	.....	.....
$\frac{1}{4}$ — $\frac{1}{8}$	tr.	tr.	tr.	tr.
$\frac{1}{8}$ — $\frac{1}{16}$	6.0	3.0	3.0	2.0
$\frac{1}{16}$ — $\frac{1}{32}$	37.6	32.4	44.0	35.0
$\frac{1}{32}$ — $\frac{1}{64}$	43.9	43.0	44.0	40.0
$\frac{1}{64}$ — $\frac{1}{128}$	10.3	19.0	7.0	19.1
$\frac{1}{128}$ — $\frac{1}{256}$	1.0	1.0	.4	1.2

Table XXVI. (Continued.)

111	112	113	Average.
Maximum hourly velocity, 19 miles.	Maximum hourly velocity 22 miles.	Maximum hourly velocity, 22 miles.	
.....
.....
.....
.....
.....
.....
tr.	.....	tr.	tr.
5.7	1.1	2.7	3.3
22.9	23.5	27.3	31.9
50.2	45.9	49.1	45.1
20.0	26.7	19.1	17.3
2.2	2.3	.9	1.3

was made of each catch. The maximum hourly velocities of the wind for each day ranged from nine to twenty miles. In this case also there was a correspondence between the wind velocities and the quantities of the dust caught, but on examining the analyses, it is seen that the coarse admixtures rather decrease than increase with the speed of the wind. The fine ingredients are quite as

Table XXVII. Mechanical Composition of Dust collected directly from the Atmosphere by means of Muslin, smeared with Glycerine, July, Aug. Sept., 1895.

Length of diameter in mm.	114	115	116	117	Average.
	From the flagpole during June and July, 1895.	Under trees in a grove.	Top cloth on flagpole, Aug. 13, 1895.	Bottom cloth on flag pole, Aug. 13, 1895.	
16—8	.....	.....	.....	.....	.....
8—4	.....	.....	.....	.....	.....
4—2	.....	.....	.....	.....	.....
2—1	.....	.....	.....	.....	.....
1— $\frac{1}{2}$	.....	.....	.....	.....	.....
$\frac{1}{2}$ — $\frac{1}{4}$	tr.	.....	.....	.....	tr.
$\frac{1}{4}$ — $\frac{1}{8}$	.3	tr.	tr.	tr.	tr.
$\frac{1}{8}$ — $\frac{1}{16}$	9.0	4.9	3.9	1.0	4.7
$\frac{1}{16}$ — $\frac{1}{32}$	32.0	40.7	19.0	24.6	29.1
$\frac{1}{32}$ — $\frac{1}{64}$	43.9	41.5	47.2	45.1	44.4
$\frac{1}{64}$ — $\frac{1}{128}$	11.3	11.5	26.6	28.7	19.5
$\frac{1}{128}$ — $\frac{1}{256}$	1.6	.9	3.0	1.1	1.7

well represented for the days with high winds as for days with low winds (Tab. XXVI).

Some dust was collected at the same place and at the same height by suspending two pieces of muslin held horizontally on a frame. The muslin was smeared with glycerine, to which the dust adhered. This was secured by washing and allowed to settle as before. One sample

consisted of a mixture of daily catches taken during part of June and part of July in 1895. These were thoroughly mixed before the analysis was made. Two samples which were taken, one on the upper cloth and one on the lower, on the nineteenth of August the same year, were separately examined, as was also some other material collected in the same manner under some trees in a grove about a quarter of a mile from the pole previously referred to. The dust taken in this way resembles perfectly that which was caught on the broom-corn. The percentages of the several grades correspond almost to within two percent in the two averages (Tab. XXVII).

It will be noticed that the composition of the mixed sample for June and July is very much like the average for the dust taken on the broom-corn in June, but it is somewhat coarser than that taken on muslin in August. The dust taken under the trees in the grove is also a little coarser than the latter.

Another device for collecting dust from the atmosphere consisted of a hollow cylinder, with apertures on the side for receiving the wind, and with strips of muslin suspended inside. These strips as well as the inner surface of the cylinder were washed once a week, and adhering particles thus secured. Eight samples were taken by this method during the months of July, August and September in 1895 (Tab. XXVIII). The cylinder was suspended at the same height and from the same flag pole as the broom-corn and the muslin previously mentioned. In this series of samples, also, there was a correspondence between the wind velocities and the quantities of dust caught, though not so well marked as in the other in-

Table XXVIII. Mechanical Composition of Dust collected directly from the Atmosphere by Means of Slack Wind in a hollow Cylinder, July, Aug., and Sept., 1895.

Length of diameter in mm.	118	119	120	121
	Maximum hourly velocity, 14 miles.	Maximum hourly velocity, 18 miles.	Maximum hourly velocity, 18 miles.	Maximum hourly velocity, 19 miles.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1- $\frac{1}{2}$	.....	.....	.....	.....
$\frac{1}{2}$ - $\frac{1}{4}$	.....	.....	.....	.....
$\frac{1}{4}$ - $\frac{1}{8}$	.5	1.0	1.0	5.0
$\frac{1}{8}$ - $\frac{1}{16}$	11.1	32.0	18.7	20.0
$\frac{1}{16}$ - $\frac{1}{32}$	33.4	40.0	51.4	44.5
$\frac{1}{32}$ - $\frac{1}{64}$	40.1	17.7	19.8	21.1
$\frac{1}{64}$ - $\frac{1}{128}$	13.3	7.5	8.2	7.3
$\frac{1}{128}$ - $\frac{1}{256}$	1.6	1.6	.6	1.2

Table XXVIII. (Continued).

122	123	124	125	Average.
Maximum hourly velocity, 20 miles.	Maximum hourly velocity, 21 miles.	Maximum hourly velocity, 23 miles.	Maximum hourly velocity, 24 miles.	
.....
.....
.....
.....
.....
.....
tr.	1.0	.....	.....	1.0
6.8	18.7	8.5	9.5	15.6
47.6	51.4	52.9	38.1	44.9
35.4	19.8	27.4	34.9	27.0
9.5	8.2	10.2	15.9	10.0
.2	.6	.2	1.2	.9

stances referred to. On the nineteenth of February in 1896, when there was a high wind and much dust in the atmosphere over the Mississippi valley, one more sample was taken in the cylinder, this time suspended only ten feet above the ground (Tab. XXIX).

All of the dust caught in the cylinder, excepting two samples, is coarser than that which was caught on adhesive surfaces.

Table XXIX. Mechanical Composition of Dust collected directly from the Atmosphere by Means of Slack Wind in a hollow Cylinder, Feb. 19, 1896.

Length of diameter in mm.	126	
	Maximum hourly velocity of wind, 29 miles.	
16—8	.....
8—4	.....
4—2	.....
2—1	.....
1— $\frac{1}{2}$	.....
$\frac{1}{2}$ — $\frac{1}{4}$	.....
$\frac{1}{4}$ — $\frac{1}{8}$	tr.	
$\frac{1}{8}$ — $\frac{1}{16}$	2.8	
$\frac{1}{16}$ — $\frac{1}{32}$	26.5	
$\frac{1}{32}$ — $\frac{1}{64}$	55.2	
$\frac{1}{64}$ — $\frac{1}{128}$	13.2	
$\frac{1}{128}$ — $\frac{1}{256}$	1.2	

The maximum grade consists of coarse dust in the former, while in the latter it is medium dust. It appears that the slack wind was not retained in the cylinder long enough to allow the fine particles to settle.

In this way the maximum has been transferred toward the coarse grades. If then, as we may suppose, the dust carried by the air was of the same average composition in both instances, the rate of decrease from grade to grade on either side of the maximum ought to be more nearly equal in the dust caught in slack wind. Such is also the case, as

may be seen from the averages of all the analyses of each kind (Tab. XXX). It is quite probable also that some of the coarse grains were shaken off from the adhesive surfaces. An average of these two averages may be taken as representing the nearest approximation to the composition of dust carried in the atmosphere at the

place where these observations were made. It may be collected in low winds as well as high, and though it appears to be slowly settling, its general presence indicates that it is easily held in suspension.

Table XXX. Average Mechanical Composition of Dust caught on Adhesive Surfaces and in Slack Wind.

Length of diameter in mm.	Average dust caught on adhesive surfaces.	Average dust caught in slack wind.	General Average.
16—8	.....	.....	.....
8—4	.....	.....	.....
4—2	.....	.....	.....
2—1	.....	.....	.....
1— $\frac{1}{2}$	.....	.....	.....
$\frac{1}{2}$ — $\frac{1}{4}$	tr. 1	.....	tr. 1
$\frac{1}{4}$ — $\frac{1}{8}$	tr. 1	.9	4.
$\frac{1}{8}$ — $\frac{1}{16}$	6.4	14.2	10.3
$\frac{1}{16}$ — $\frac{1}{32}$	27.0	42.8	34.9
$\frac{1}{32}$ — $\frac{1}{64}$	44.5	30.1	37.3
$\frac{1}{64}$ — $\frac{1}{128}$	19.6	10.4	15.0
$\frac{1}{128}$ — $\frac{1}{256}$	1.6	.9	1.2

DUST TAKEN ON NATURAL SURFACES ABOVE THE GROUND.

Several analyses have been made of dust found adhering to surfaces of objects more or less elevated above the ground (Tab. XXXI). Eight such samples were washed from the foliage of trees, on which appreciable deposits of dust may always be observed. The maximum grade in this material is medium dust, but the lesser weight and the smaller size of the particles smaller than this renders them less subject to dislodgement by the wind and by occasional shaking and rubbing of the

Table XXXI. Mechanical Composition of Dust Collected from Surfaces elevated some Distance above the Ground. (Unless otherwise stated the collecting was done at Rock Island, Ill.)

Length of diameter in mm.	127	128	129	130	131
	Shaken from the bark of an oak tree.	Taken in rain water fr. the roof of a house.	From rain water from the bark of an oak tree.	From the trunk of an oak tree.	Taken in rain water fr. the roof of a house.
16—8	.....	.....	.....	.....	.....
8—4	.....	.....	.....	.....	.....
4—2	.....	.....	.....	.....	.....
2—1	.....	.....	.....	.....	.....
1— $\frac{1}{2}$	tr. ,	2.0	.....	tr. ,	4.0
$\frac{1}{2}$ — $\frac{1}{4}$	tr. ,	1.8	.....	tr. ,	3.0
$\frac{1}{4}$ — $\frac{1}{8}$	.3	2.2	tr. ,	tr. ,	5.0
$\frac{1}{8}$ — $\frac{1}{16}$	6.0	7.7	4.0	2.9	7.5
$\frac{1}{16}$ — $\frac{1}{32}$	42.8	36.0	42.0	38.5	25.6
$\frac{1}{32}$ — $\frac{1}{64}$	46.0	36.0	43.0	41.3	47.9
$\frac{1}{64}$ — $\frac{1}{128}$	3.7	14.1	9.7	19.2	6.0
$\frac{1}{128}$ — $\frac{1}{256}$	.5	.2	1.1	.....	.7

leaves against each other. When collected in the early part of the summer this dust is therefore found to be coarser than it is later on, owing to the more frequent removal of the coarser particles and the more persistent adhering of the finer. In some dust which was washed from the leaves of some oak trees in the months of May and June in 1895, there was about twenty per cent of fine dust (Nos. 136, 137), while in two samples taken in August and September, there was a little over thirty per cent of the same ingredient (Nos. 138, 139), and in another sample, which was washed from leaves remaining on some trees in February, the fine dust was the maximum ingredient making nearly forty per cent of the whole sample. Four of these analyses are of dust taken on the bark of some trees, and two are of dust coming with rain

Table XXXI. (Continued).

132	133	134	135	136
Washed from the trunk of an oak tree.	Washed from poplar leaves.	Washed from the leaves of a hickory tree.	Washed from the leaves of a linden tree.	Washed from the leaves of an oak tree, June '95.
.....
.....
.....
.....
.4	.....	.....	.....	.....
1.0	.....	.....	.....	tr.
6.2	tr.	tr.	tr.	tr.
13.0	11.0	2.0	.8	2.0
20.1	17.0	23.0	17.8	13.0
30.1	34.0	42.0	58.7	60.0
26.0	33.0	30.0	21.9	17.0
2.5	3.0	2.0	1.3	8.0

Table XXXI. (Continued).

137	138	139	140	Average.
Washed from the leaves of an oak tree, May '95.	Washed from the foliage of trees at La Salle, Ill.	Washed from the leaves of trees at New Bedford, Ill.	From dry leaves of oak trees, Feb. 1895.	
.....
.....
.....
.....
.....	.....	tr.	.....	.4
.....	tr.	.1	.5	.4
.2	.1	.5	1.7	1.1
2.5	1.0	1.0	3.0	4.6
16.8	17.1	17.0	20.0	24.7
57.2	40.8	44.0	27.0	43.4
22.0	31.7	32.0	38.5	21.7
3.0	8.8	7.3	9.1	3.4

water from a house-roof. Such rough surfaces as these give a secure lodgement to grains of sand as well as dust. From the analyses it is quite evident that some coarse material is moved even by the gentle winds of the Mississippi valley. It may be that many of these grains are raised by the aid of lighter objects to which they adhere, such as bits of straw and leaves. But their abundance in these last samples is best accounted for by the action of occasional strong convection currents and by the increased chances for larger grains to find lodgement on rough surfaces. This may be inferred from two analyses, one of which gives the composition of some dust collected from the trunk of a small tree by striking it repeatedly with a hammer (No. 127), while the other shows the ingredients in the material which remained on the bark after this procedure and which was secured afterward by washing (No. 132). The former has a small and the latter a large proportion of the admixtures on either side of the maximum ingredient. Aside from the greater proportions of the extreme grades, which may be accounted for by the diminished proportionate chances of the grains of the maximum ingredient to find and maintain a secure lodgement, all of these samples resemble those collected on surfaces rendered adhesive by the application of glycerine. The averages of these two series of samples correspond closely for each grade. Both are perhaps, on the whole, slightly finer than the dust which is constantly floating in the air over the central part of the upper valley of the Mississippi.

SHOWER DUST.

Deposits of an impalpable dust are sometimes observed over this region, especially during winter, when it is apt to fall on the snow and discolor its surface. It generally appears after strong westerly winds, which have been called dust storms. Eighteen samples of such dust have

Table XXXII. Mechanical Composition of Shower Dust fallen west of the Mississippi River.

Length of diameter in mm.	141	142	143
	Dust from Kansas City, Mo.	Dust from Alta, Iowa, June 7, 1895.	Dust from Alta, Iowa, June 8, 1895.
16—8	.....	.....	.....
8—4	.....	.....	.....
4—2	.....	.....	.....
2—1	.....	.....	.....
1— $\frac{1}{2}$	.....	.....	.....
$\frac{1}{2}$ — $\frac{1}{4}$	.....	.....	.....
$\frac{1}{4}$ — $\frac{1}{8}$	2.	1.6	1.7
$\frac{1}{8}$ — $\frac{1}{16}$	6.6	8.3	4.0
$\frac{1}{16}$ — $\frac{1}{32}$	59.5	58.2	46.0
$\frac{1}{32}$ — $\frac{1}{64}$	27.7	28.0	42.0
$\frac{1}{64}$ — $\frac{1}{128}$	4.3	2.7	7.6
$\frac{1}{128}$ — $\frac{1}{256}$	.5	.3	.7

been examined, and these represent six different storms. The coarsest fell in Kansas City in the summer of 1890. Nearly sixty per cent of its weight consists of coarse dust, and less than thirty per cent is medium dust (Tab. XXXII). Two samples taken near Alta in Iowa come next to this in coarseness. An average of the two analyses has fifty-two per cent of coarse dust and thirty-five

of the medium. This was collected during and after a heavy wind in the early part of June in 1895.

Thirteen samples were gathered from the surface of ice and from snow at Rock Island in Illinois and these represent three different showers. One such shower occurred in the latter part of November in 1894 (Tab. XXXIII), one in the latter part of January in 1895 (Tab. XXXIV),

Table XXXIII. Mechanical Composition of Shower Dust fallen at Rock Island, Ills., November, 1894.

Length of diameter in mm.	144	145	146	Average.
	Taken on the ice of a small pond.	From the ice of the Mississippi near the bank.	From the ice of the Mississippi, centre of channel.	
16—8	.....	.....	.....	.....
8—4	.....	.....	.....	.....
4—2	.....	.....	.....	.....
2—1	.....	.....	.....	.....
1— $\frac{1}{2}$	.2	tr.	.....	.1
$\frac{1}{2}$ — $\frac{1}{4}$	2.5	.5	.....	1.0
$\frac{1}{4}$ — $\frac{1}{8}$	6.4	3.4	1.0	3.6
$\frac{1}{8}$ — $\frac{1}{16}$	13.5	15.0	8.9	12.5
$\frac{1}{16}$ — $\frac{1}{32}$	50.0	33.0	33.4	38.8
$\frac{1}{32}$ — $\frac{1}{64}$	25.6	43.0	46.8	38.5
$\frac{1}{64}$ — $\frac{1}{128}$	.9	4.3	8.9	4.7
$\frac{1}{128}$ — $\frac{1}{256}$	.....	.7	5.	.4

and one in February in 1896 (Tab. XXXV). The selection of these samples was made with a view to find out not only the average composition of the sediment from each shower but also the range of variation in composition which might be due to changes in convection currents in the atmosphere and to the admixture of local material. Dust gathered on the ice close to land contains compar-

Table XXXIV. Mechanical Composition of Shower Dust fallen at Rock Island, Ill., January, 1895.

Length of diameter in mm.	147	148	149	150
	From the ice of the Mississippi, near bank.	From the ice of the Mississippi, near bank.	From a crack in ice of the Mississippi, in channel.	From the ice of the Mississippi, centre of the channel.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1-1/2	.....	.....	.....	.....
1/2-1/4	tr.	1.2	.5	.....
1/4-1/8	2.0	10.9	1.4	.7
1/8-1/16	18.0	13.8	15.2	9.0
1/16-1/32	32.0	41.5	44.6	36.3
1/32-1/64	37.0	29.8	34.0	36.3
1/64-1/128	9.0	3.9	4.7	15.1
1/128-1/256	7.0	.....	.3	1.8

atively large quantities of coarse admixtures, evidently derived from the ground close by (Nos. 144, 145, 147, 148, 151), and the same is the case with some material which had accumulated in a long crevice in the ice, across which the wind had been drifting after the deposit had settled (No. 149). The dust taken near the center of the channel of the Mississippi river has less of the coarse admixtures, as does also that taken on snow (Nos. 146, 150, 152, 153, 154, 155, 156).

Table XXXIV. (Continued).

151	Average.
From the ice of the Mississippi, near the bank.	
.....
.....
.....
.....
.....
tr.	.3
.2	3.1
11.2	13.0
30.0	36.9
49.0	37.2
7.0	7.9
1.1	.8

Table XXXV. Mechanical Composition of Shower Dust fallen at Rock Island, Ill., February, 1896.

Length of diameter in mm.	152	153	154	155
	From snow in timber.	From snow just above the river bluffs.	From snow near a ravine.	From snow close to a tree.
16-8	.....	.....	.....	.....
8-4	.....	.....	.....	.....
4-2	.....	.....	.....	.....
2-1	.....	.....	.....	.....
1- $\frac{1}{2}$	.....	.....	.....	.....
$\frac{1}{2}$ - $\frac{1}{4}$	.....	.....	.....	.....
$\frac{1}{4}$ - $\frac{1}{8}$	.3	.3	1.2	tr.
$\frac{1}{8}$ - $\frac{1}{16}$	5.7	7.3	4.4	3.2
$\frac{1}{16}$ - $\frac{1}{32}$	49.9	47.9	40.7	43.9
$\frac{1}{32}$ - $\frac{1}{64}$	39.2	38.2	44.0	46.5
$\frac{1}{64}$ - $\frac{1}{128}$	4.7	6.3	7.9	5.6
$\frac{1}{128}$ - $\frac{1}{256}$	.3	.2	.4	.3

Table XXXV. (Continued).

156	Average.
From snow on an open field.	
.....
.....
.....
.....
.....
.....
tr.	.4
1.6	4.4
30.9	42.6
54.3	44.4
11.4	7.2
.4	.3

Over level areas, as out on the ice of the river away from the banks, and on an open field, a greater proportion of fine dust is noticeable (Nos. 146, 150-156), due most likely to a more even progression of the atmosphere permitting more of its load to settle, while near places where timber or topographic contours had set up convection currents, less of the finer dust seems to have been able to come down (Nos. 144, 152, 153). In the averages from each of these three showers the me-

dium and the fine dust are present in nearly equal proportions and constitute from seventy-four to eighty-seven per cent of the whole. In the samples collected on the ice, there is nearly three times as much of the two grades of sand as in those taken on snow, owing, it seems, to the greater quantity of local drift raised by the wind from bare ground along the banks of the river.

Table XXXVI. Mechanical Composition of Shower Dust, Averaged for five Localities.

Length of diameter in mm.	Kansas City, Mo.	Alta, Iowa. (Average).	Rock Island, Ill. (Average).	157		158	
				Chicago, Ill.	Maysville, N. Y.		
16-8	.....	.....	.....	.....	.....	.....	.....
8-4	.....	.....	.....	.....	.....	.....	.....
4-2	.....	.....	.....	.....	.....	.....	.....
2-1	.....	.....	.....	.....	.....	.....	.....
1- $\frac{1}{2}$	.....	.....	tr.	.2	.....	.....	.....
$\frac{1}{2}$ - $\frac{1}{4}$	.....	.....	.4	3.0	.....	.....	.....
$\frac{1}{4}$ - $\frac{1}{8}$	.2	1.6	2.1	5.5	.....	.....	.9
$\frac{1}{8}$ - $\frac{1}{16}$	6.6	6.1	9.6	7.8	.....	.....	4.1
$\frac{1}{16}$ - $\frac{1}{32}$	59.5	52.1	39.5	31.5	.....	.....	16.0
$\frac{1}{32}$ - $\frac{1}{64}$	27.7	35.0	40.3	36.2	.....	.....	53.6
$\frac{1}{64}$ - $\frac{1}{128}$	4.3	5.1	6.9	14.1	.....	.....	22.0
$\frac{1}{128}$ - $\frac{1}{256}$	.5	.5	.5	1.5	.....	.....	2.0

A sample of dust was taken just west of Chicago, soon after the shower which occurred in the latter part of February in 1896 (Tab. XXXVI). It contains a considerable admixture of local coarse fragments, but aside from this it is slightly finer than the average deposit from the same storm at Rock Island. Still another sample was collected at Maysville in New York, after this storm. This also contains a small quantity of sand, but it is otherwise the

finest of all the samples of the shower dust examined, having a larger percentage than the rest of all the grades containing particles less than one thirty-second of a millimeter in diameter.

The common belief that this shower dust is brought from distant places receives some support from the wide

Table XXXVII. Mechanical Composition of Storm Dust; (an average for eighteen samples).

Length of diameter in mm.	Average.
16—8	.....
8—4	.....
4—2	.....
2—1	.....
1— $\frac{1}{2}$	tr.
$\frac{1}{2}$ — $\frac{1}{4}$	.5
$\frac{1}{4}$ — $\frac{1}{8}$	2.1
$\frac{1}{8}$ — $\frac{1}{16}$	8.6
$\frac{1}{16}$ — $\frac{1}{32}$	40.3
$\frac{1}{32}$ — $\frac{1}{64}$	39.5
$\frac{1}{64}$ — $\frac{1}{128}$	7.8
$\frac{1}{128}$ — $\frac{1}{256}$	.6

Table XXXVIII. Average Mechanical Composition of 57 samples of Atmospheric Dust.

Length of diameter in mm.	Average.
16—8	.....
8—4	.....
4—2	.....
2—1	.....
1— $\frac{1}{2}$	.1
$\frac{1}{2}$ — $\frac{1}{4}$	.2
$\frac{1}{4}$ — $\frac{1}{8}$	1.1
$\frac{1}{8}$ — $\frac{1}{16}$	7.9
$\frac{1}{16}$ — $\frac{1}{32}$	33.1
$\frac{1}{32}$ — $\frac{1}{64}$	40.4
$\frac{1}{64}$ — $\frac{1}{128}$	14.9
$\frac{1}{128}$ — $\frac{1}{256}$	1.6

areal extent of the storms which bring it. The prevailing westerly direction of the winds in these latitudes, taken in connection with the gradual change exhibited by these samples (see Tab. XXXVI) from coarse in Missouri to fine in New York, may be looked upon as supporting the same view. This change in the deposits may be the result of a slow sifting out of the coarser particles during transit

from west to east. But with only a single sample from three of these places and only two from another, this evidence is of little weight. Again, it seems quite certain that part of the shower dust is local material. This is indicated not only by the sand it contains, but also by the color of the deposit. When collected from regions where there is a rich black soil, it is apt to be dark, and when observed in the lee of sandy and less fertile lands, it is brownish or reddish. It appears most probable, that part of the shower dust comes directly from distant places, while a part is picked up from the ground nearer to the place where it falls, or from the surface of plants, on which it has previously lodged. Some other observations indicate that there is a constant migration of dust particles in the lower part of the atmosphere. These are apparently picked up and let down unceasingly by the wind. Just what proportion of the deposits which settle from this migrating dust at any particular place or time, is local, and just how much of it comes directly from distant places, is difficult to say. That coarse dust is capable of being transported long distances in the atmosphere can, however, under no circumstances be doubted. It floats along in considerable quantities even on the calmest days when the maximum hourly velocity of the wind does not exceed ten or fifteen miles. It constitutes from twenty-two to forty-four per cent of the totals of the dust caught on such days (Nos. 102, 107, 108, 109, 110, 118), and the smallest proportion which it forms in any of the fifty-seven samples of fine atmospheric sediments I have examined, is thirteen per cent (No. 136). It seems safe to conclude that dust, which is present in such

quantity in the atmosphere, even in calms, cannot escape being carried a hundred miles or more in a strong wind. Medium dust must be capable of being transported still farther and fine, and very fine dust evidently settle with great slowness even in perfect calm, unless present in such quantity that flocculation will take place. This probably seldom occurs except near places of active wind erosion.

If we now take a review of all the analyses of atmospheric dust here presented, that artificially collected as well as the storm dust, we notice that the maxima are scattered over three grades. In sixteen samples the maximum occurs in the coarse dust, in two it is right between this and the medium dust, in thirty-eight of the samples it occurs in the medium dust, and in one it is in the fine dust. This one sample was collected from dried foliage exposed to the winds for several months, during which time a large proportion of the coarser particles had, no doubt, been dislodged. In all the cases where the maxima consist of coarse dust (except perhaps nos. 152, 153), special conditions of collecting account for the greater quantity of coarse materials. The diversity in composition of the atmospheric dust is hence more apparent than real. In two of the samples ninety per cent is distributed among five different grades; in seventeen samples, among four; in thirty-six, among three grades, and in one sample it is divided between two. The average position of the precise maximum (as we may designate that length of diameter, which, if taken as a limit for separation, would divide the bulk of the dust into two equal parts) appears to be a little below but not far removed from the limit between the coarse and

the medium dust. This in part accounts for the low percentages of the maxima, which never exceed sixty per cent of the entire weight of each sample and which range down to thirty. The decrease from the maximum to either extreme ingredient is uninterrupted, except in two samples collected from rain-water, which came from the roof of a house. In these the coarse sand is present in greater quantity than the medium sand. The slope from the maximum toward the coarse admixtures is more gradual than that toward the fine admixtures in nineteen of the samples. Most of these were taken near the surface of the ground in places favorably situated for the admixture of local material, as from the trunks of trees, from house-roofs, from ice near river banks, and from snow near bare patches of ground. In thirteen samples the decrease is, on the other hand, rather more gradual toward the fine admixtures. Such is nearly always the case when the dust has settled in slack wind, as in the hollow cylinder, among the trees, or under shelter. In twenty-five samples the two slopes are about equally steep. These include most of the dust caught on surfaces smeared with glycerine and some of the shower dust. In an average of all the samples, owing to the large admixture of local coarse materials in a few instances, the slope is more gradual in the direction of these admixtures. But the difference is slight (Tab. XXXVIII).

The significance of this last feature is quite evident. The elimination of the sand from the settling dust follows the same law as the separation of material which is still finer, from this dust. The greater vertical components in the wind near the surface of the ground are able to keep

the dust in suspension, while sand is dropped, and in the same way lesser vertical components higher up in the air mostly retain particles less than one sixty-fourth of a millimeter in diameter, while particles larger than this are slowly settling. Where no exceptional conditions prevail, the two slopes should therefore be symmetrical, since both are determined by the velocity of the atmospheric currents.

GENERAL CONCLUSIONS.

While the wind-borne materials which were collected for these analyses may not represent the greatest extremes of wind work, such extremes were sought in their selection. Even if more extended observation should show, as it hardly can fail to do, that pebbles considerably larger than any seen in these samples, may be moved by the wind, it is evident that atmospheric transportation is confined to rock fragments of comparatively limited range of sizes. The largest pebble found in any of these analyses, measured less than eight millimeters in diameter. In the opposite direction infinity is of course the extreme limit, but in the dust collected for this study the quantity of particles measuring less than one two hundred and fifty-sixth of a millimeter in diameter probably in no case amounted to as much as one per cent of the whole, and generally it constituted merely a trace, when at all present. It was therefore neglected in the analyses.

The limited range of coarseness of wind-borne materials is, of course, due to the lightness of the air. Within

the same limits of velocity a lighter medium will not move such large fragments as a heavier. Water currents dislodge masses immensely greater than the largest pebble in these samples. As a result of this restriction on the work of the atmosphere, its deposits are necessarily less diverse in their mechanical composition than those of water.

Another circumstance, which increases the uniformity of atmospheric sediments, is the great effectiveness of the atmosphere as a sorting agent. In different media the sorting power increases with the decrease of the carrying power. It is a familiar fact, that moving glacier ice can effect no sorting. In the same way a highly viscous liquid is a bad sorter, for its motion is slow, and the small particles it carries are not brought sufficiently far ahead of the larger ones.

In a current of water the velocity is greater and the different grades of fragments are farther removed from each other in a horizontal direction, before all have time to sink. In the much lighter air this separation is still wider, owing to the higher velocities which obtain, and still more perfect sorting is the result. Whatever the air lacks in viscosity and weight must be made up by velocity of its currents, if any material at all shall be transported.

It might be inferred that this great sorting power of the atmosphere should produce diversity rather than uniformity in the deposits.*) Such is indeed the case whenever the load, dropped during each transient period of somewhat uniform velocity, is sufficient in amount to

*) See letter from Prof. Dana, *Journal of Geology*, Vol. III, p. 342.

appear as a distinct layer in the deposit. But this probably never occurs except in the drifting dunes, and near them. In dune sand the most perfect lamination is often to be seen, even when the actual difference in the coarseness of the separate seams is very small (Nos. 47, 48). The deposits which accumulate nearest in the lee of drifting tracts may also sometimes become more or less stratified, when coarse layers from exceptionally heavy storms are thick enough to remain separate. This does not always happen, for rains and growing plants are effective agents in mingling successive laminae, when not too thick, into a homogeneous unstratified mass.

But the lulls which occur even in the strongest winds soon cause the coarser particles of their load to fall out, and after a while only the finer ones remain suspended. This is plainly indicated by the composition of the samples of sand, which were collected in front of dunes (Nos. 64, 75). As the wind travels away from the place of loading, its many convection currents, turns, and windings cause it to disperse vertically and horizontally, and the load is *pari passu* dispersed and thinned. From such an atmosphere sedimentation is very slow. From each transient current, marked off by cyclonic, diurnal, or shorter irregular periods, deposits are laid down, which no doubt are different from each other in mechanical composition, but the quantity from each is never sufficiently great to form a separate lamina. Each deposit is thoroughly mingled with that which has settled before, either by the settling of the particles of the latest deposit in the interstices of that laid down before, as this is not thick enough to completely cover the ground surface, or

else by the subsequent superficial mixing effected by various forces. Such mixing results from the direct action of the winds; indirectly, from the action of the wind on various objects which are caused to move on the surface of the ground; from rain; from frost; from the works of insects and other small animals; and from growing plants. All these agencies acting together can hardly fail to prevent any sub-aerial deposit of dust from acquiring such a fine lamination as is often seen in silts and clays, which are deposited under water and which have accumulated much more rapidly. Eolian loess is never markedly laminated, and the primary cause of the absence of this structure is the great velocity of the atmospheric currents, which scatter the materials in suspension over so wide areas that the deposit from each passing current becomes too small to remain as a distinct layer.

These analyses plainly indicate that atmospheric sediments are rendered uniform also by the elimination of the finest particles, such as measure less than one one-hundred-and-twenty-eighth of a millimeter in diameter, and even to some extent the particles of the next coarser grade. It will be noticed that the very fine dust in but a few cases exceeds three per cent of the total weight of each sample examined. The fact that this fine material is not specially abundant in the dust caught on the calmest days indicates that it is easily held in suspension. This is no doubt the kind of dust which follows the wind around the globe. It is carried everywhere and must be settling everywhere in exceedingly small quantities, inversely proportionate to the greater area over which it is being

spread. Falling on the land it will be washed away by erosion or enter as an inconspicuous component in the coarser atmospheric dust, and falling in the sea it will be lost among the more copious aqueous sediments there, unless places exist where these are absent. On account of this slow settling of the finest dust we cannot expect to find it forming separate laminae in eolian deposits, for over regions where these are built up, the wind will never remain quiet long enough to permit a sufficient quantity of only fine material to settle and form such layers.*) It appears therefore that the finest wind sediments, which may be laid down in such quantity as to form appreciable deposits, consist in the main of particles ranging from coarse to fine dust, and do not have any markedly laminated structure.

SUMMARY.

The work of the atmosphere begins with erosion. This erosion is confined to much smaller areas than atmospheric sedimentation. One such area of erosion may be regarded as one of the corners of an isosceles triangle, pointing against the wind. Between the two equal sides of this triangle transportation and sedimentation is taking place. The quantity of work performed is greatest near the area of erosion. In this area materials of varied coarseness are moved, up to pebbles which measure at least eight millimeters in diameter. Deposition of the coarsest material, such as gravels, takes place immediately. They are left as a thin veneer on the surface.

*) It is interesting to notice that separate layers of such fine material are seldom absent from the silts and clays deposited in water.

and this tends to prevent further erosion. The coarser grades of sand, those containing grains from one to one fourth of a millimeter in diameter, are dragged along a greater distance, but they are unable to keep pace with dune sand, which is mostly finer. When present in sufficient quantity in the eroded terrane, the medium and the fine sand, and especially the latter, are heaped up into the dune drifts. These may creep over considerable distances in course of time. The sand grains which measure from one half to one eighth of a millimeter in diameter, do not seem to be lifted very far in a single leap by the strongest wind, probably seldom as far as a few hundred yards, and much more often only a few feet. The very fine sand, which is next in texture, appears to be mostly dropped before it is carried many miles. Course dust remains much longer in suspension. Most of it probably settles before it is carried two or three hundred miles. The general presence in all kinds of winds of medium dust renders it likely that much of this may be carried as far as five hundred or a thousand miles before having time to settle. Dust finer than this is no doubt carried still farther. It must be largely scattered around the globe and is perhaps often kept floating, until it is brought down by rain. It should be understood that these estimates are for such winds as prevail over the continents. In a tabular form they may be stated thus:

Table of Approximate Maximum Distances over which Quartz Fragments of Different Dimensions may be lifted by Moderately Strong Winds in Single Leaps.

Gravel (diameter from 8—1 mm.).....	A few feet.
Coarse and medium sand (diam. 1— $\frac{1}{4}$ mm.)..	Several rods.
Fine sand (diam. $\frac{1}{4}$ — $\frac{1}{8}$ mm.).....	Less than a mile.

Very fine sand (diam. $\frac{1}{8}$ — $\frac{1}{16}$ mm.).....	A few miles.
Coarse dust ($\frac{1}{16}$ — $\frac{1}{32}$ mm.).....	200 miles.
Medium dust ($\frac{1}{32}$ — $\frac{1}{64}$ mm.).....	1,000 miles.
Fine dust ($\frac{1}{64}$ mm. and less).....	Around the globe.

It is evident that the place of greatest deposition is never far from the place of greatest erosion, when the eroded terrane consists of coarse as well as fine materials. It is generally marked by the accumulation of dune sand. From this point deposition decreases, owing to the transversely horizontal and the vertical dispersion of the load by spreading winds and owing to the previous settling of the coarser particles. A limit is sooner or later reached, where aqueous erosion is more rapid than the accumulation of atmospheric sediments. Beyond this limit the latter will of course not appear.

It is also evident that *the different grades of materials are so far separated from each other in the direction of the wind movement, that even with considerable changes in velocity, the principal area of the deposition of sediments of one grade will not far encroach upon that of the deposition of materials much coarser or much finer.* Gravel or coarse sand, for instance, will never be carried to the region of the main dust deposit, nor will the fine sand. For any particular locality a wind sediment will hence be quite uniform in composition in a single triangle.

In nature we must, however, expect to find a multiplicity of these triangular areas of wind action, wherever the conditions are such that erosion by the atmosphere may take place. They must be found overlapping and inclosing each other. The sediment in any particular place may hence be found to contain grains of varied

coarseness, within the limits of the transporting power of the air, and the proportion of the different ingredients will be determined by the position of the place of its accumulation with regard to different areas of erosion. Small areas of erosion are found almost everywhere, and local material will therefore seldom be absent from any wind deposit. Should places of erosion be numerous in any particular region this may itself be regarded as the windward angle in a great triangle with a great area of deposition to the leeward.

THE PROBLEM OF THE LOESS.

It seems probable that the Western plains and the Mississippi valley maintain the windward-leeward relation to each other. Dust which is stirred up over the plains must be carried east by the prevailing winds, and a part of it no doubt settles over the great central valley. The loess and surface silts, which are spread over most of the territory in this valley, resemble atmospheric sediments considerably in their mechanical composition.*)

It is generally finer in the east and coarser in the west, and it decreases in thickness from west to east. The question whether it is, in the main, aqueous or eolian, cannot be considered as yet settled. It seems doubtful if the deposition at present exceeds erosion over all of this area, but a very slight change in elevation or in climate may lately have reversed the condition in this respect. The question of changed conditions is a very complex one.

*) See *Report on the Examination of Some Soils from Illinois*, by Milton Whitney in the *Report of the Illinois Board of World's Fair Commissioners*; also *Preliminary Report of the Driftless Area of the Upper Mississippi Valley*, by Chamberlin and Salisbury.

The following statements, which were made in a letter written by Professor Dana just before his death, set forth certain objections to the eolian hypothesis. "With regard to the eolian work along valley plains, I think great caution is necessary because eolian work is of a fitful kind. The more powerful winds blow in gusts or rather a succession of them, and each of the gusts is of a rather narrow limit; and in each gust great velocity is succeeded by a decline in which the depositions vary accordingly as to fine and coarse and limit. Making loess — unstratified — by the winds would require a steady breeze sufficient to move the light earth or sand long in a common direction, but too near unvarying in force or velocity to produce alternations from coarse to fine. It is an even kind of work that winds are not often fit for."*) In the last edition of Dana's classic Manual the correctness of Richt-hofen's theory of the Chinese loess is regarded as improbable owing to the absence of winddrift structure (lamination)**). Possibly the absence of such structure was Dana's chief objection to an eolian hypothesis of the origin of the American loess. His argument that the deposit from every changing gust of wind must vary in coarseness according to the velocity, expresses a general law which certainly is true, but it seems that there are some special conditions which supervene, as explained above, and that these will necessarily modify the results of the operation of this law and limit its application to such deposits as are accumulating rapidly near places of atmospheric erosion.

*) See *Journal of Geology*, Vol. 3, p. 342.

***) *Manual of Geology*, p. 195.

Other objections to an eolian origin of the American loess have been made. These refer especially to some geographical features, which cannot be considered here, but which will nevertheless have to be taken into account in a full discussion of the subject. Some distinguished American students of this puzzling formation appear inclined to suspend judgment or to ascribe its genesis to several distinct processes. Though the eolian hypothesis has been more or less considered by all geologist who have had occasion to study the loess, it seems that the nature of the work really performed by the atmosphere is too imperfectly known to admit, as yet, of any thorough discussion of the efficiency or inefficiency of the wind as a loess-maker in America. A study of this work should precede a final verdict on the origin of this formation, and this thought has been a stimulus while pursuing the studies whose results are here recorded. Further studies of this kind coupled with a careful examination of the loess and associated silts in all their varied phases promise to aid in the eventual solution of the "problem of the loess".



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Vol. 100

An
Old Indian Village.

BY

JOHAN AUGUST UDDEN.



ROCK ISLAND, ILL.
LUTHERAN AUGUSTANA BOOK CONCERN, PRINTERS.
1900.





A piece from a chain mail, found on the old village site on Paint creek, McPherson county, Kansas.

An
Old Indian Village.

BY

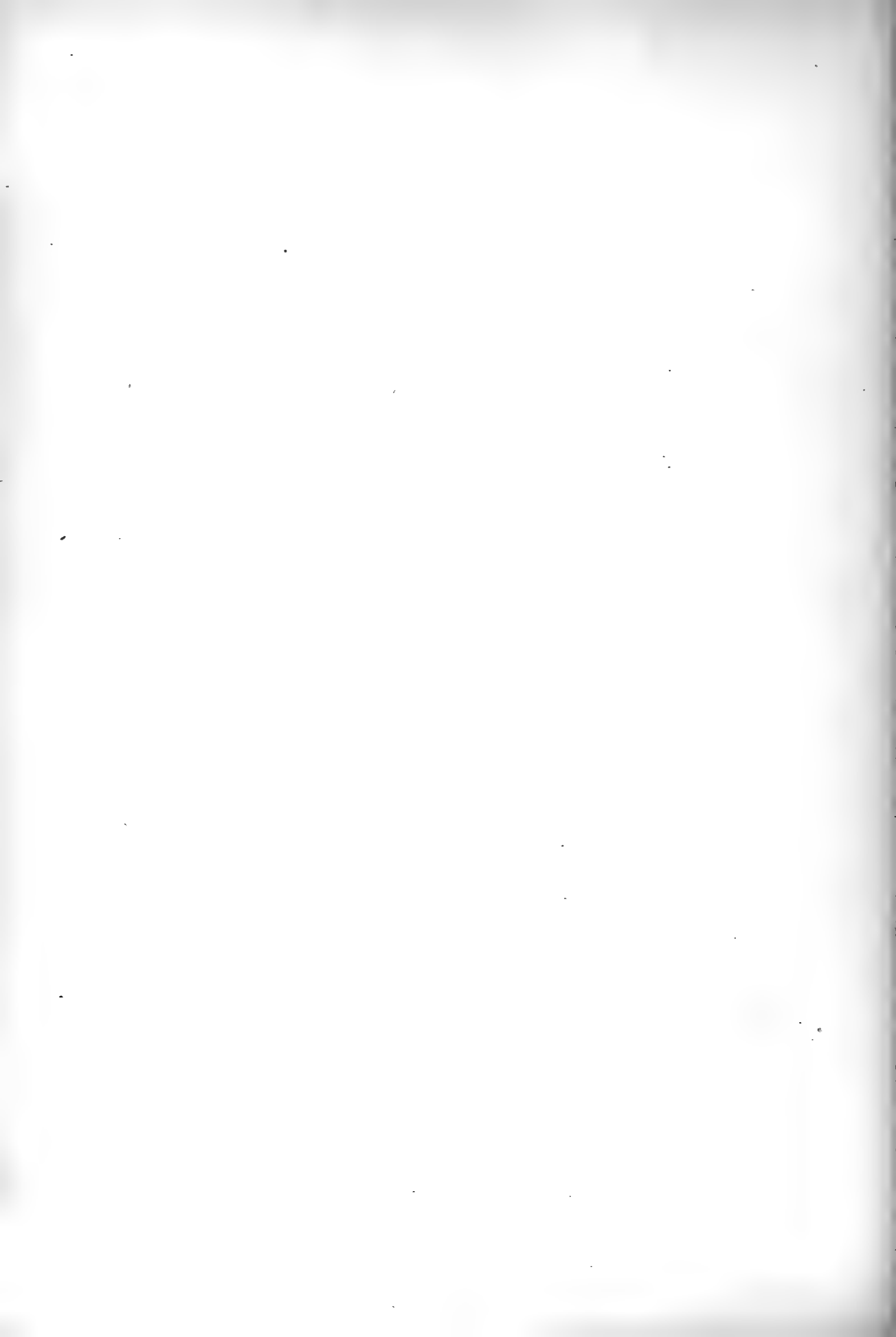
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AUTHOR'S NOTE.

*I*n the fall of 1881, while engaged as instructor in Bethany Academy, now Bethany College, at Lindsborg, Kansas, one of my scholars called my attention to some mounds south of the Smoky Hill river, where various antiquities had been picked up by the settlers. I visited the locality and saw that it gave promise of interesting finds of aboriginal relics. Here was something worth taking care of. During the subsequent seven years I frequently went to the place, sometimes in company with fellow teachers and with students. The contents and the structure of the mounds were noted and their locations were marked on a small plat of the land. In course of time a collection of relics accumulated. This is yet intact in the possession of the institution in whose service I was then employed, and additions are still being made by my successor Professor J. E. Welin.

At the Emporia meeting of the Kansas Academy of Science in 1886 I made a brief report of my observations on these antiquities. But it was impracticable at that time to present the details. It seems that these mounds and their relics are of more than passing interest and in a way are representative of the archaeology of the state. Before I parted with the material which had been secured up to 1889, I concluded to write an account of the collections then on hand. This account has served as a basis for the present paper.

In preparing the following pages I have deliberately had two objects in view. I have sought to present some brief and correct descriptions of a collection strictly limited to one single locality. This is done in the hope that the descriptions together with the photographic reproductions presented in the figures and plates may prove serviceable to science. The author is, however, no archaeologist. This will be his last as well as his first paper bearing on topics of this kind, unless, perchance, he should again find his residence in the front yard of some prehistoric domicile. I have also sought to write these few pages in such a way that they may prove profitable reading to such of the general public as are interested in the study of Indian relics. It is believed that the material lends itself to such a double purpose.

*The average American has a scientific instinct, which he is fond of cultivating wherever he be. Many farmers, merchants, and professional men in the West are making small collections of Indian relics. Should this paper come into the hands of collectors or students of this class, I hope that it may whet their appetite for more and better literature of the same kind. I also hope that it may aid and encourage them in their efforts to study and to take care of the antiquities **found in their own immediate vicinity**. To do this is at the same time their particular privilege and their special duty to the cause of science.*

To former pupils, fellow teachers, and others who aided in making the explorations on Paint creek I extend my thanks and my greetings of most pleasant recollections. In particular I keep in grateful remembrance the kindly interest, aid, and valuable advice always freely bestowed by the venerable pioneer and scientist Dr. John Rundstrom, formerly of McPherson county, Kansas. For special aid in preparing the paper I am under obligations to Dr. C. A. Sorensson, president of Bethany College, to Professor Frank Nelson, Superintendent of Public Instruction of the State of Kansas, and to Professor J. E. Wetin of Bethany College.

The photographs for the illustrations were, with one exception, made by Mr. B. G. Gröndahl of Lindsborg, Kansas, and figures 6 and 27 were drawn by Professor Olof Grafström of Rock Island, Ill.

J. A. U.

Augustana College, May 1st, 1900.

INTRODUCTORY.

The monuments left by prehistoric races in the United States are much more numerous in the eastern part of the Mississippi valley than over the Western Plains. This is plainly shown on a map issued some years ago by the Bureau of Ethnology and prepared to exhibit the geographical distribution of prehistoric works east of the Rocky Mountains.* From the Mississippi river and eastward, the localities of mounds and other prehistoric works appear numerous and crowded, while westward from the great river they are few and scattered. Evidently in prehistoric times as at present the more fertile and more richly watered eastern plains afforded a more congenial environment to the inhabitants than the less favored western country. In another respect, also, the monuments of early man in America bear witness to a comparatively small population in prehistoric times westward from the great river. On the Western Plains we find none of those magnificent earthen structures, that were erected by the prehistoric people of the Ohio valley and by those who dwelled near the Mississippi. The conditions of existence in the west evidently did not result in the development of such powerful communities as could spare the energy needed for the construction of great mounds.

* Catalogue of Prehistoric Works east of the Rocky Mountains, by Cyrus Thomas, Smithsonian Institution, Washington, D. C., 1891.

But the greater observed frequency of antiquities east of the Mississippi river is to some extent due to a less complete knowledge of the western territory. A number of explorers have been at work in the eastern territory for more than three quarters of a century, while comparatively few have paid any attention to archaeological explorations on the west slope of the great central valley, and this for only the last few decades. This region has only tardily received the attention it deserves. There can be no doubt that future work will bring to light many more localities in the west where prehistoric man has left traces of his existence. Some recently made discoveries give decided promise that this will be the case. In the last few years Mr. J. V. Brower has located some sixty hitherto unknown sites of aboriginal villages in the eastern part of the state of Kansas,* and others have reported similar localities from the region north of this state.

From such explorations in Kansas as are known to the author of this paper, it appears that the antiquities in this state are associated with two distinct types of mounds: burial mounds and elevated dwelling sites. Many of the latter, perhaps the greater number, are no mounds at all but merely the flat surface of the ground where the dwellings of an earlier race have once been standing. These would never be noticed, were it not for the relics of household art, chase, and warfare scattered about the place. But frequently there occur

* *Memoirs of Explorations in the Basin of the Mississippi*, Vol. II, Harahey, by J. V. Brower, p. V., St. Paul, 1899.

together with these relics heaps of earth a foot or two high and perhaps a rod wide. These village sites, as they have been called, do not occupy any conspicuously high places, but usually lie on or near some flat and fertile lowlands as on the border of an alluvial plain. The burial mounds are different. They are higher and somewhat less flat on top. Frequently there is a pile or a layer of rocks within them, and under this, some human remains. They are usually built on high bluffs or on upland hills overlooking some extensive lowlands. They can almost always be found on bluffs near the junction of larger streams and their size is somewhat proportionate to that of the confluent waters. Mounds of this kind have been reported from near the mouth of the Kansas,* near the junction of the Big Blue and the Kansas, and near the junction of the Republican and the Smoky Hill.** The author has seen some along the Smoky Hill river west of the latter locality and on several of the high buttes in Saline and McPherson counties, and he has opened two in the latter county. One of these is on the summit of the highest butte of the Smoky Hills and the other is west of Gypsum creek near the northeast corner of McPherson county. Both mounds were partly built of rocks, under which there were charred human bones and some roughly chipped flints. In the present state of our knowledge of the antiquities of Kansas we are hardly justified in making any conjectures as to whether these two types of mounds

* Traces of the Aborigines in Riley County. Prof. G. H. Failyer. Trans. of the Kansas Acad. of Sci., 1879—1880, p. 132.

** Kansas Mounds, F. G. Adams. Trans. of the Kansas Acad. of Sci., 1877—1878, p. 51.

are the products of two different people or whether they have been made by the same race for different purposes. In either case there is little doubt that the burial mounds served some purpose in connection with some mortuary or religious customs, or possibly military practices, among entire tribes or nations, while the dwelling sites merely mark the place of the abode of some household or clan, occupied in ordinary and peaceful every day pursuits.

THE PAINT CREEK DWELLING SITES.*

On the west bank of Paint creek about a mile and a half south of the Smoky Hill river in McPherson county there is a group of some fifteen low mounds which must be classified as dwelling sites in an aboriginal village. They are scattered over the southeast quarter of the northwest quarter of section twelve in township eighteen south and range four west of the sixth principal meridian. For the most part the group occupies a gentle slope to the southeast and east, which extends from the left bank of the creek. The mounds do not seem to be arranged in any particular order, but the distance separating them is, in most cases, about 125 feet, or a multiple of this distance. (Fig. 1). This left a convenient space between the dwellings. A line running through the outer members of

* These are the same mounds that Mr. J. V. Brower has called the Udden Village Site in his *Quivira*, Vol. I, *Memoirs of Explorations in the Basin of the Mississippi*, p. 55. It is from no disregard for the distinguished explorer that the present author prefers to here retain the designation above used.

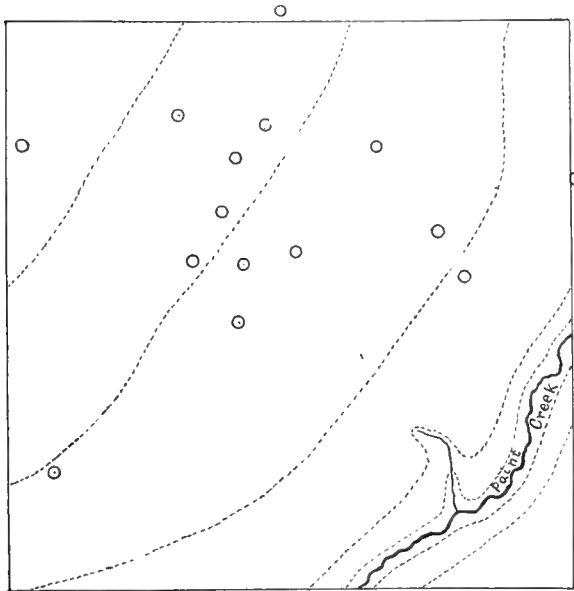


FIG. 1. Plat of the mounds on the old village site on Paint creek in McPherson county, Kansas. The plat covers the southeast quarter of the northwest quarter of section twelve, township eighteen south, range four west of the sixth principal meridian. The dotted lines are contour lines, with ten feet intervals.

the group would inclose an area of about twenty acres. The site may have been chosen with regard to convenient access to water and fuel. There are some good springs in the creek a short distance to the south and there is some small timber along its banks. In other respects the choice seems to have been equally fortunate. To the south and west there is a gravel containing boulders of chert, from which darts and scrapers could be made. The southeast slope of the ground would tend to modify the severity of the northwest winds in winter. Fishing was profitable in the Smoky Hill river near by to the north. The surrounding hilly slope of the upland and the river bottoms to the north afforded a variety of game at all seasons. It was an ideal village site for a savage tribe.

STRUCTURE OF THE MOUNDS.

Each mound is circular in form and has a diameter of from twenty to twenty-five feet. None are more than three feet high. The average height is somewhat less than two feet, and some rise only slightly above the ground. The material of which these mounds are composed is principally loose soil or mud, which is heaped up on the surface of the prairie. On digging down the material was found to be soft until the original prairie level was reached, when the ground became hard. Below this it had apparently never been disturbed. Through the upper loose soil there were all sorts of relics, mostly broken. There were also broken bones of animals, pieces of pottery, here and there bits of charcoal, pockets of ashes, flint chips, various kinds of arrowpoints, scrapers, and knives of flint. Occasionally small blocks of sandstone or limestone were met with, which had been subjected to the action of fire. It was not possible to detect any order in the arrangement of the contents of the mounds and there were no buried human remains. Just how the mounds were built seems uncertain. The mud perhaps accumulated inside the dwellings during a repeated residence of the natives, which occurred at some certain season of the year. All the materials found imbedded, were such household goods as may be supposed to have become useless to the inhabitants, or such as may from time to time have been lost. Most of them were broken. The pockets of ashes occasionally found may mark the site of the places where fires were

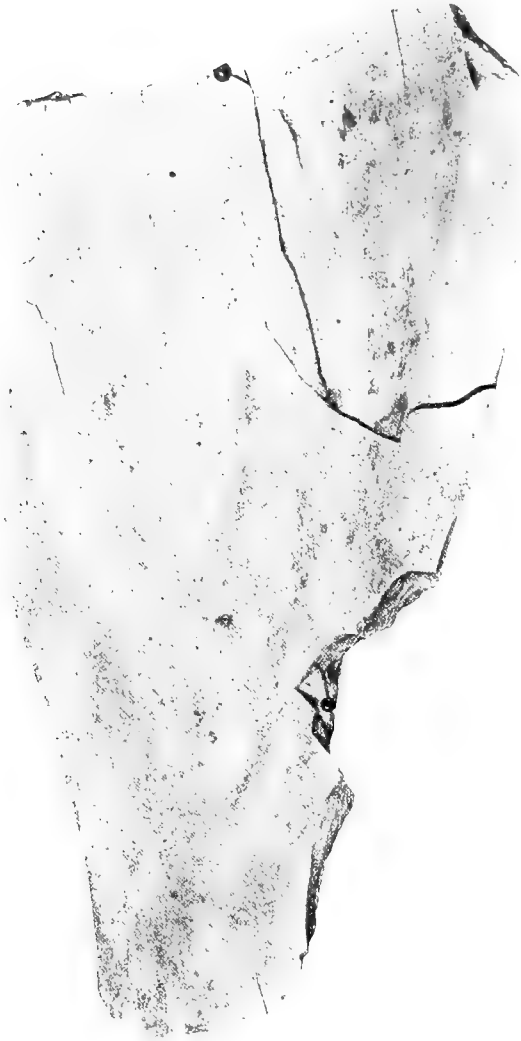


FIG. 2. Hoe, made from a shoulder blade of the bison.

Reduced about $\frac{1}{3}$.

made. Possibly the ground was built up for the purpose of keeping the run-off away during rains. If such was the case, additions must have been made from time to time, for discarded household articles are found in the lower part of the heaps as well as in the upper. Evidently the mounds were not completed all at once. The bones found in the upper part are not as far advanced in decay as those found near the bottom. Indeed it seems possible that the mounds may have been built up from wind-blown dirt and sand settling in dwellings which were left vacant during some season by a nomadic tribe which occupied them during only a part of the year.

ANIMAL BONES.

The abundant presence of animal bones testifies that the people who lived here secured a great part of their sustenance by hunting. The meat of the bison must have been their staple food. The long bones of this animal have almost always been broken. Evidently the marrow was eaten. Considering the great number of these long bones there was a noticeable scarcity of skulls, ribs, and vertebrae. This circumstance may be taken to indicate that the hunters were in the habit of leaving in the field such parts of the bison as did not furnish the most suitable food. Bones of the antelope, the wolf, the wild-cat, the skunk, and the wild turkey were also observed, as well as the vertebrae of various fishes, and the valves of common river clams.

ARTICLES MADE FROM BONE AND SHELL.

Bones were manufactured into various kinds of implements. The shoulder blade of the bison is frequently found beveled on the vertebral border in such a way as to suggest that it has been used as a spade or as a hoe (Fig. 2). From the fragments of the long bones gouge-shaped tools were prepared by beveling one end on the concave side (Fig. 3). About a dozen of these gouges were found, two of them entire, the others being more or less fragmentary. It seems probable that such tools may have been useful in the preparation of hides, or for digging in the ground. One piece of a bone, about eight inches in length, evidently a part of a rib of a bison, was marked by a number of transverse grooves. This may have been some sort of a record or calendar (Fig. 4). Three specimens

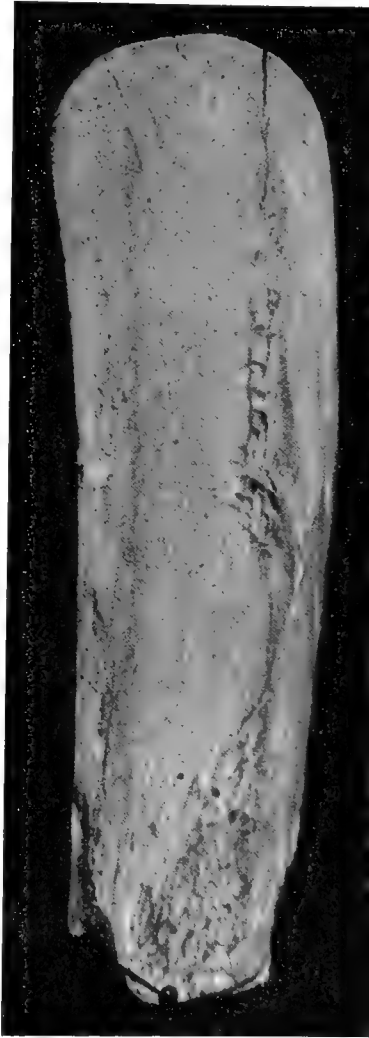


FIG. 3. Gouge-shaped tool made from a long bone of the bison. Reduced about $\frac{1}{8}$.



FIG. 4. Notched record on a rib of the bison. Slightly reddened.

of clavicles of some animal were cut off at both ends and smoothed and polished as from wear. It has been suggested that these may have been used as hair-pins (Fig. 5). One specimen of the lower jaw of a bison had the teeth worn down straight and smooth to about half their length, as if rubbed against a concave object. The lower end of a tarsal bone of a prong-horn antelope was detached by a circular groove running around the entire bone. There were three tools of bone shaped with one smooth and rounded end, very much like the handle of a tooth brush and marked by irregular transverse cuts near the other end (Fig. 5). These were perhaps used as flakers in shaping flint tools, for they can still be applied so as to detach small flakes from flint chips. This is described by some ethnologists as being done by holding the flaker firmly in one hand and pressing it against the flint, which is placed between the bone and the thumb and held in the other hand (Fig. 6). In his paper on *Arrowpoints, Spearheads, and*

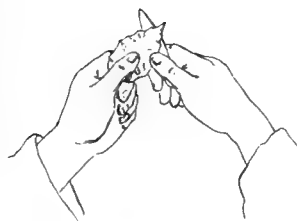


FIG. 6. Method of chipping flint with a bone tool.

Knives of Prehistoric Times Dr. Thomas Wilson has mentioned some similar objects, which are believed to have been used in this way. He says they are usually made of deer horn and are "short and round with a point like one's little finger". It is difficult to see for what other purpose such bones could serve.

A few long beads, made from bones of birds, were picked up (Fig. 5), as were also some bear's teeth.

Two large *unio* shells were found, which had been ground round on the edges and carefully polished so as to resemble spoons. These were in a far advanced state of decay and fell to pieces

before they could be properly cared for. It may be of interest to note that these shells, as near as the author could ascertain, belonged to a species which inhabits the water of the Smoky Hill river.

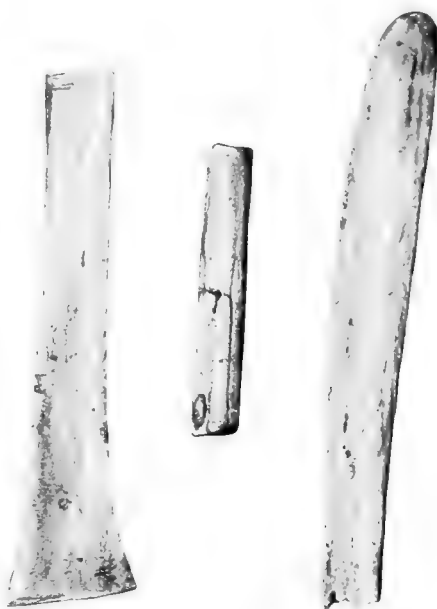


FIG. 5. Figure to the left: hairpin? made of bone. Middle figure: bead made from the bone of a bird. Figure to the right: Flint flaker? made from bone. All slightly reduced.

EXPLANATION OF PLATE I.

<p>FIG. 1. A handle stuck with its upper end to the rim of a vessel. The lower end is inserted in a perforation and strengthened with a bracing ring.</p>	<p>FIG. 2. Like fig. 1.</p>	<p>FIG. 3. A handle with both ends inserted into perforations and braced with rings of clay.</p>
<p>FIG. 4. A handle with both ends inserted into perforations and braced with rings of clay.</p>	<p>FIG. 5. Like fig. 4.</p>	<p>FIG. 6. Like fig. 4. The bracing ring is specially conspicuous below.</p>
<p>FIG. 7. Like fig. 4. The bracing rings have fallen off.</p>		

All the figures are slightly reduced.

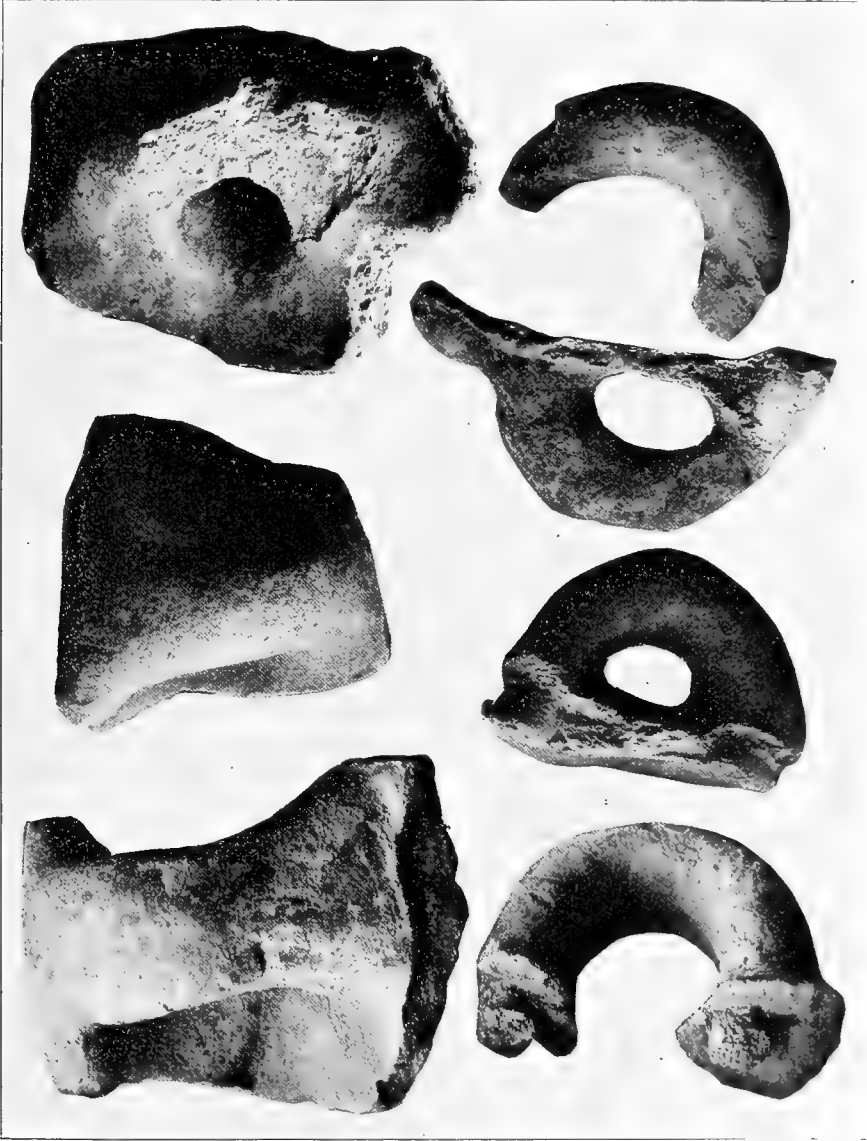


PLATE I.

POTTERY.

All through the material of the mounds there was a great number of broken pieces of earthenware, several hundreds of which were gathered up. This earthenware is made from a clay which is mixed with sand, ground shells, or bone. It does not show any great skill on part of the workmen. Most of the vessels have been made with little care. This can be seen in the variations in the thickness of the broken pieces and in their uneven edges wherever these follow the upper rim of the vessels. Finger marks are often to be found on the surface of the sherds. The inferior quality of the workmanship is also evident in the method of attachment of the handles and in occasional rude attempts in decoration. The burning also seems uneven and imperfect. Only one vessel was found in nearly entire condition, and the workmanship of this was greatly superior to that of the rest.

Forms and Kinds of Vessels. It is not possible in every instance to make conjectures as to the real shape of the vessels that are thus found only in broken fragments. Some are large enough to indicate the general

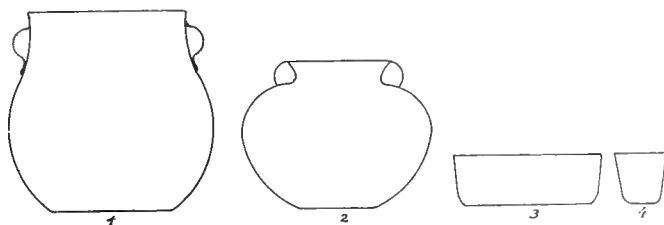


FIG. 7. Various forms of earthenware.
1) Large jar. 2) Smaller jar. 3) Bowl. 4) Cup.

EXPLANATION TO PLATE II.

<p>FIG. 1. A handle ornamented with a line of round indentations.</p>	<p>FIG. 2. A broken handle ornamented with three parallel grooves.</p>	<p>FIG. 3. A broken handle ornamented with a protruding knob.</p>	<p>FIG. 4. A small handle, stuck on, and produced at each end into an ill defined knob.</p>
<p>FIG. 5. A handle ornamented with a single straight groove.</p>	<p>FIG. 6. A large handle with a small ornamental knob at the upper end.</p>	<p>FIG. 7. A handle embellished with two parallel shallow grooves and two rows of indentations.</p>	

Figures 1, 3, and 5 are slightly reduced.

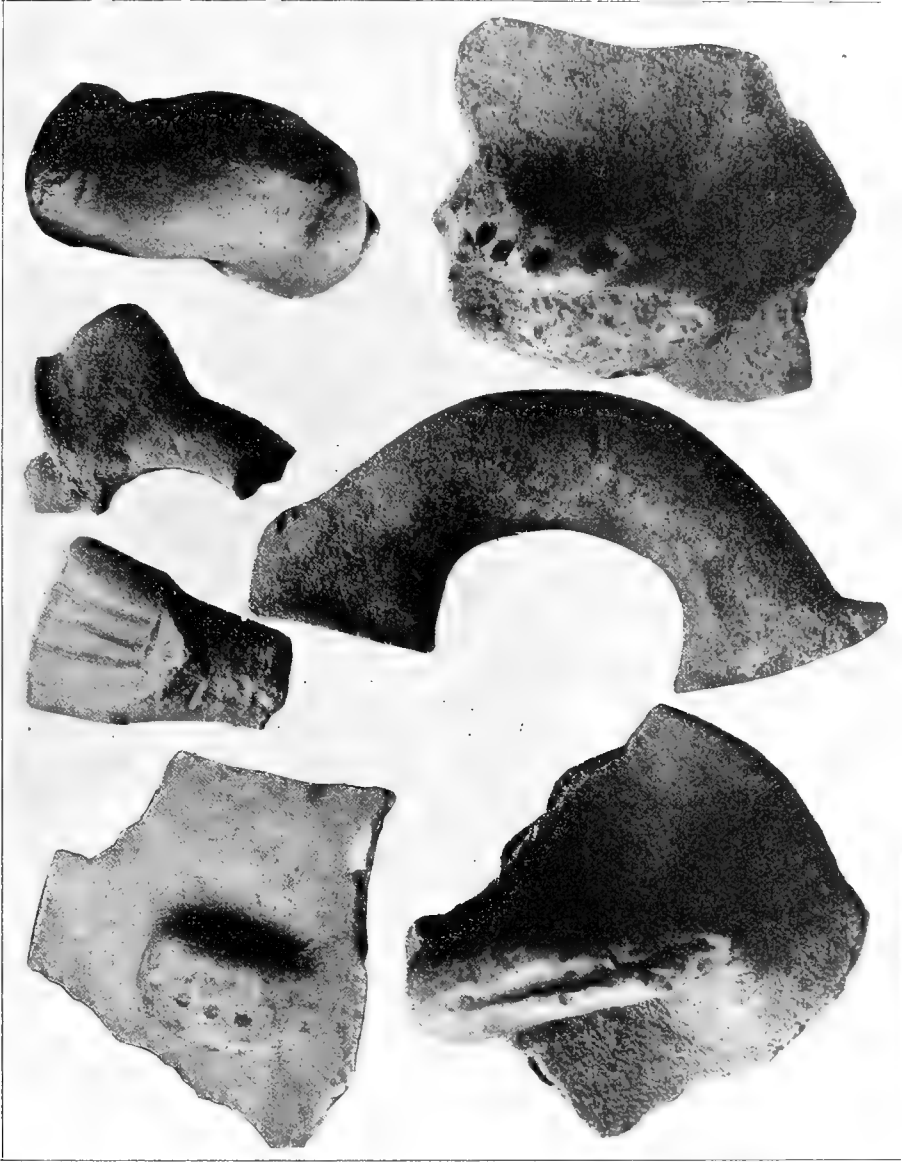
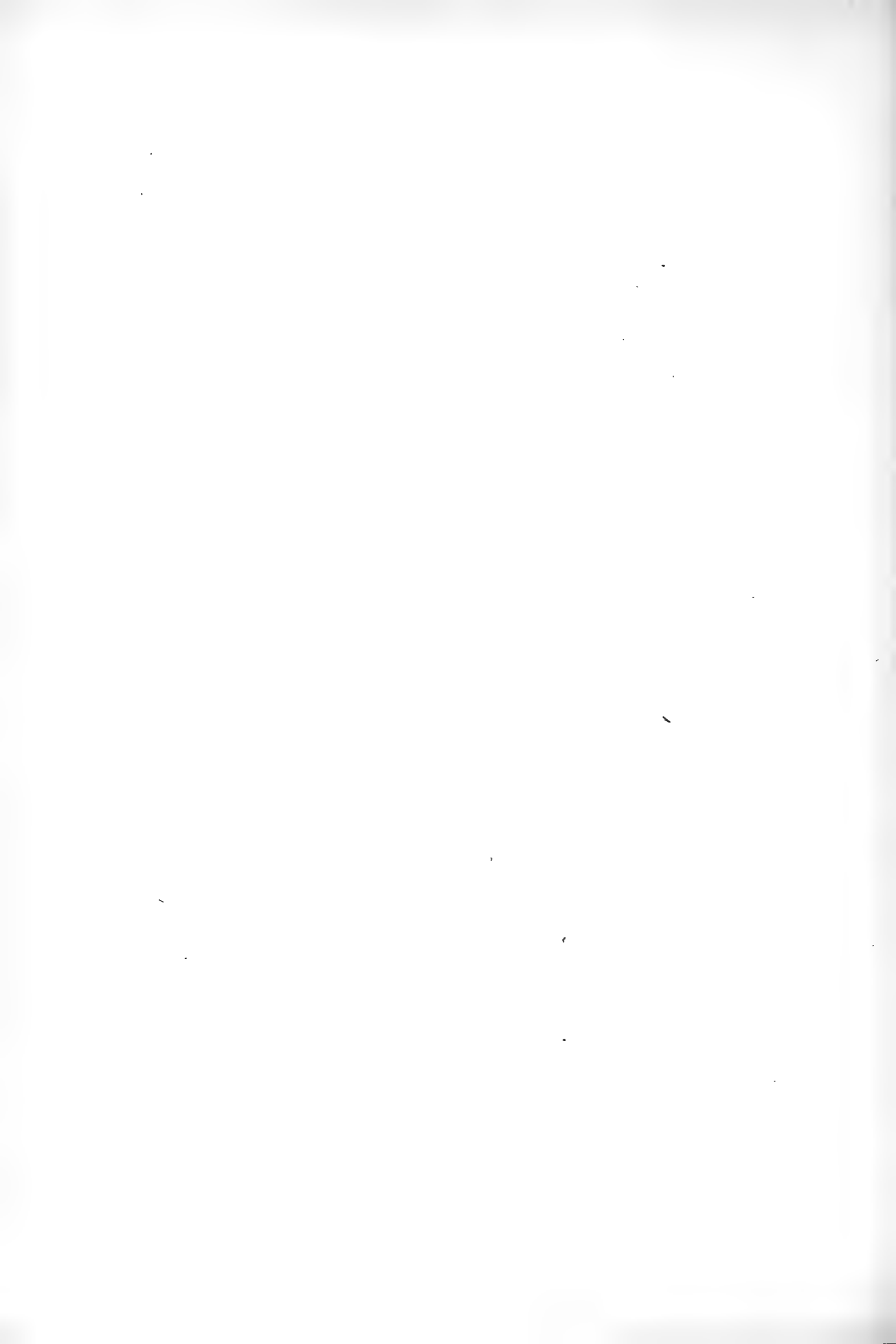


PLATE II.



form. The greater number appear to have been large jars, about a foot in diameter and from eight to ten inches in height, with an opening more narrow than the widest part (Fig. 7, nos. 1 and 2). The upper rim was either vertical or more or less abruptly flaring. One fragment indicated a form quite similar to that of the modern tea-cup (Fig. 7, no. 4). Another must have been a part of a wide elliptical bowl (Fig. 7, no. 3).

Methods of Fastening the Handles. Handles were attached to the rim of all large pots. There were two methods in use for fastening these to the vessel. One was that of perforating the sides of the vessel and inserting the ends of the handle into the perforation and then bracing it by placing a ring of clay around the inserted ends (Plate II, figs. 4, 5, and 7). The other method consisted in merely plastering the ends of the handle to the outer side of the vessel (Plate II, fig. 3). In some cases the two methods were combined and the upper end of the handle was stuck on the rim, while the lower end was inserted into a perforation (Plate I, figs. 1 and 2). When the handles are stuck on, there is also often a bracing ring applied to make the joint stronger. The first method was used in larger vessels as a rule, and the latter method was more common in the case of the smaller ones. In many cases when the handle is stuck on, it is too small for the insertion of a finger and may have been used for the purpose of suspending the vessels by means of a thong or string. Near the place of attachment of the two ends of the handle, there is often a protruding knob, which may be absent, however, either above or below (Plate I, fig.

6, Plate II, figs. 3, 4, 6). All of the handles observed, with one exception, were placed vertically. In the case of the exception it extended laterally in a horizontal plane, about one inch and a half below the upper rim of the vessel.

Ornamentation. The style of ornamentation occasionally seen on the common pottery is particularly crude and consists mostly in the placing of linear and



FIG. 8. A potsherd with partially obliterated indentations of some plaited fabric. The impressions are on the outer (convex) surface. Slightly reduced.

dotted indentations on the handles, or ears, and on the upper rim of the vessels. (Plate II). These indentations are arranged in the simplest kind of patterns, such as single, double, or triple lines. No attempts to represent animate objects have been observed on any specimens. The convex surface of a few sherds is painted red. On many pieces

there were some shallow indentations suggesting partly obliterated impressions of some coarse plaited fabric (Fig. 8), which indicates that the vessels were moulded in some sort of plaited form. This is known to have been a common method of moulding clay among the Indians. On the sherd from the bottom of one vessel there was a circular raised ring (Fig. 9). This seems to be too small for increasing the stability of the vessel on the ground and was perhaps rather intended to secure its equilibrium when placed on the head, where Indian water carriers are in the habit of supporting



FIG. 9. A potsherd with an elevated ring, forming the base of the vessel.
Slightly reduced.

them. In one of the mounds there was found, standing in an upright position, a broken fine vessel of large size, not far from fourteen inches in diameter and about a foot high (Fig. 10). The sides of this vessel were quite thin, only little exceeding an eighth of an inch in thickness. The upper outer surface was decorated by straight parallel lines forming V-shaped patterns. Below the widest part of the vessel the outside was smooth. A number of ears adorned the outside of its upper rim. Parts of the upper rim as well as of the bottom were wanting.

In its imperfection of manufacture and in its crude ornamentation the pottery gathered from the mounds is related to that of the aboriginal people in the northern Mississippi valley.* From the tempering it appears

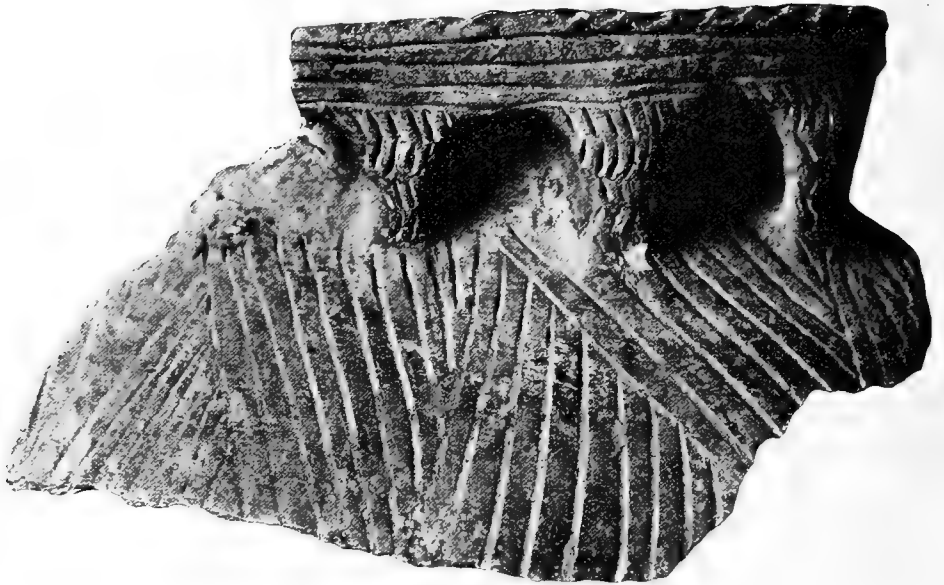


FIG. 10. A piece of a broken ornamented vessel.
Slightly reduced.

that the potters were familiar with the use of ground shells, which is found in the southern pottery, as well as with the use of sand, which was commonly mixed with the clay for the same purpose among the prehistoric people in the north.*

* See Ancient Pottery etc., Holmes, Rept. Bur. of Ethn., Smithsonian Institution, Wash., D. C., 1882—1883, p. 426.

ARTICLES MADE OF CHERT.

Chips and implements of flint are found all through the material in the mounds and are scattered on the surface on the ground between them. Some of the chert contains silicified *fusulinas*. This was perhaps brought from the region of the cherty limestone farther east in the state. Other material resembles that found in the Equus gravel and may well have been taken in the surrounding country. It was manufactured into a variety of objects such as scrapers, knives, arrowpoints, spearpoints, awls, drills, hoes, spades, tomahawks, and hand-hammers.

SCRAPERS.

The scraper was the most common tool made from chert. They are found everywhere. The author collected some two hundred specimens and many have been carried away by others. These implements average one and three-fourths of an inch in length and one inch in width. It is triangular, with a rounded point at one end and a convex wider base at the other (Figs. 11, 12 and 13.) The scrapers occur in all conditions of perfection of workmanship and in all stages of wear and hard usage. There are great variations in size. The length runs from seven-eighths of an inch to nearly four inches; the width, from one to two inches; and the thickness, from one eighth of an inch to two thirds.

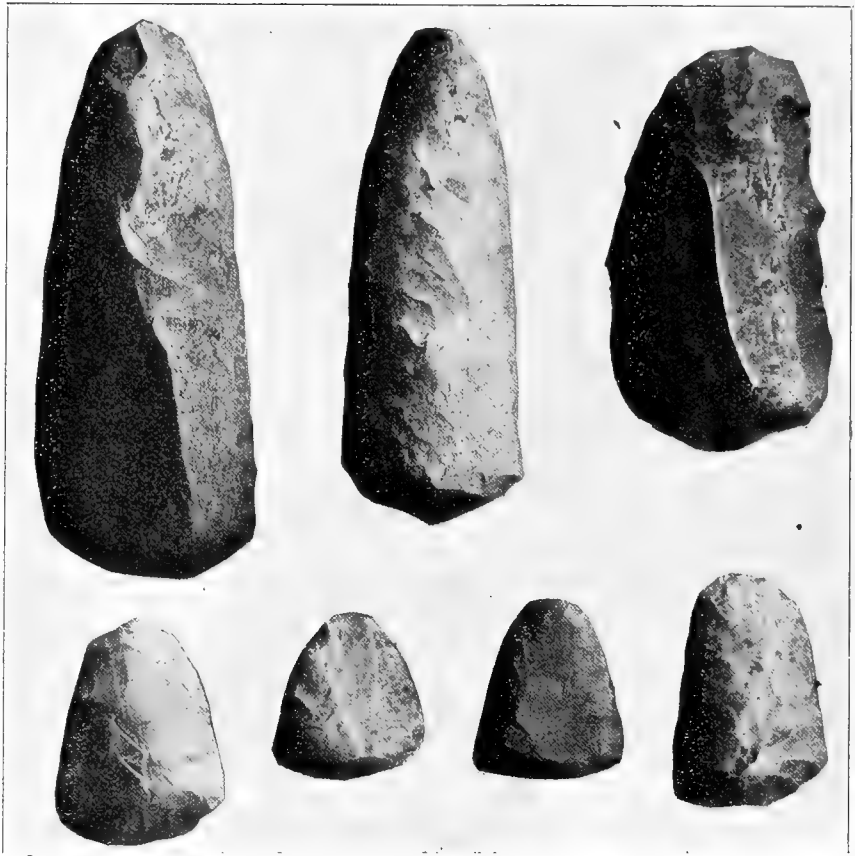


FIG. 11. Typical scrapers. Natural size.

The method of making this tool seems to have determined its form. It is always a flake with one flat side showing no chipping. On this side it was evidently detached from a larger piece of chert. Then the edges were trimmed and straightened by small flaking on the outer convex edges. This was the easiest and quickest way of making an edged tool from chert. Some flakes have been put into service without any finishing whatever, as is evident from their worn unchipped edges.

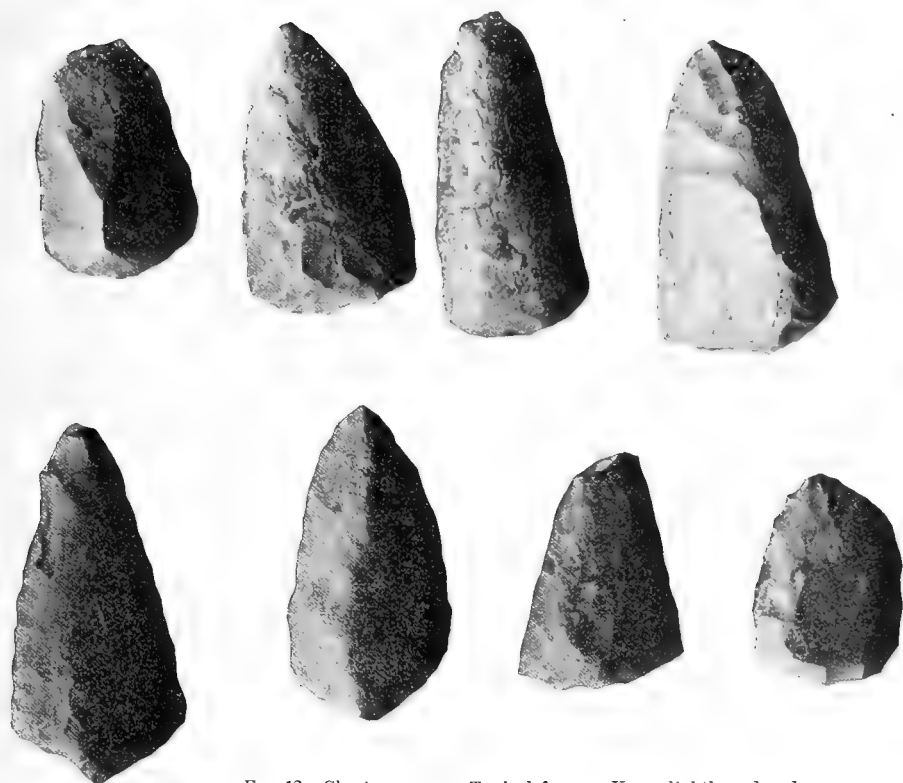


FIG. 12. Chert scrapers. Typical forms. Very slightly reduced.

But the scrapers that are well finished show the most wear. In two hundred specimens which were carefully examined, one hundred and twenty-two were rounded on the left edge and one hundred and thirty-three showed wear on the right edge. Twenty-six of these specimens were also worn on the edge of the base. In this whole number only fifty-two specimens showed no signs of having been blunted by wear. Of thirty-five roughly finished specimens, twenty-three showed no signs of wear. This indicates a preference among the users for finished tools. Some of the specimens indicate

that the edge, after having been worn round, subsequently was again sharpened by chipping.

The uses to which such scrapers could be applied were no doubt quite varied, such as removing meat from bones and

scraping the bark from the shafts of arrows. It

seems to be an instrument that was capable of being made very generally useful in primitive industries. It appears

to have been held between the

thumb and the forefinger when in service, the flat side no doubt preferably being turned against the thumb. If the users were right-handed, it ought to follow that the average wear of the right edge of the scrapers ought to be greater than that of the left edge. Such appears also to be the case.



FIG. 13. Typical scrapers. Natural size.

IRREGULAR FORMS OF SCRAPERS.

Some scrapers had a lengthened and sharpened point and an irregular base, which did not seem to have been shaped for the hand (Plate III, fig. 5). These did not exhibit any wear of the edges and may have had



FIG. 14. 1, 2, 3. Thin chert flakes, fashioned to knives with sharp edges. 4. Broken specimen of the same kind. 5. Entire knife, finely finished. 6. Roughly finished scraper or knife. 7. A scraper with a rounded spoon-shaped termination. 8. A broken scraper or knife. All natural size.

some special use for which the sharp point was designed. They would be effective instruments for flaying a rabbit or for opening a fish or a fowl. Several scrapers agree in being fashioned with a rounded spoon-like termination instead of a point (Fig. 14, no. 7). The edges of these are well rounded and worn. Nine specimens were long and narrow and had only been chipped on one

 EXPLANATIONS TO PLATE III.

FIG. 2.

A very evenly chipped thin and small knife

FIG. 1.

A form of flint tool intermediate between a scraper and a knife.

FIG. 4.

A typical knife, chipped very smooth.

FIG. 3.

A small flake knife only slightly chipped.

FIG. 5.

A long and pointed scraper.

FIG. 6.

A typical flaked knife.

FIG. 7.

The largest scraper found. The reverse flat side of the specimen has a concave flexure of .1875 of an inch in the direction from point to base.

All figures are the natural size.

PLATE III.



edge, the other edge being a fracture inclined at a high angle to the flat side. Only three of these had the chipped edge worn; one of them was broken. The form suggests an adaptation of an accidentally formed chip for easily obtaining a tool with a long edge.

FLINT KNIVES.

Some of the flint implements which have a particularly sharp edge, may properly be called knives, as they were probably used for cutting. These are made of thin flakes which are more straight and usually longer than the scrapers (Fig. 14, nos. 1, 2, 3, 4, 5, and Plate III, fig. 1, 2, 3, 4, 6). In a lot of fifteen none exhibited the rounded blunted edges commonly seen among the scrapers. By proper effort and care they can yet be used to cut off stems of shrubs and small branches of trees. One of these knives shows a considerable amount of skill and care by the

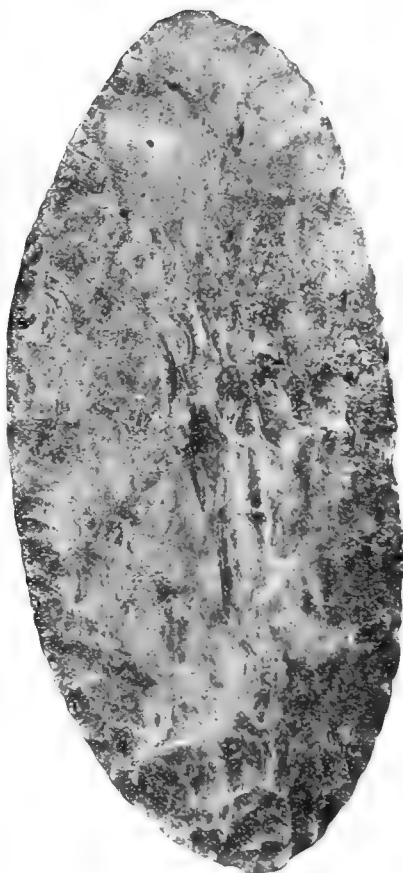


FIG. 15. A perfect flint knife.

maker (Fig. 15). It is nearly five inches in length and measures almost two inches in width and not more than a quarter of an inch in thickness, with an even, sharp edge all around. Another flint which was sharp enough to be used as a knife, showed no finish whatever.

ARROWPOINTS.

Forty-five arrowpoints of flint were found, and of these only ten were entire. The rest were more or less broken. The greater part are so called bird's arrowpoints. These are about three quarters of an inch in



FIG. 16. Arrowpoints. Natural size.

length and a little less than one half of an inch in width and very thin (Fig. 16). Near the base they are quite thin, and have a triangular form, without any barbs or notches for attachment. Only three of them had such notches (Fig. 16, no. 5), and these otherwise perfectly resembled the other specimens. Another type of arrowpoints was somewhat larger, being a little more than one inch in length and slightly less than one inch in width, generally with notches above a narrow base. No points with true barbs have been noticed on the village site, as far as the author knows.

Flints of this kind are among the most common of prehistoric relics, and the number found in this locality seems rather small in comparison with that of the scrapers. It should be remembered that they are of small size and not quite as conspicuous in the field as the scrapers. Nor is it likely that scrapers were as well taken care of as the arrow-points, which were more difficult to make. Arrows were used and lost on the hunting grounds rather than in the village, beyond the limits of which the scrapers may not so often have been taken.

SPEARHEADS.

There were also found thirty-two chipped flint implements, which are supposed to have been used as spearheads. Only six specimens were entire. Ten were broken-off points, six of the fragments had the base entire, and ten had both the base and the point broken off. Three different types may be distinguished in the lot. In two of these types the left edge has been beveled upward and the right edge downward in such a way that when thrown the spear would tend to rotate from right to left (Plate IV, figs. 1, 2, 3, 4, 6). In the other type the chipping is equal on both sides of each edge and the edge itself is sharper (Plate IV, fig. 5). There are two kinds of the beveled spearheads. One has a base which is separated from the point by wide notches, evidently intended for strengthening the attachment (Plate IV, figs. 2, 4), while in the other kind the base is drawn

EXPLANATIONS TO PLATE IV.

FIG. 1.

A large bevel edged spearhead with a flat base. Not much used.

FIG. 2.

A narrow, probably several times re-chipped bevel edged spearhead with notched base. Broken.

FIG. 3.

A broken, probably re-chipped bevel edged spearpoint with a flat base.

FIG. 4.

A broken bevel edged spearpoint with a notched base.

FIG. 5.

A spearhead with a flat base and equally much flaked on the two sides of the edges. The point is down and the original photograph is somewhat imperfect.

FIG. 6.

A bevel edged spearhead with flat base. Made of dark yellow flint.

All are nearly the natural size.

PLATE IV.



out into a flat point without any notches (Plate IV, figs. 1, 3, 6). Most of the specimens seem to be of this latter kind. The users of these spearheads were probably in the habit of sharpening them by chipping off flakes on the beveled edges, whenever these would become blunt, for in some of the specimens that seem to have been much used, the point tapers very slowly at first and then rapidly toward the base, the whole edge presenting a concave outline instead of a convex one (Plate IV, figs. 2, 3). The edge may originally have been made straight, and sharpened by flaking afterward. The same is also indicated by the nature of the edge itself. The largest of the spearheads were four inches in length and one and three quarters of an inch in width.

Archaeologists have found it difficult to establish a precise distinction between arrowpoints and spearheads.* Some of the above described specimens may have been used for large arrows. The chief difference in the use of the spear and the arrow was that the former was thrown from the hand while the latter was impelled by the bow-string. Both were used in warfare and in chase. The spear was probably also used in fishing.

Dr. Thomas Wilson, who has made a special study of the bevel-edged spearheads, states that in their distribution these flints are confined to the interior part of the United States and to the South. He also regards it as evident that the beveling was intended to make the missile rotate in its flight, and notes that this

* Arrowpoints, Spearheads, and Knives of Prehistoric Times by Thomas Wilson, An. Rept. Smith. Inst., 1897, p. 889.

might have been more easily effected by twisting the feathers on the shaft. It should be remembered in this connection that if the point were not also twisted in a rotating spear, its penetration would no doubt be less, as the cutting edge would be made to traverse a plane which would always be more or less oblique to the plane of the point itself.

AWLS.

About a dozen implements of flint were of such form as to suggest a use like that of the awl, for making perforations through hides. These had an extended sharp point from half an inch to an inch in length,



FIG. 17. Awls made from flint. Very slightly reduced.

about three sixteenths of an inch in width, and almost the same thickness, extending from a base of variable shape (Fig. 17). In one instance this base showed that the implement had been made from a scraper. These points can readily be used for making stitches through leather and, if proper care be taken, for boring small holes in soft wood.

DRILLS.

Related to the awls, there are some carefully chipped drills, which differ from the awls in being thicker, longer, less sharply pointed, more straight, and more uniform

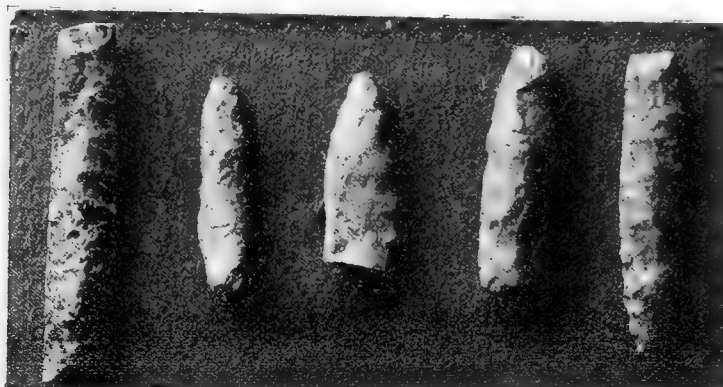


FIG. 18. Drills made from flint. Very slightly reduced.

in width (Fig. 18). These have no widened base to be used as a handle. Most of them show considerable wear on the edges and the nature of this wearing is such as to suggest that it may have been produced by turning the instrument in a hole. The drilling observed in some catlinite pipes, described farther on, may have been made by means of these tools.

LEAF-FLINTS AND TOMAHAWKS.

Quite a number of large chipped flint pieces were found which may have served as hoes or spades for cultivating the soil and for digging in the ground (Figs. 19, 20). Only two of these specimens were found entire. One was six inches long, three and one half



FIG. 19. Hoe (?) made of flint.
Reduced to about $\frac{1}{2}$ of the natural size.



FIG. 20. Hoe (?) made from flint.
Considerably reduced.

inches wide, and three-fourths of an inch thick. Some of them must have been about a foot in length, perhaps six inches wide, and about an inch in thickness. They are oval in shape and are chipped to an irregular edge all around. They resemble the leaf-flints common in the mounds in the Mississippi valley. One large flint is evidently a tomahawk (Fig. 21). It is nearly five inches long, and has a wide constriction, produced by flaking around the middle, dividing it into two lobe-like ends. This constriction is worn smooth and polished by the handle to which it had been fastened.

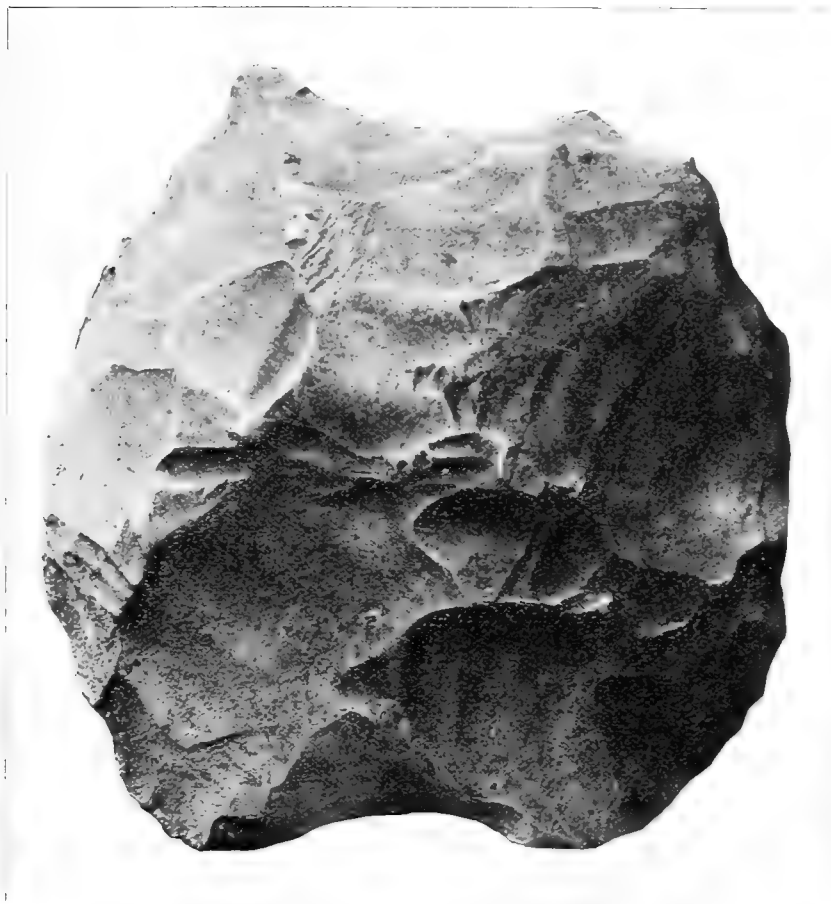


FIG. 21. Tomahawk made from flint. Somewhat reduced.

HAND HAMMERS.

Some irregularly shaped flint pieces were perhaps raw material for the manufacture of implements. Others were rounded and battered and have probably been used as hand hammers, as balls in games, or as nut crackers (Fig. 22).

ARTICLES MADE FROM SANDSTONE.

Grindstones. Several kinds of useful implements were made from sandstone. The most important of these were perhaps the grindstones, or metates and pestles (Figs. 23, 24). These are sandstone slabs some eighteen inches long, ten inches wide, and from two to six inches in thickness. They have a shallow concavity on one of their flat sides. This hollow was evidently produced by wear in grinding. The upper stone, or pestle, as it may be called, was about eight inches in length, three and a half inches in width, and about two inches in thickness. It

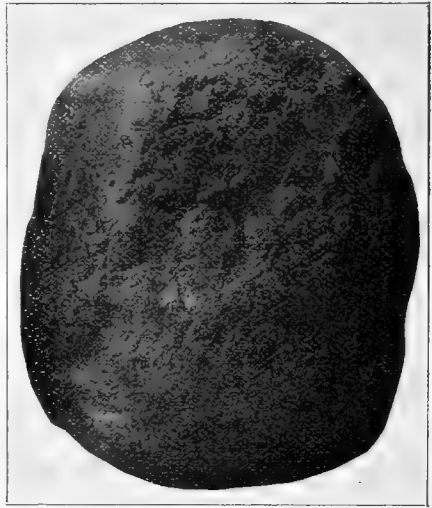


FIG. 22. Battered hand hammer made of flint. Reduced to about four-fifths of the natural size.

was convex on both sides, but more flattened on the side which was applied to the lower stone. Three entire and several broken lower stones have been found on the site of the mounds, and more than a dozen pestles. Prof. J. E. Welin has kindly furnished the following measurements of these stones.

MEASUREMENTS OF METATES.

Number.	CONDITION.	LENGTH in inches.	WIDTH in inches.	THICKNESS in inches.
1	Entire (Fig 23).	21.	14.	6.
2	Entire (Fig 24).....	18.	9.2	3.
3	Entire.....	16.5	10.	3.8
4	Much worn, and broken....	10.5	15.5	5.
5	Entire.....	14.	8.2	1.5
6	Entire.....	9.5	5.5	1.6
7	Broken at both ends	5.5	9.	2.2

MEASUREMENTS OF UPPER OR HAND GRINDSTONES.

Number.	CONDITIONS.	LENGTH in inches.	WIDTH in inches.	THICKNESS in inches.
1	Entire.....	10.	3.8	2.6
2	Entire.....	9.2	3.7	2.9
3	Entire.....	8.7	3.6	1.8
4	Entire.....	8.7	3.8	1.7
5	Entire.....	8.2	3.6	2.
6	Entire.....	8.	3.5	2.2
7	Entire, much worn.....	7.2	3.5	1.4
8	Entire.....	7.	2.7	1.6
9	Entire.....	6.5	3.3	1.7
10	Entire.....	6.	3.2	1.4
11	Entire.....	6.2	2.8	1.6
12	Entire.....	6.2	3.7	1.7
13	Entire.....	4.7	4.1	1.4
14	{Entire, but changed into a mallet by cutting a groove around the middle}	5.7	3.7	3.2
15	.....	5.2	3.3	1.7
16	Imperfectly shaped.....	8.2	4.	1.9
17	Possibly a broken metate..	6.7	3.6	1.7
18	Broken.....	5.5	3.6	1.7



FIG. 23. Much worn large lower grindstone, or metate, with a hand grindstone, both made from sandstone. The metate is twenty-one inches long.

Most, if not all, of these grindstones are made from the Dakota sandstone. Specially indurated blocks have been selected. The metates have not all been dressed to their present form. A few appear to be merely broken, oblong, irregularly rectangular blocks, worn smooth on one side. More pains were taken with the hand grinders. Some slightly worn specimens of these show the pick marks of the dressing tool, whatever that may have been. Other ones have been further smoothed by special grinding or by wear in use. Several specimens bear the mark of long continued service, as do also most of the metates. A thickness of nearly two inches has been ground off from the upper face of some of the latter, and from the form of some of the hand stones we must infer that these have been reduced by nearly half of that thickness. There can be no doubt that these stones were used for grinding corn. Their number and condition testify that this grain was an important part of the food among the natives who used them. It is quite evident that these people must have had some knowledge of agriculture.

ARROW-SMOOTHENERS.

Thirty-five specimens of arrow-smootheners were taken up out of the material of the mounds (Figs. 25, 26.) These were all made from Dakota sandstone. Only five seem to be entire specimens. Of thirty broken ones quite a number show unmistakable evidence of having been used after they were broken. In one instance two



FIG. 24. Metate, or grindstone, made from sandstone, with hand grindstone of same material. The hand grindstone is turned over, so as to show the lower face, which has been worn flat. The lower stone measures eighteen inches in length.

such pieces were found to fit together endwise by their fractured surfaces, while one of them had its sides considerably more worn than the other (Fig. 27). These implements are pieces of sandstone of suitable size and



FIG. 25. Arrow-smootheners made from sandstone. The upper specimen shows the typical form. The lower specimen is perhaps a piece of an arrow-straightener. The grooves run out before reaching the end of the stone. Slightly reduced from the natural size.

shape for being held in the partly closed hand. They have one or more longitudinal grooves on one or several sides. It may be that the arrow-shafts were not the only objects ground on these stones, for the grooves are not always round. Some of the grooves have deep-

enings, widenings, and turns, and such stones cannot have been intended for use in smoothing a straight stick. The greater number of forms of this kind were probably used in straightening crooked arrowshafts, as has been suggested in a recent paper by Dr. Thomas Wilson. Some specimens which seem well adapted for such a purpose, are wider than the rest and have on one side two or three parallel grooves, which terminate before coming to the end of the stone (Fig. 25). In the straightening process the crooked part of the shafts are supposed to have been pressed into these grooves. The stone was probably heated for the purpose of temporarily softening the wood. Such a procedure would account for the fact that nearly all the stones of this kind were broken across the middle.



FIG. 26. Arrow-smoothener, made from sandstone. Reduced to $\frac{3}{4}$ of the natural size.

CUPPED STONES.

Some pieces of sandstone of irregular shape had cup-like cavities on their flat sides. These cups were about an inch or an inch and a half in diameter and had a

depth of a little more or less than a quarter of an inch. It is believed that these may have served as mortars for preparing paint used in personal decoration.

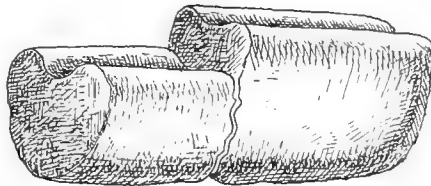


FIG. 27. Broken arrow-smoothener. Left fragment worn after breaking. Reduced to $\frac{2}{3}$.

CATLINITE PIPES.

In the collection are four fragments of catlinite pipes (Fig. 28). Three of these were from very finely finished specimens, which, it may be supposed, had been used for some time and then broken by accident. One of them was the elbow of a pipe which had never been finished. Its outer surface showed the coarse scratchings made in grinding it into shape. The polishing was perhaps left until after the drilling of the holes, and in this case the drill went too far to one side so as to break through, thus causing the specimen to be discarded. The nature of the ends of the perforations show that the drill was not a hollow reed, but solid and somewhat pointed. One of the fragments was ground on the fractured surfaces and may perhaps have been carried about as a totem. Two small pieces of catlinite appeared to be chips struck off by the workman in roughly shaping the pipes. On a farm southwest of the site of the mounds, several finished and entire pipes have been picked up and also a piece of pipestone about three inches square and one inch in thickness. The

pipes are about two inches long, with a short bend near the end for the attachment of the stem. They are not

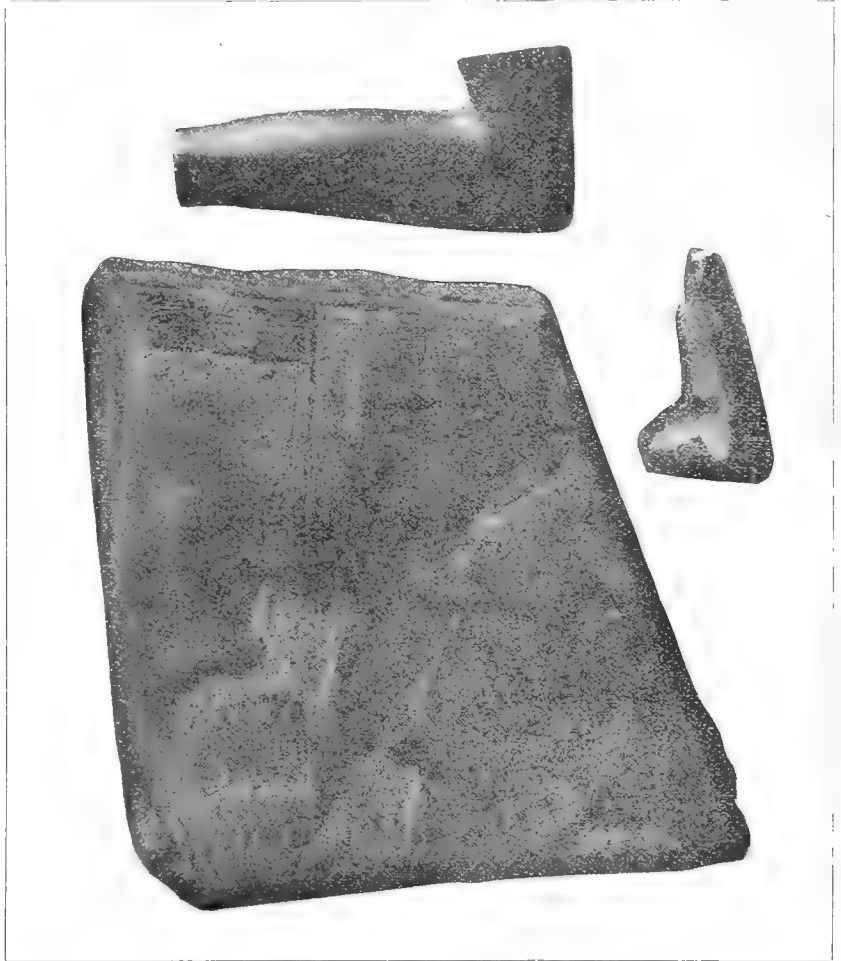


FIG. 28. Uppermost figure: Small catlinite pipe. Lower left hand figure: Piece of worked catlinite. Right hand figure: Fragment of a broken pipe (unfinished). All slightly reduced.

much more than five eighths of an inch in their greatest width, and the perforation is about three eighths of an inch in diameter. The piece of catlinite must have

been a stone in the rough intended for the manufacture of pipes. Pieces had been taken off from three of its edges by cutting grooves on both sides and then breaking along the grooves. On one side the groove is crooked, as if the part broken off had been intended for an elbow pipe. The two flat sides were somewhat convex and smooth and polished, as by wear. It was no doubt brought from the pipe-stone quarry in Minnesota and kept as a precious article by some native, who finally lost it. The small pieces taken from the mounds on the old village site, indicate that those who lived there had communication with the same distant place, either directly or through the channels of primitive trade. All of the pipes found, broken as well as entire, belong to the Siouan type as defined by McGuire.*

ARTICLES MADE FROM VARIOUS MATERIALS.

Stone Mallets. Several implements taken on the site of these mounds must be classed as mallets, or large hammers. These consist of cylindrical or slightly quadrangular rounded stones having a groove around the curving surface midway between the two ends (Plate V). Most of these implements were made from brown or red, strong sandstone, but two were of limestone. One consists of a highly ferruginous and tough sandstone or quartzite, with a bright red matrix. The sandstone in this specimen and that in some of the others does not resemble any of the local modifications of the

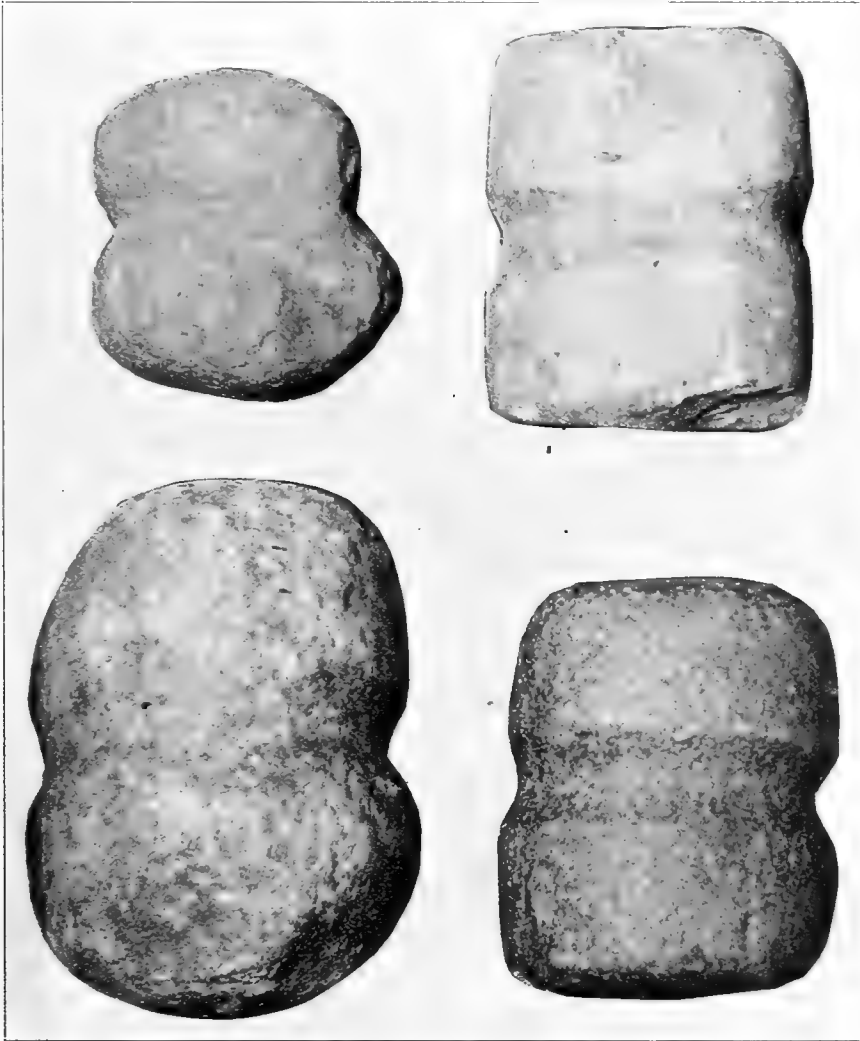
* Ann. Rep., Smithsonian Institution, 1897, p. 571.

EXPLANATIONS TO PLATE V.

<p>FIG. 1. Imperfectly shaped small mallet, made of local Dakota sandstone.</p>	<p>FIG. 2. Perfectly formed mallet, made from a hard ferruginous sandstone of unknown locality.</p>
<p>FIG. 3. Large, old and worn mallet, made of limestone.</p>	<p>FIG. 4. Perfectly formed mallet, made from a hard ferruginous sandstone or quartzite. Probably not much used. Pickmarks are still to be seen on the surface.</p>

Reduced to slightly less than one half the natural size.

PLATE V.



Dakota rock in this vicinity, known to the author, nor do they resemble the usual form of the Sioux quartzite. The rock has no doubt been brought from some distance, and its presence here gives further evidence that aboriginal art was not limited to the resources of its immediate surroundings in the raw materials which it employed.

As to the particular purpose for which these implements were prepared it is difficult to form an opinion. The author must leave this to the conjecture of the reader, and to students who have more material for comparison and a better knowledge of the arts and customs of the prehistoric races. When in use they were perhaps attached to wooden handles. These may have been bent around the body of the stone, following the groove, and the bent end tied to the main handle, this mode of attachment being used in the case of stone axes similarly grooved. Mallets of the same size and shape are known to have been in use, probably as hammers or clubs, by some of the Sioux Indians in the region of the Yellowstone.* Such a weapon might be useful in hunting the buffalo or in warfare. The smallest ones are light enough to be thrown from thongs or ropes and to be used like the bolos of the Indians of South America.

Prof. Welin of Lindsborg has made the following measurements of the mallets now found in the collection. Linear dimensions are given in inches.

* See note by F. W. Putnam, *Ethnology*, U. S. Geogr. Surv. West of the 100 Mer., Vol. VII., p. 206.

MEASUREMENTS OF STONE MALLETs.

Number.	CONDITION AND MATERIAL.	Weight in av. ounces.	Greatest length.	Greatest diameter.	Diameter in groove.
1	Ends flat; hard sandstone.....	63.	4.3	3.6	3.3
2	Rounded ends; hard sandstone	53.5	4.5	4.5	4.
3	Flattened; hard sandstone.....	53.5	4.4	3.6	3.3
4	Irregular in shape; limestone....	51.	5.	3.9	3.5
5	Hard sandstone.....	36.	4.4	3.7	3.2
6	Hard sandstone.....	28.5	3.6	3.2	2.9
7	Hard sandstone.....	24.5	3.6	3.4	2.8
8	Broken; limestone.....	?	?	?	?

THROWING-STONES?

Ten disc-shaped or wheel-shaped stones were found (Fig. 29). These measured about three inches in diameter and from one inch to one and a half in thickness. The most carefully shaped specimens of this description have the circular surfaces flat and the round border straight. In several instances the border is convex, as is also to some extent the flat sides. In some cases there was only a rude approximation to this type. Two specimens were broken in halves. Some were made of limestone and some of sandstone. It is to be inferred that the texture of the rock was of no consequence in the use to which these stones were applied. Perhaps they represent some instruments in games. Their size permits them to be thrown from the hand with comparative ease, and they may then readily be caused to roll for a considerable distance on the surface of the ground.

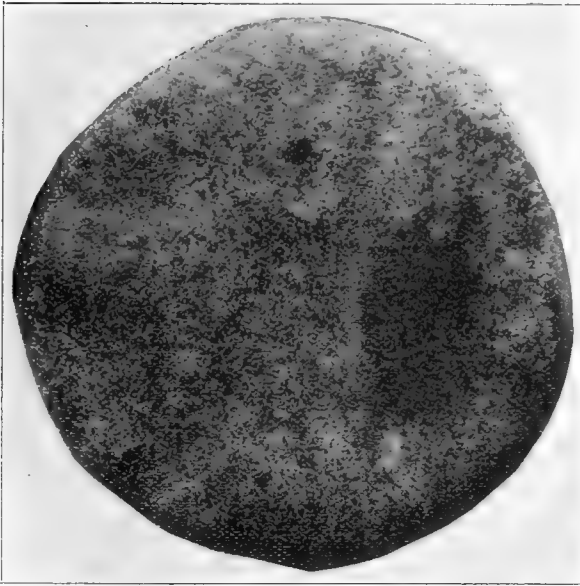


FIG. 29. Disc-shaped throwing-stone. Reduced to $\frac{5}{8}$ of natural size.

A PROBLEMATIC RELIC.

A piece of white quartz, carefully worked and polished, is a relic of somewhat uncertain character (Fig 30). It may be described as a circular piece of rock an inch and a half in diameter, with one side convex and drawn out in the center into a blunt and rounded protuberance about half an inch in height. The other side is concave with a depth in the center of about three sixteenths of an inch below the

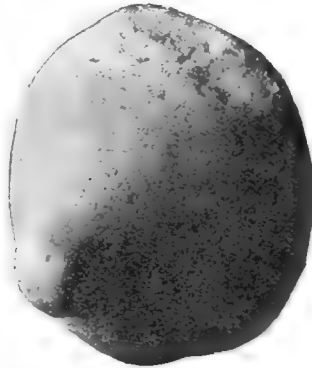


FIG. 30. Convex (anterior) side of a cupped piece of quartz. Slightly reduced.

rim (Fig. 31). The convex surface of this specimen is very smooth and almost polished, while the concave surface is less nicely finished. The edge of the disc is a fractured surface. The writer has seen no similar relic described anywhere from our aboriginal races. Its use seems, indeed, enigmatic. The concave side may have served as a paint cup, but this will not explain why the convex side has been so well finished. It has been suggested that the specimen may have served as a weaning-nipple. If such is the case, it is easy to understand why the convex side, with its protuberance, has been finished with such great care. It quite perfectly resembles the human nipple. This theory also explains the concavity on the opposite side. The suggestion is mentioned for what it is worth.



Fig. 31 Outline of a diametral section through a disc-like piece of worked quartz. There is a protrusion like a nipple on one side, and a concavity on the other. Slightly reduced.

A PIECE OF AN OLD ARMOR.

One of the relics found has a special historical interest. It demonstrates that this village was inhabited by Indians after the European race had come over to this continent. In one of the mounds located near the center of the group, there was found at the depth of six inches below the surface, a piece of chain-mail made of iron (Frontispiece).* It measured about two inches square and the size of the oval rings was a little less

* This relic was dug out in the author's presence by Mr. C. A. Even, now of Garfield, Kansas.

than one half of an inch in length. The metal had suffered much from oxidation and the spaces between the rings were filled with rust so thick that the whole specimen was almost a solid mass. Unfortunately the precious relic was lost. The author took the precaution, however, to have it photographed soon after it was found. So far as the author is aware, the object itself was seen by only two parties who had a knowledge of antiquities of this kind and who could be considered competent to identify it as a piece of chain mail. It was shown to Dr. J. A. Enander of Chicago, then on a lecturing tour in the west. He is regarded as one of the best authorities in America on the antiquities of the Northmen. This gentleman stated that the metal fabric had a close resemblance to that of a Swedish *brynja*, the coat of mail used by the vikings. It was also examined by Dr. John Rundstrom, an accomplished gentleman and naturalist residing near Lindsborg at the time. He is well informed on European antiquities since the time of his residence as a student at the University of Lund in Sweden. In his judgement the relic was a fragment of a piece of chain mail.

On the surface of one of the mounds there were picked up one or two perforated beads of blue glass. Lying out in the open field on the opposite side of a creek from the nearest farm house, built and occupied by a lone bachelor, these beads are not likely to have been lost by recent settlers. More probably they once belonged to some inhabitant in the old village. It is needless to say that the beads were made in Europe or in some European colony in America.

PROBABLE CHARACTERISTICS OF THE TRIBE.

In describing these products of aboriginal art it seemed desirable to classify them as to the nature of the material from which they were made. If we wish to study the people to whom the relics once belonged, their mode of life, their habits, and probable tribal relationships, it will serve our purpose better to make our classification on the basis of the known or probable uses for which the relics once served. It is not the purpose of the author to say much on this phase of the subject. But a few remarks quite naturally suggest themselves in this direction also.

It must be remembered that the uses of some relics are uncertain. Notched bones (see page 18) have been variously regarded as records,* as instruments used in making bowstrings, and as appliances used in weaving. Recently Professor Starr has shown that some Indians use bones of this kind for producing rattling noises in certain dances. To do this another bone is drawn across the notches in rhythmic strokes that accompany the movements of the dancers.**

Disregarding such uncertainties we may, nevertheless, take into consideration the number of each kind of different relics and make a sort of inventory of the stock in hand, and thus draw some conclusions as to the occupations, customs, and wants of the original owners. Such an inventory is presented in the following table.

* See "Marked Human Bones from a Prehistoric Tarasco Indian", etc., Vol. X, Bulletin of the American Museum of Natural History.

** See Notched Bones from Mexico, by Prof. Fredrick Starr, Proceedings of the Davenport Academy of Science, Davenport, Ia., Vol. VII., p. 101.

INVENTORY OF THE VILLAGE RELICS.

KINDS OF RELICS FOUND.	NUMBER.
IMPLEMENTS USED IN DOMESTIC WORK	<u>240</u>
Scrapers.....	200
Knives.....	15
Millstones.....	25
HOUSEHOLD UTENSILS	<u>54</u>
Earthenware jars (number estimated)	50
Spoons, made of shells.....	2
Bowl (earthenware)	1
Cup (earthenware)	1
AGRICULTURAL IMPLEMENTS	<u>16</u>
Hoes and spades, made of flint.....	10
Hoes and spades, made of bone.....	6
IMPLEMENTS OF CHASE AND WARFARE.....	<u>87</u>
Arrowpoints	45
Spearheads.....	32
Stone mallets?.....	8
Tomahawks.....	2
TOOLS USED IN SPECIAL TRADES.....	<u>56</u>
Arrow-smootheners	30
Awls.....	12
Hand-hammers (for chipping flint?).....	5
Drills	6
Flint flakers (bone).....	3
OBJECTS RELATING TO PERSONAL ORNAMENT AND COMFORT	<u>10</u>
Paint mortars? (cupped stones).....	3
Catlinite pipes	2
Bone beads.....	2
Hairpins?.....	2
Weaning-nipple?.....	1
OBJECTS USED IN SPORTS AND GAMES?.....	<u>10</u>
Throwing-stones	10
Total.....	<u>473</u>

It will be seen that there are nearly five hundred objects represented in the collection. About half of the number consists of implements which have been used in

domestic work. This is quite natural. Things used about the dwellings would also be lost in their immediate proximity. The scraper is particularly abundant. It was a tool easily prepared (Fig. 27). Its manufacture required no particular skill. When lost it was easily replaced. By far the greater number of the scrapers are entire. They have not been thrown away. They have been lost. With the knives it is different. These were made with greater care and apparently also selected from fortuitously well adapted flakes; such as were thin and straight and had an even grain. There are only two or three entire knives. The others are broken and have evidently been thrown away only after becoming useless. A flint knife was a precious article, worth searching for if lost, and so we find a less number of them now. The many potsherds testify that these people took some pains in preparing their food and perhaps their drink. It is difficult to estimate to what extent they engaged in agricultural pursuits. The small number of implements adapted for tilling the ground seem out of proportion to the number of stones used in grinding the crops. Possibly wooden implements were used in this primitive farming. Or the cultivated land may have been at some distance from the village site and the hoes and spades may have been left and lost out in the field. Or it may be that the natives lived in the village only during the cold season and took up their abode at some other place during summer. The relative abundance of tools useful in primitive handicraft, such as arrow-smootheners, awls, flakers, and also scrapers, suggests that the inhabit-

ants were engaged in such work to a considerable extent, during the time of their stay on these grounds. The colder part of the year would seem to be specially conducive to such occupation.

These people do not seem to have been a warlike tribe. There are only two flints in the collection that resemble tomahawks. Their arrowpoints and spearheads seem better suited for the killing of small game than for the battlefield. But few of the relics can be regarded as implements of war. This may perhaps be taken as an indication that the inhabitants were a peaceful race, who quietly subsisted on the natural resources of the western plains, before the strife had yet begun which was a result of the encroachments of civilization from the East.

ETHNIC RELATIONSHIP.

A guess may perhaps be warranted as to the ethnic relationship of the tribe. We have seen that some fragments of catlinite pipes picked up with the other material were of the so called Siouan type and that the stone mallets are of a kind that is known to have been used by some tribes of the Sioux Indians of the west. The Sioux Indians were to some extent an agricultural people. They raised corn. So did also the inhabitants of this village. They possibly belonged to some tribe of the great Siouan family. But if such was the case, they lived on the outskirts of the Siouan domain. To the south and the west there were other Indians. Those of this village seem to have ground their corn on

mills that are more like those of their southern and western neighbors. Stone metates are more common in the southwest than in the territory to the north. The beveled form of spearheads seems also to be a feature of their rude art, which they had in common with the Indians of the south. Tribes of the Ponca family, as the Wichitas and the Pawnees, have at different times lived on the Arkansas, the Kansas, and the Platte rivers in the central part of the Western Plains. They seem to have migrated occasionally both north and south. Mr. Hodge says that the "Wichitas shifted their settlements from time to time as necessity demanded and that more than one time their settlements were on and north of the Arkansas river."* At an early time their home was farther south. In a border tribe there would inevitably be some mingling of arts and customs of the neighboring nations with those of its own. The use of ground shell as well as sand for tempering the earthenware may have such a significance. Captain Marcy, who visited a Wichita village near Washita river in 1852, says that their "lodges were about twenty-five feet in diameter at the base", and consisted of a frame-work of poles placed in a circle in the ground, bound together with withes and thatched with grass. He also states that they raised corn and other vegetables, using hoes for cultivating the soil, but depended on the chase for their sustenance during the greater part of the year.** It is

* Harahey, J. V. Brower, St. Paul, 1899, p. 72.

** Exploration of the Red River of Louisiana in the year 1852, by R. B. Marcy, p. 77.

quite probable that the Indians occupying this old village were Wichitas or perhaps some of their relatives, the Pawnees. On the basis of the character of the mounds and their relics alone, however, an inference as to their tribal relationship must be regarded as but little more than a guess. But it is none the less interesting to note in this border land of ancient nations a mingling of northern, southern, and western features of primitive industry and art.

A VISIT FROM THE SPANIARDS?

The finding of a piece of chain-mail with the other relics makes it certain that the village was occupied by Indians at least as late as after America had been discovered by the Europeans. At the Emporia meeting of the Kansas Academy of Science in 1886 the author suggested that this relic might have come to the Indians from Coronado's expedition to this region in 1542 and called attention to Col. Simpson's study of the route which this explorer followed in traveling from Tiguex to Quivira showing that he probably passed through the central part of the state of Kansas.* Several old Spanish documents relate the adventures of Coronado. They all state that he marched east from the mountains in New Mexico and across the plains for more than a month. Then selecting forty men he left his main army and marched with these few followers

* Coronado's March in search of the Seven Cities of Cibola," by J. H. Simpson. Annual Report, Smithsonian Institution, 1869, pp. 336—340.

first north, and then northeast for another month or a little more. Here he discovered a country called Quivira, and remained in it for twenty five days, visiting several villages and exploring the country generally, possibly going as far north as the fortieth degree of north latitude. Most of the students of the Spanish papers seem to agree that Quivira was located in the central or in the eastern part of the state of Kansas. Simpson has mapped the probable route that Coronado followed in going out and in returning. On his outward route he is supposed to have entered the present borders of this state somewhere near its southwest corner (Fig. 32). From there he is supposed to have pursued an easterly course over the country of the Cimarron, turning to the north from a point fifty miles or so west of the site of the present city of Wichita and returning from the northwestern part of the state by a more southerly route.

A. F. Bandelier, a well known archaeologist and student of early Spanish history in the southwest, believes that Quivira is to be sought in the central part of the state of Kansas about a hundred miles north of the Arkansas, but he thinks that Coronado's route of march was for most of the way in the territory south of Kansas.*

More recently Mr. G. P. Winship has made an exhaustive and critical study of the Spanish accounts of Coronado's Expedition.** This author doubts that

* Fray Juan de Padilla, by A. F. Bandelier, *American Catholic Quarterly Review*, Vol. XV, p. 551. Also *The Gilded Man*, New York, 1893.

** *The Coronado Expedition, 1540—1542*, by George Parker Winship, 14th Annual Report of the Bureau of Ethn., Washington 1896, Part I, pp. 329—613.

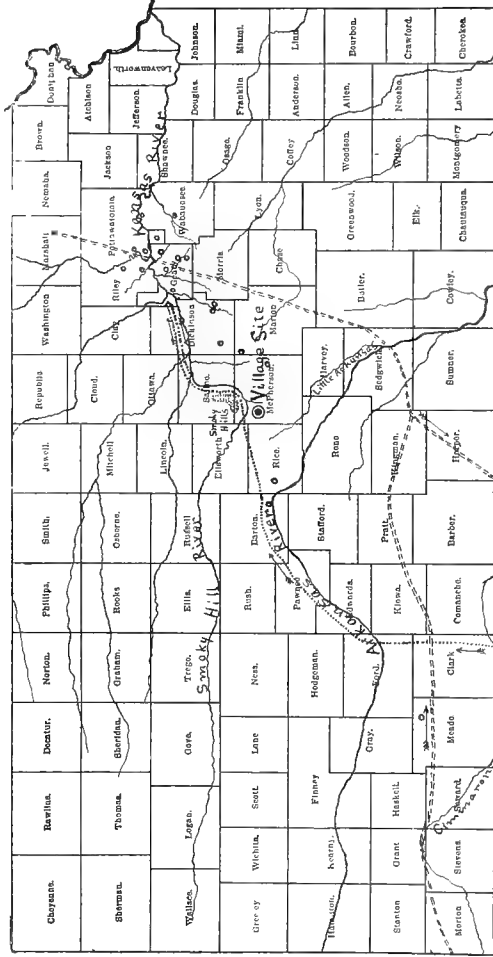


Fig. 32.

Map of Kansas, showing the probable routes of Coronado's march within the state and the location of ancient village sites. ○ The Village site on Faint creek. ● Other village sites. (Some of these are taken from Brower's Hervey.) — = Coronado's march according to Simpson. - - - - - Coronado's march according to Hodge.

Coronado, after leaving the main army, "went much beyond the south branch of Kansas river, if he even reached that stream." Quivira should then have been located to the south and perhaps a little east of the centre of the state of Kansas.

The latest contribution to the history of this expedition is made by Mr. F. W. Hodge,* who is inclined to the opinion that Coronado, after having turned north, crossed the Arkansas river on its south bend not far from the place where Dodge City now stands. It was probably from this point that he marched (according to the Spanish chroniclers) six days to the northeast, following down the right side of the stream, and finding the first native village on the Great Bend. From there he continued to the northeast and "either followed down the Smoky Hill or crossed that stream and also the Saline, Solomon, and Republican forks, reaching Kansas river not far from Junction City." "After learning what they could about the province, the Spaniards then . . . retraced their steps for two or three days, where they provided themselves with fruit and corn for the return journey . . . This place was probably but a few miles from the present Salina" (Fig. 32).

It will be seen from the above that the Paint Creek dwelling site lies in the region which Coronado visited. It is recorded that during the twenty five days he and his forty followers remained in Quivira, he sent out captains and squads in various directions to visit different villages, of which, he says, there were not more

* Harahey, by J. V. Brower, St. Paul, Minn., 1899, pp. 29—73.

than twenty-five.* Taking all of this into consideration it is quite possible that the piece of chain-mail may have been obtained by the natives of these villages, in barter or otherwise, from Coronado's soldiers. Col. Henry Inman has stated his positive opinion that it came from some soldier either of the command of Cabeça de Vaca, Coronado, or of De Soto,† most likely the latter. But our best historians doubt that De Soto's expedition came as far west as Kansas.‡

The archaeological evidence perhaps to some extent supports the view that it came from Coronado's expedition. The accounts we have of the people which he met in Quivira characterize in some respects the residents of the old village, as we know them from their dwelling sites and from the relics which these contain. In the anonymous Spanish document *Relacion de Suceso* we learn that the inhabitants of Quivira lived in houses built of straw. There were several villages of these houses. The inhabitants raised corn and made bread. This bread was cooked in fires under the ashes.|| In Jaramillo's narrative we are told that the straw-houses were round and that "the straw of the walls reached down to the ground like a wall". People who have lived on the Plains will realize that in such a shelter the prevalent sandstorms would deposit drifts of dust and sand. In course of time there would then be a

* Winship, op. cit., p. 582.

† The Santa Fe Trail, New York, Mac Millan & Co., 1897.

‡ Narrative and Critical History of America, Justin Winsor, Vol. II., p. 296
Also History of United States, Geo. Bancroft, Vol. I., p. 52.

|| Winship, op. cit., p. 578.

mound. In Coronado's own letter to the king of Spain he relates that these people used skins for clothing, and that they wandered around and hunted the bison. Such appear also to have been the habits of the Indians who lived on Paint creek. But other tribes did the same. At the best this evidence is not conclusive. The piece of chain-mail may have come from some other source. Future researches of the historian, the ethnologist, and the archeologist may eventually throw more light on this subject.



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STUDIES IN

THE IDYL IN GERMAN
LITERATURE

BY

GUSTAV ALBERT ANDREEN.

PUBLISHED BY AUTHORITY OF THE BOARD OF DIRECTORS OF
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TO MY WIFE

THIS STUDY
IS LOVINGLY DEDICATED.

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CHAPTER I.

INTRODUCTORY: THE IDYL IN CLASSIC LITERATURE.

The purpose of this dissertation is to set forth the origin, development, and character of the idyl in German literature up to the time of the publication of the *Luise* by Voss, in 1795. This includes three main parts: 1. idyllic literature in Germany before Opitz; 2. the development of the pastoral idyl depicting an ideal existence and its culmination in Gessner; 3. the reaction which followed, resulting in the realistic idyl of Maler Müller and Voss.

In this thesis the term *Idyl* is used in the sense of a *small "Genrebild," complete in itself, which pictures simple life in close communion with nature, as over against the more complex conditions of an advanced civilization, especially of city life.*¹

This *Genrebild* or *Idyl* may depict real life (as in Theocritus and Voss), or idealized existence in an imaginary Golden Age (as in Gessner).

¹ This definition of the *idyl proper* is based mainly on the full treatment of the theory of the idyl in Herman Baumgart's *Handbuch der Poetik*, p. 268, ff., and p. 346, ff.

Koberstein's definition of the idyl (*Gesch. d. Deut. Nat. Lit.*, V. 63) better fits the idyllic epos, than the shorter *Genrebild* or idyl proper, showing that he must have had *Luise* or *Herrman und Dorothea* in mind. He says: "*Die Idylle*—diejenige Dichtungsart, welche die Mitte zwischen der streng epischen und der mahlerisch-beschreibenden Gattung hält, indem sie die Erzählungsform—die aber auch öfter durch die dialogische vertreten wird—weniger auf die Darstellung von Thaten und Handlungen als auf Schilderung von Zuständen und Ereignissen anwendet."

Cf. also Fritzsche-Hiller's *Theokrit*, p. 4.

In the literature of the world idyllic and pastoral poetry has flourished especially during four periods. It first appeared in the third century before Christ in the idyls of Theocritus, followed by those of Bion and Moschus. Then in the first century before the Christian era, Vergil laid the foundation of his poetic fame by writing his allegorical idyls, in which he found many imitators. The third period has its roots in the Italian Renaissance, which eventually produced the allegorical pastoral drama and romance, affecting and moulding the literature of all Europe, especially of the other romance countries and of England. In Germany, where the Reformation completely absorbed all other interests, it did not assert its influence before the beginning of the seventeenth century, when Opitz introduced the shepherd drama, and Weckherlin the pastoral idyl, the influence of Opitz being paramount in German literature for a hundred years.

The fourth great period in which idyllic literature flourished belongs especially to Germany. During the latter half of the sixteenth century this literature again took the form of the *idyl proper*, bursting into bloom in the works of numerous authors. In Gessner the idealized pastoral idyl reached its culmination; a reaction necessarily followed, and the idyls of Müller and Voss came back to a realistic portrayal of actual life, as is found in Theocritus. The circle was complete.

These different periods have, of course, organic connection with each other. Hence it seems necessary to give a short sketch of the characteristics of the preceding periods as an introduction to the main subject.

During the great classical age of Hellas, the Greek, "the most versatile man the sun ever shone on," as Gosche¹ says, had seem-

¹ See the excellent article by Dr. Richard Gosche in *Archiv für Literaturgeschichte*, Vol. I. (1870), pp. 169-227: *Idyl und Dorfgeschichte im Altertum und Mittelalter*.

The Idyl in Greek Literature. Theocritus. ingly exhausted all the forms of literature. Then came the non-productive and critical Alexandrian era, no longer believing in the gods, and subjecting the old heroes to historical criticism. New motives and styles of poetry were sought for, and with an advanced civilization came a surfeit of city life, a dissatisfaction caused by complex social conditions.¹ The idyls of Theocritus, grounded in this general feeling, were hailed with joy. These idyls led one away from the bustle and hollowness of over-refinement back to nature, to ascend the mountains, to listen to the rustle of the brook, walk over the meadow covered with pasturing flocks, and rest in the shadow of the tamarisks.

But this description of nature, beautiful as it is, was not the most important part. It served after all only as the background for those who peopled it. These characters, simple, natural, in full accord with their surroundings, far away from the disordered state of Greece and Egypt, in Sicily "rich in flocks," pipe and sing, talk in dialogue or soliloquy so naturally that we really seem to hear them. They lay bare before us the primary and common emotions and passions of the human heart. All is fresh and has the flavor of reality; like the shepherd's skin in the seventh Idyl: "*The smell of rennet clinging to it still*;"² or, like the bowl in the first: "*Smacking still of the knife of the graver*."³

Idyllic elements are found in literature before Theocritus.⁴ But Theocritus stands before us as the creator of this form of litera-

¹ This thought is also brought out by E. C. Stedman in his *Victorian poets* (Boston 1876) in the chapter entitled *Tennyson and Theocritus* (p. 201), in which he shows the similarity of these two idyllic authors and of the periods in which they lived. He claims the superiority of Tennyson over the Syracusan "because his thought and period are greater" (p. 187).—Cf. also Fritzsche-Hiller's *Theocritus*, p. 11, and Lang's *Theocritus*, p. XXXVI.—Cf. Gosche *ALG.*, I., p. 184, ff.

² Idyl VII, 15: *νέας ταμίσιου ποτόσθον*.

³ Idyl I, 28: *ἔτι γλυφάνοιο ποτόσθον*.

⁴ Even the *Iliad* (XVIII. 525) shows us Hephaestus inscribing on the shield of Achilles a pastoral scene. The *Odyssey* has more of such elements, as in the story of Nausikaa, or Polyphemus, or the description of Calypso's cave. Furthermore, the satyr-drama, comedy, and mimes have material of idyllic nature. See Fritzsche-Hiller's *Theocritus*, p. 5, ff.—Gosche, p. 183, ff.

ture,¹ and his idyls have ever been the model to which all later authors are obliged to return, like the works of Homer and Phidias, unsurpassed, perhaps unattainable. Three qualities especially mark the work of Theocritus: power of depicting genuine emotion and passion, love for nature, and the ability to give to his characters the background that most harmoniously blends with their disposition and state of feeling.

In the next century Bion and Moschus³ followed in the footsteps of Theocritus. But we appreciate keenly the greatness of Theocritus as soon as we compare his work with that of his successors. For with all their grace and skill, there appears already in them, especially in their treatment of love, a tendency towards sentimentality and trifling, towards rhetorical ornamentation, which became so prominent characteristics of later pastoral poetry. The idyl was on its way to Vergil.

The eminently practical Romans had a less keen sense for poetry *per se* than the Greeks, and with all their love for outdoor life,⁴ they saw nothing in pastoral life to arouse their admiration or to celebrate in song. Only when the shepherds became the mask for prominent personages did this added spice make the idyl acceptable to the palate of literary Rome. This allegory and personal allusion, which in Theocritus had been mere episode,⁵ became rule and aim in Vergil's eclogues.⁶ The shep-

*The Idyl in
Latin Literature.
Vergil.*

¹ Fritzsche-Hiller's *Theocritus*, p. 1, 11.

² So in Idyl II, Simaetha endeavoring to reconquer her lover by magic, does it under the moonlit sky, some distance from town and within the sound of the sea. Cf. also Idyls III., VIII., etc.

³ See Fritzsche-Hiller's *Theocritus*, p. 23.

⁴ This, as well as their practical tendency, is witnessed by their rich literature on agriculture.

⁵ In Idyl VII. Theocritus refers to himself; in XIV. to Ptolemy.

⁶ Cf. *Les Oeuvres de Virgile* par E. Benoist (Paris 1867), p. LIII; also Fritzsche-Hiller's *Theocritus*, p. 23. Also *History of Rom. Lit.* by Teuffel and Schwabe, Vol. I., p. 430. In the very first eclogue Vergil, under the mask of Tityrus, praises Augustus for restoring his land to him; in III., VI., X. he praises and flatters his patrons, and so on.

herd's dress became but a mask, the pastoral poem was to be allegorically interpreted. Vergil's influence in this respect was of lasting importance, determining for more than seventeen centuries the character of pastoral literature in the Romance countries, in England and in Germany, until nature and healthy realism again asserted themselves in the idyl of the eighteenth century. Classic Latin literature, however, has given us at least one perfect idyl, some say *only* one: the *Moretum*, of unknown authorship.¹

In the third century, when the classic era was nearing its close,² Greek literature produced one more work of enduring power, the shepherd romance *Daphnis and Chloe*, attributed to Longos.³ It has all the healthy enjoyment of simple life that we find in Theocritus, and is of importance as being the great model for the later pastoral romance.

CHAPTER II.

IDYLLIC LITERATURE IN GERMANY BEFORE THE TIME OF OPITZ.

As we enter the Middle Ages, when the classics fast became a sealed book, the idyl as a literary form almost disappears.⁴ We

¹ W. Hertzberg in the *Gedichte des Virgilius* (Stuttgart 1856), p. 93, speaks of this, calling it a "literarisches Unicum"—Cf. Gosche, *ALG.*, I., 205.

² Of the followers and imitators of Vergil may be mentioned: Calpurnius, the gross flatterer of Nero; Nemesianus, Ausonius of Bordeaux, the first Christian writer of eclogues, the best being *Mosella*, a description of a journey along the rivers Mosel and the Rhine (before 375).

³ Gosche in *ALG.*, I., p. 211, says: The old Græco-Roman world completed its idyllic poetry in these three stages: The great *Theocritus*, the unknown author of the *Moretum*, and *Longos*.

⁴ Its place is, perhaps, supplied by Christian legends and stories, some of which, especially those of the hermits, contain idyllic elements. But these are few, as the very seclusion of the hermits was to show in what utter contempt they held the outer world.

do not meet it again till the beginning of the ninth century, at the German court of Charlemagne. Here a renaissance movement had led to the forming of an academy for scientific and literary study.¹ The study of Latin authors soon led to the cultivation of the idyl, especially under the influence of Vergil and Calpurnius. Most of these poems² possess no value apart from their historical interest. They teem with classical phrases and allusions, oddly mingled with Christian views.³

One idyl, however, written by some member of the circle around Charlemagne, deserves our special attention as being "the first real eclogue of the Middle Ages,"⁴ namely: *Confictus Veris et Hiemis*. It is full of dramatic movement, representing Spring and Winter as vying with each other in song. Spring greets the cuckoo, while Winter threatens the bird in order to drive it away, until Palaemon bids him cease (*Desine plura, hiems*), and welcomes the cuckoo (*Salve, dulce decus, cuculus, per saecula salve*).⁵ The winter described is the winter of Germany, not the mild win-

¹ This circle chose names from antiquity, biblical and classical, in odd confusion. Charlemagne was David, Alcuin (of England) Flaccus, Angilbert Homer, and other court dignitaries bore the pastoral names of Menalkas and Thyrsis. See Wattenbach: *Deutschlands Geschichtsquellen im Mittelalter* (Berlin 1885), Vol. I., p. 147.

² These poems are found in E. Dümmler's collection *Poetae Latini Aevi Carolini* (Berlin 1881) Vol. I.

³ Angilbertus, in the academy called Homer, wrote an *Ecloga ad Carolum Regem* (David) in which he offers fulsome praise to the king (Dümmler's *Poetae Latini*, I. 360). There are several refrains, each repeated nine times, which in themselves show the character of the poem. These are:

Surge, meo dovano dulces fac, fistula, versus.
David amat Vates, vatorum est gloria David.
David amat Christum, Christus est gloria David.
Surge meis caris dulces fac, fistula, versus.

In an *ecloga* by Naso (Dümmler's *Poetae Latini*, I. 385, ff.) a youth and an aged man converse of song, after which follows a description of nature and outdoor life.

⁴ Gosche *ALG*, I., p. 213.

⁵ In a later idyl by the Anglo-Saxon Alcuin (See Dümmler's *Poetae Latini Aevi Carolini*, Vol. I., No. LIX.), who possibly wrote the *Confictus*, too, a similar theme is treated (beginning: *Nunc cuculus ramis etiam resonavit in altis*). A description of spring is given in which Phoebus, Bacchus, and Cupid are mentioned. It closes, however, with an admonition to praise Christ: "*Dulcisono Christum resonantis semper in ore.*"

ter of the south; and the cuckoo as harbinger of spring also belongs to Germany.¹ This idyll is of importance, too, as being the origin of the *Streitgedichte*,² so popular during the Middle Ages, and which may be traced down even to Hans Sachs.

In the history of the development of Germany, the *Dorf* occupies a very prominent position. Around this cluster the first beginnings of the *Dorfgeschichte* (Tales of Country Life). The Latin poem *Ruodlieb*³ is one of the first to contain elements of this nature. We find these elements, too, in such works as *Gudrun*⁴ and *Parzival*,⁵ and more especially in the lyrics of *Neidhart von Reuenthal*.⁶ But the oldest German *Dorfgeschichte* is *Meyer Helmbrecht*⁷ by Wernher der Gartenære. It is a social tragedy—a warning to peasant sons not to leave their sphere.

During the following centuries contempt for peasant life as-

¹ See article by Adolf Ebert: *Naso, Angilbert und der Conflictus Veris et Hiemis* in *Zeitschrift für deut. Alt* XXII., pp. 328-335.

² See W. Scherer: *Geschichte der deut. Lit.* (1884), p. 53. Also Adolph Ebert, *ZfdA*, Vol. XXII., p. 333.

³ *Ruodlieb*, a rhymed Latin poem of the eleventh century, is really a romance of chivalry; the third and fourth fragments, however, describe the arrival and stay of Ruodlieb in a small village, and his intercourse with the shepherds.

⁴ Especially Horant's song (See p. 86, ff., in Martin's *Kudrun*, Halle 1872).

⁵ In the third book of *Parzival*, Wolfram sets over against the world of chivalry the life of Herzeloÿd in the wilderness Soltane; in this idyllic world *Parzival*'s childhood is spent.

⁶ His summer and winter songs, dances, etc., describe the peasant world in a realistic manner. See E. T. McLaughlin's *Studies in Mediæval Life and Literature*, p. 71.

⁷ Written before 1250. It describes a peasant's son, who, despising his father's occupation, enters the service of a robber-knight. After a year he returns home, and by his swaggering manners, grieves his father, who laments the decay of court life. The wayward son induces his sister to run away with him and become the wife of one of his companions. At the wedding the rest of the robbers are caught, but he escapes, though maimed. At home he is disowned by his father, and later hanged by peasants whom he had robbed. Cf. *Studies of Mediæval Life and Literature* (N. Y. 1894) by E. T. McLaughlin, who speaks at length of this work (p. 102).

serts itself more and more.¹ We see it in the very words: *villanus* becomes *villain*, *Dörfer* degenerates into *Tölpel*. The awkwardness and stupidity of the "boors" is the never-ending subject of jests, fables, and *Fasnachtsspiele*; especially in these carnival plays is he made the butt of rough and obscene ridicule, always drubbed, drubbing being one of the most indispensable parts of old German comedy.²

During the fifteenth century, in spite of the oppressed condition of the peasant class, the peasants began to feel more and more conscious of their own worth.³ Others, too, placed their hope for the future in them. We find some echoes of this in literature, especially in the *Meistergesang*.⁴ When this feeling culminated in the uprising of 1525, even Luther was terrified, and attacked the peasants most bitterly. The revolt was put down with much bloodshed, and the condition of the peasants was worse than before.

To sum up: The idyllic element in early German literature had ever been but a small rivulet; we find now and then along its course some inviting idyllic spots; but finally it is lost in the swamps of contempt for rural life, and blindness to the beauties of nature.

¹ Little or no influence was exerted on German literature by the French *pastourelle*, of which the drama *Robin et Marion* by Adam de La Halle was a development. Cf. Gosche, *ALG*, I., 219, ff.

² This feeling is expressed in the old couplet:

Der Bauer ist an Ochsen statt
Nur dass er keine Hörner hat.

³ Cf. Bezold's *Geschichte der deutschen Reformation* (Berlin 1890), p. 142, ff. See also *A social Reformer of the XV. century*, a paper by Frank Goodrich, in *Yale Review*, Aug. 1896.

⁴ Rosenblüt, who wrote from 1431-60 at Nürnberg, turned from court poetry to sing the praises of the lower classes:

"Iche lobe dich du edler Bauer
für alle Kreatur
für alle herrn auf Erden
Der Kaiser muss dir gleich werden."

Hans Sachs in his *Gespräch zwischen dem Sommer und Winter* (Cf. *Streitgedichte*, p. 6), shows a deep appreciation of nature and simple life; yet he, too, made the peasant and his foibles the object of his jests.

The humanistic movement in Germany did not produce any idyllic literature of enduring value, or any that inspired later writers. The *Bucolicon* of Eobanus Hessus appeared at Erfurt 1509, containing twelve eclogues, the second edition of 1528 increasing the number to seventeen. They were written in imitation of Vergil's allegorical eclogues. The ease with which Hessus composed made his style vague and full of rhetorical bombast.¹ He also made a translation of Theocritus into Latin verse.

In the year 1580 the gifted Nicodemus Frischlin² delivered at Tübingen a speech, *De vita rustica*, as introduction to his lectures on Vergil's *Bucolics*, in which he bitterly attacks the inhumanity and corruption of the nobility and the court,³ and lauds the honest simplicity and occupations of rural life. But the appeal died away like an echo, unnoticed or soon forgotten.

Humanism in Germany led to no real idyllic literature, and what little there is entirely lacks originality in thought and form, and left no trace of influence upon succeeding literature. Other countries, especially Italy, were meanwhile producing the literary models, which for a century and a half were to determine the form and character of pastoral literature in Germany.

¹ See *Allg. Deut. Biog.* In his *Carmen* or *Song of praise of Nürnberg* 1732 (*Noriberga Illustrata*, edited by J. Neff, Berlin 1896), are idyllic traits, especially lines 387, ff., and 601, ff., which contain a description of a woodland fountain.

² See *Allg. Deut. Biog.* Many of his plays contain idyllic elements, especially one *Der Weingärtner*, 1576, setting forth the conditions and feelings of the people; but unfortunately this has been lost.

³ This speech and his views on this matter lost him his position, his liberty, and finally his life.

CHAPTER III.

PASTORAL LITERATURE FROM OPITZ TO GESSNER.

When the classic studies again began to flourish in Italy, Vergil was at once enthroned as king of poets, and became the pattern whom all imitated. Lyric, romance, and dramatic literature alike were soon influenced and controlled by his pastoral allegory. The allegorical eclogue was first re-introduced by Petrarch¹ and Boccaccio; the latter also wrote a pastoral romance, *L'Ameto*. The pastoral was first developed into the shepherd drama by Poliziano in the shepherd-play *Orfeo*,² 1471, which had for its subject the descent of Orpheus into the lower world.

The pastoral romance *Arcadia*, by Jac. Sannazaro,³ occupies a most important place in popularizing the pastoral element and fixing it upon later literature. It electrified all Italy; and was published more than sixty times during the sixteenth century.⁴ Influenced by the great popularity of this work, Tasso wrote his shepherd-play *Aminta*, which in turn was imitated in Guarini's famous *Il Pastor Fido* (1585).

The character of these works is to a great extent determined by the fact that the scene is laid in the Golden Age⁵ of which

¹ On account of the allegorical element, Petrarch had to give a key to his poems, in order to be understood.

² This was the first *theatrical* representation which differed from the so-called mysteries. See P. A. Budik: *Leben und Wirken der vorzüglichsten lateinischen Dichter des XV.-XVII. Jahrhunderts*.

³ He always celebrated Vergil's birthday by a feast. He wrote Latin eclogues which show the influence of Theocritus, whose first seven idyls had been translated into Latin hexameter by *Phileticus* in 1483.

⁴ *Arcadia* was first printed 1502-4. In it Sannazaro describes, in prose and verse, the hardheartedness of his mistress, his wanderings and misfortunes, laments the death of his mother and of his shepherdess, disclosing to us the secrets of his life and the history of his time.

⁵ In *Pastor Fido*, end of act IV., a chorus sings of the *Golden Age* and the *Guilty Age*:

even Theocritus had sung. The accepted name of the home of this ideal existence is *Arcadia*,¹ which was inhabited not only by shepherds and nymphs, but also by all the divinities of the ancients, and by allegorical figures of all kinds.² Into this ideal world the poet was ever introducing the characters of contemporary men whom he wished to praise. With these incompatible elements (shepherds, gods, allegory, and contemporary men), how could incidents ever seem real, or characterization be anything but vague?³

The pastoral literature of Italy was admired and imitated in the other romance countries and in England. In the year 1558 Montemayor published his great Spanish shepherd-romance, *Diana*. Upon this, as well as upon *Pastor Fido*, the Frenchman Honore d'Urfé, modeled his allegorical pastoral novel, *Astree* (first part 1609). These works ushered in a long series of imitations, which were even more unreal and turgid than their models. In English literature⁴ the eclogues of Alexander Barclay, Spenser's *Shepherd's Calendar* (1579), and *Faery Queen* (1590-6), show this pastoral influence. Of especial importance for us is the famous *Arcadia*⁵ by Sir Philip Sidney. This is not a mere imitation of Spanish and Italian models, as Sidney describes scenes not only from pastoral life, but also, with equal skill, from hunting and chivalry.

The seeds of this pastoral literature were now wafted into Germany, where they sprang into luxurious growth, producing fruit that was abundant, though not of superior quality.

At the beginning of the seventeenth century German poetry had reached its lowest ebb. Not only the upper but also the mid-

¹ Vergil in eclogue VII. speaks of Corydon and Thyrsis as *Arcades ambo*.

² Cf. Jacob Burckhardt: *Die Cultur der Renaissance in Italien*, p. 349. ff.

³ So Boccaccio makes one of his nymphs a good catholic. Cf. Burckhardt, p. 350.

⁴ A clear presentation of this whole subject is given by Homer Smith: *Pastoral influence in the English Drama*, in the Publications of the modern language association of America, 1897. Vol. XII., No. 3 (New Series, Vol. V., 3).

⁵ *Arcadia* became the model of the *Hercynle* by Opitz; see p. 21.

dle classes held the German language in contempt; everything was to be written in Latin. The glorious era of German poetry during the Middle Ages seemed utterly forgotten. What poetry did exist in the *Volkslieder* of the time did not interest the educated. It was the example set by the neighboring countries of using, cherishing, and developing their own language, their vernacular, and making it a fit vehicle for their literature, that also turned the attention of the Germans to their mother-tongue. This was done in the first place by translations of foreign literature into German. The pastorals occupy a most important place among these translations,¹ especially as they to a great extent determined the character of German literature for the next century and a half. The two most important poets who usher in this era are Weckherlin and Opitz.

The author who, more than any one else, established the supremacy of this foreign and pastoral literature in Germany was Martin Opitz.² But as he did this by *translations* of foreign models into good *German*, he also stands at the head of the movement whose special aim was to cherish and cultivate the German language. In his first important work, *Aristarchus, sive de contemptu linguæ Teutonicæ*,³ 1619, he praises the German language, claiming that it is just as capable of producing a literature based upon the models of antiquity, as Italian, French, or English. This work, and his *Buch der Deutschen Poeterei* (published seven years later), opened the eyes of the educated to the importance of cultivating the German tongue.

¹ We notice the following: *Bergeries de Juliette* by Nicholas de Montreaux, transl. 1595; Guarini's *Pastor Fido*, 1619; D'Urfe's *Astree*, 1619; Sidney's *Arcadia*, 1631.

² 1597-1639. Opitz was born in Silesia; early distinguished himself by the ease and grace with which he wrote Latin poetry; this accomplishment opened to him the doors of famous scholars and of princes, whose fame he sang. During the greater part of his life he was in the service of Silesian princes.

³ It is characteristic of the times that this work, in defence of *German*, had to be written in Latin, so as to attract the attention of the educated.

There now follows in Opitz's life a period of translations, or paraphrases, of foreign works, whose importance consists in the fact that they created the literary diction of Germany, and became the standard for succeeding writers.¹

In the year 1627,² Opitz introduced the pastoral opera into Germany by his translation of the Italian opera *Dafne*.³ This was followed by the most famous and most original of Opitz's works, the pastoral drama *Hercynie* (1628). It seems to have been suggested to Opitz directly by Sir Philip Sidney's *Arcadia*,⁴ which he was at this time translating.⁵ The influence of *Hercynie* on subsequent works, both in diction and form, was so widespread and lasting, that its place in the history of literature, even though its intrinsic literary value is small, is of the greatest importance. The action of the story is given in prose, while the lyric elements are reflective.

Some idea may be gained of this kind of literature from the

¹ "Die erste (Schäfferei) in Deutschland, gleichwie auch die edelste, ist Opitzens unvergleichliche *Hercynie*" says Birken in *Teutsche Rede-Bind-und Dicht-Kunst* (Nürnberg 1679), p. 301. So Harsdörffler (see Tittman's Opitz, p. 57).

² Previous works of Opitz also contain pastoral elements: *The praise of rural life*, 1625, based upon a similar poem by Fischart, both a paraphrase of Horace's *Beatus ille*.—Pastoral echoes are also found in his *Oden* or *Gesänge*, in *Zlatna oder Getichte von Ruhe des Gemüthes*.—For Fischart's poem: *Fürtreffliches artliches Lob des Landlustes*, etc., see Goedeke's ed. of Fischart (Leipzig 1880), p. 251.

³ The pastoral drama had developed, or from a literary point of view, deteriorated, into the Opera (see Introduction, p. LXXIV. of Opitz's *Ausgewählte Dichtungen*, edited by J. Tittman). The opera *Dafne* was first given at Florence 1594. The court at Breslau, standing in intimate relations to Florence, obtained it to enhance the festivities at the marriage of Prince George. Opitz in translating it into Alexandrine verse, added much of his own invention, whence the court musician had to write new music to it, the nature of which is not known. *Dafne* has five acts, each concluded by a chorus (of shepherds and nymphs). Apollo, after slaying a monster to the great joy of the shepherds, is himself overcome by Cupid, for having twitted him on his bow and arrow. He falls in love with *Dafne* (a mortal), who flees his advances: When he is about to overtake her, she is by her own prayer changed into a laurel-tree.

⁴ See Friedrich Strehlke: *Martin Opitz—eine Monographie* (Leipzig 1856), p. 135.

⁵ This translation was published 1631, followed by a second improved edition 1638.

plot of the *Hercynie*, which is as follows: When the scene opens, the poet (Opitz) is wandering over hills and fields. While carving a poem on a tree, he is joined by other shepherds, who converse with him of love¹ and travel. Near a fountain they meet the nymph *Hercynie*, who conducts them into the cave of the nymphs, from which cave flows the source of the fountains of the vicinity; she delivers a lengthy panegyric upon the ruling family of the country,² of whose genealogy she shows an intimate knowledge. After the disappearance of *Hercynie*, the poets praise the landscape before them, the effects of winter and spring, sing sonnets to the fountain and in honor of the ruler of the country. The author recites the concluding song, of which the burden is, that the Muses alone bestow immortality.

This work created a pleasing German style, which at once became the standard for succeeding writers. But they also adopted and carried to the extreme elements which were detrimental in their effects upon literature.

The pastoral *Hercynie*, like his works in general, show that Opitz possessed neither great originality nor power of imagination, as they were all based upon foreign models. But the very fact that he stood so little above the level of his contemporaries, and was so intelligible to them, made his influence the more immediate and extensive. He broke down the sway of the Latin language among the educated; the German language was again cherished and cultivated, so that eventually the literature could, and in the eighteenth century did, penetrate into and permeate the nation as a whole. In this sense he may still be called the father of German poetry, or with Paul Fleming³ one may say:

¹ One of them (Nüssler) says in words which only too well characterize the writings of this and the following periods: "It is the manner of poets in representing love to make no concessions to nature, but to invent things which never have been, nor ever will be, and which he himself has never experienced, nor intended to perform."

² This panegyric is really the heart of the play. Much of it is in Alexandrine verse.

³ Fleming in a wedding poem of 1631 surpasses his model Opitz. See *Gedichte von Paul Fleming*, edited by J. Tittman (Leipzig 1870), pp. 36-44—Cf. also Barthold: *Geschichte der Fruchtbringenden Gesellschaft*, pp. 210-12.

"Die schönen Pierinnen
Die nun durch Opitzen auch hochdeutsch reden können."

The other important Renaissance poet, Georg Rudolph Weckherlin,¹ possessed greater power than Opitz, and may claim the priority in having introduced the Renaissance style into Germany.² He felt keenly the contempt in which German poetry was held at the German courts, at the same time appreciating its inferiority, when compared with that of France or England. Early he determined to become a regenerator in this respect, and to make German poetry "presentable at court." In imitation of foreign models he began to sing the praises of princes in *Hofgedichte*, which lacked great depth, and teemed with mythological allusions. They were received, however, with pleasure by those in whose honor they were sung.³ In these *Hofgedichte* he was imitated by Opitz and other seekers after courtly favors.

Among Weckherlin's best works are his six *shepherd-poems* or *eclogues*,⁴ published in 1648.⁵ These show, especially in form, the influence of Opitz; but as idyllic literature they are superior to anything that Opitz wrote; in fact, they surpass any pastoral poetry written in Germany during the seventeenth century. They suffer, to be sure, from the ordinary faults of the allegorical pastoral, with its conceits and trifling sentiment. Yet by introducing into these idyls *himself* (under the name of Philidor) and his *wife* (under the name of Myrta), to whom he was exceedingly devoted, he has infused into some of this poetry a glow and affec-

¹ Weckherlin (1584-1653) was born thirteen years before Opitz; after traveling through Germany, France, and England, he obtained a position at the court of Würtemberg. He was married to an Englishwoman, Elizabeth Raworth of Dover; in 1620 he settled down in England, rose to the position of Secretary of Foreign Tongues (1644), was superseded by Milton 1649, later becoming Milton's assistant.

² He was the first to introduce the sonnet and the Alexandrine verse in Germany.

³ In a poem of 1610 he could boast that German poetry was no longer derided: even the gods (the members of the court) were delighted with it.

⁴ *Hürtegedichte*, given in *Weckherlin's Gedichte*, edited by Herman Fischer, Tübingen, 1894.

⁵ The first eclogue had been published in 1641.

tion, and hence a *genuineness*, that we miss in other pastoral poetry of this period.

The first eclogue is written in praise of his wife¹ and of mutual love. Eclogues II-V² sing of the four seasons.³ The contents of the VIth may be summed up in the couplet:

" 'Tis better to have loved and lost
Than never to have loved at all."

Though Weckherlin's works show more originality and power, his influence was entirely overshadowed by that of Opitz.⁴ This is explained in the first place by Weckherlin's residence in England during the last thirty-three years of his life; in the second place, by the fact that Opitz, through his translations and paraphrases, which were excellent in form and style, introduced the great pastoral works of other languages, which were the literary fads of the time. From now on the pastoral element enters into and controls all the various kinds of literature, romance, dramatic, didactic, and lyric, for more than a hundred years, till finally the sound of the shepherd's flute dies away at the end of the eighteenth century.

The flood of pastoral literature which followed Opitz came in two large waves: the former, the smaller wave, reaching its highest point about the middle of the seventeenth century. After a subsidence this was followed by a larger wave, reaching *its* highest point about the middle of the eighteenth century (see table No. 1). The former period and the earlier part of the latter with all their pastoral poetry did not produce

*The Imitators
of Opitz. Ten-
dency Towards
Marinism.*

¹ Philidor expresses his joy at having won "this crown of the island of Albion."

² In the third eclogue, as in no other, Weckherlin gives free play to silly trifling, both in form and contents, using diminutives and dallying expressions *ad nauseam*. So Chloris says in verse 106, etc.: "(wie selig bin ich)

Dass den Täublein gleich wir uns einander schnabeln,
Mit Küssen Nektar-gleich begabeln, erlabeln."

Eclogue IV., though containing some conceits, gives a good description of a harvest festival, in which occurs a vigorous responsive song; the shepherds celebrate Bacchus, the nymphs Cupid.

³ They remind one somewhat of Thomson's *Seasons*, even to the occasional incidents.

⁴ See Scherer's *Gesch. d. deut. Lit.*, p. 320.

an idyl proper. Hence, only a brief survey and characterization of this body of literature is necessary for our purpose.

The influence of Opitz and of pastoral literature in general was greatly furthered by the *Sprachgesellschaften*, which were founded all over Germany. Their chief purpose and aim was to cherish and cultivate the German language, and to preserve German customs. The first and most important of these societies was *Die Fruchtbringende Gesellschaft*, or *Palmenorden*,¹ founded 1617, of which Opitz later became a member. Most prominent of those that sprung up in imitation of it was *Die Gesellschaft der Pegnitz-Schäfer*, instituted 1644 at Nürnberg by Harsdörffer and Klaj. Especially did these Pegnitz-shepherds recognize Opitz as their chief model,² and they imitated him in numerous shepherd-plays. But they "outheroded Herod" and went far beyond Opitz in the introduction of allegory and metrical conceits into their works; so that compared with their plays the *Hercynie* of Opitz really seems a work of superior merit.

The ascendancy of foreign literature which Opitz introduced soon showed itself in numerous *romances* and *pastoral dramas*. The *romances*³ imitated *Hercynie*, with its alternating prose and

¹ *Die Fruchtbringende Gesellschaft* was founded by some princes and noblemen the very year that Opitz wrote his *Aristarchus*. See F. W. Barthold's *Geschichte der Fruchtbringenden Gesellschaft*, Berlin, 1848.

Other similar societies were *Die aufrichtige Tannen-gesellschaft*, Strasburg 1633, Weckherlin being one of its members; *Die Teutschgesinnte Gesellschaft*, Hamburg 1643; *Der Elbschwänenorden*, founded by Johann Rist 1660.

² Siegmund v. Birken (1626-1681), for some time "Oberhirte der Pegnitzschäfer," in his *Deutsche Redebind und Dichtkunst* 1679 (p. 301), in speaking of the pastorals says: "Die erste in Teutschland, gleichwie auch die edelste, ist Opitzens unvergleichliche *Hercynie*: massen auch er der erste und edelste Teutscher Poet ist."

³ Up to 1640 the following pastoral romances were published: *Theatrum Amoris* 1630, *Schäfferey oder keusche Liebesbeschreibung* 1632, which went through eight editions, *Wintertags Schäfferey* by Dachsdorf 1636, *Filamon und Belliflora* by Neumark 1640. (For full titles see table No. 2).

These romances also imitated *Hercynie* in the use of alternating prose and poetry; the *action* was carried on by the prose, while the lyric parts were *reflective*.

poetry, while the pastoral drama took Guarini's *Pastor Fido* and Tasso's *Aminta*¹ for its models. All the stress was laid upon form. The attempt to be original, however, led to conceits and fantastic metrical schemes of the most varied kinds. As to the contents, the poet was not supposed to express his own feelings in his writings; everything was conventional. In the words of Birken: "*Das Herz ist weit von dem was eine Feder schreibt.*"²

Another characteristic, too, inherited from Opitz, added to the conventionality of the pastorals: they were usually written in honor of the powerful and wealthy, and hence thrived mainly by the favor of the courts. To become a *Hof-poet* was the aim of every writer of verse; every prominent man, every court festival (births, marriages, deaths, namedays, return from journeys, etc.), was celebrated in high-sounding poems, *Gelegenheitsdichtung* in the worst sense.³ It seems as though this personal element

¹ One of the first is *Daphnis u. Chrysilla* by Schere, Hamburg 1638, the interludes being mainly in low German. Five pastoral dramas treat of the close of The Thirty Years' War, the stress of the times naturally turning the thoughts and longings toward an ideal happy world. The authors were all members of the *Fruchtbringende Gesellschaft*. Birken and Schottelius were also *Pegnitzschäfer*. These dramas were (for full titles see table No. 2):

1. *Lamentatio Germaniae Expirantis*, by Schottelius, 1640.

2. *Das Friede-wünschende Teutschland*, by Rist, 1647. It went through four editions.

3. *Teutschland Kriegs Beschluss u. Friedensschluss* vom Schäfer Floridan, Birken, 1650.

4. *Margenis, das vergnügte, bekriegte und wieder befriedigte Deutschland*, by Birken, 1651.

5. *Das Fridejauchzende Deutschland* by Rist, 1653.

² See also note 1, p. 22.

³ Even *Hercynie* was written in honor of a court (see p. 22). Of the numberless poems of this kind we may mention the following of those that were pastoral in form (for full titles and persons celebrated see table 2):

Der Elmen-Nymphen Lust.-Gebäu by Glaser, 1750.

Der getreue Hürte by Geller, 1653, *Verlibtes Gespenste* by Gryphius, 1660, *Pegnesische Gesprächspiel-Gesellschaft*, by Birken, 1665; *Jauchzende Cupido* by Cronpusch, 1669; *Der unbeglückte Schäfer* by Reich, 1686; *Etliche Schäfergedichte* by Wernicke, 1701; *Schäfergedicht* by König, 1730; *An Friedrich II* by Lindner, 1741; *Schäfergedanken* by Neukirch, 1742 (?); *Schäferspiel die Herbstfreude* by Neuberin, 1753; *Idylle auf Marien Charlotten* by Regelsperger, 1768; *Der beglückte Frühling* by Rautenstrauch, 1770. To show the extent to which this tendency was carried may be mentioned the poems of Joh.

ought to have imbued their poems with some life; but all realistic tendencies were entirely smothered by other elements: 1. the desire on the part of the authors and those whom they celebrated to withdraw as much as possible from the crude realities of life;¹ 2. the thought of a Golden Age, an ideal shepherd world, which colored the character of the productions, even though in many of them the shepherd garb was but a mask;² 3. the introduction of the gods of Greek and Roman mythology; 4. the personification of all the affections and qualities of man; symbolism carried to the extreme.

What made this ideal shepherd world so general in the literature of the time was the fully accepted belief that it once had really existed.³ In portraying scenes from an ideal pastoral existence the poet felt confident that he was going back to the very source and origin of poetry. This Arcadian life, however, could furnish but few character-types, as they were all to be good and virtuous, or, at least, not vicious. Hence the same characters and *motifs* keep recurring continually. There is a dreary sameness in all these pastoral works, brightened by only an occasional flash of individual genius.

Many of these pastorals were after the model of Opitz's *Dafne*,

Ulrich v. König. In his works published at Dresden, 1745, there are 98 poems of which 82 are *Gelegenheitsdichtungen* in the sense mentioned above.

¹ The founders of the *Blumenorden* in the preface to the *Pegnesische Schäfergedicht* state that the description of actual peasants' conversation and real boorish manners would be more disgusting than entertaining, and that the shepherds who appeared in their works denoted "*durch die Schafe ihre Bücher, durch derselben Wolle ihre Gedichte, durch die Hunde ihre von wichtigen Studien müssigen Stunden.*" (See Koberstein II 193-4).

² So in *Hercynie*, under the mask of the shepherd dress we are expected to recognize the poet himself, or some one he wishes to celebrate, or even the personification of some quality.

³ Cf. Scaliger, *Poet.* 1:4.— See Birken's *Teutsche-Redebind und Dicht-Kunst* (Nürnberg 1679), especially the *Zuschrift* and *Vorrede*. The first sentence of the *Zuschrift* reads; "Dass die Dicht-Kunst in Feldern und Wäldern gebohren und erzogen worden, erscheint aus deme, was in nächst folgenden Vorrede hiervon gesagt worden. Sie ist eine Tochter der ersten güldenen Zeit." — And page 293: "Die Poesy hat das Feldwesen zum Vatterland, und die Hirten zu ersten Urhebern."

set to music, which had the effect of still further increasing the unreal character of the play.

The pastoral and allegorical elements also forced their way into religious poetry.¹ Only when these elements entered the popular lyrics did they acquire more life and naturalness.² The tendency towards Marinism and affectation reached its highest point in the works of Hoffmanswaldau (1617-1679) and Lohenstein (1635-1683), the leaders of the so-called Second Silesian School. Literature had become more and more smothered with allegory, conceits, and bombast, and in the search for fine phrases, foreign words forced their way into the works of some authors to an incredible degree.³ As a consequence, popular interest in literature almost died out. A revulsion had to come, and it took the form especially of a return to the contemplation of nature. This brings us to the second and greater wave of idyllic and pastoral works (see table 1), on the crest of which are Gessner's idyls, the culmination of the pastoral literature in Germany.

About the beginning of the eighteenth century there was a revolt against the bombast and unnaturalness of the so-called Second Silesian School. We can trace the influence of *Reaction Against Bombast* such a reaction in the few idyls written at this time; but especially did it arouse men to contemplate and describe nature with a deeper appreciation of its beauty. The tendency to realism which lay dormant in this movement was indeed suffocated by the influence of

¹ The extreme of this tendency is perhaps represented in a work by Laur. v. Schnifis, which went through many editions: *Mirantisches Flötlein oder Geistliche Schäßferey, in welchem Christus unter dem Namen Daphnis die in dem Sündenschlaff vertieffte Seel Clorinda zu einem bessern Leben aufferwecket. Constanz 1682*. Cf. Koberstein II 218.

² See *Die deutsche Renaissance Lyrik* by Waldberg; also Koberstein II 28.

³ "Deutsch kann jeder Bauer reden" said a learned man, Biedermann: *Deut. Volks u. Kultur Gesch.* Book V., p.65, 66. —

In a play composed to celebrate the peace of Westphalia the following sentence occurs: "Ein Cavalier ist welcher ein gut courage hat, maitiniret sein etat und reputation und gibt einen politen courtisanen ab."— Of Birken's free use of foreign words and phrases, see *Euphorion* 1897, Heft 3, article by Burekhardt.

Gottsched and his followers, but yet Gessner owes this descriptive literature much of what is best in his idyls.

The first great opponent of the turgid style was Christian Weise. He wrote but one pastoral: *Die betäubte und getröstete Galathea*, 1674, which shows unmistakable signs of dramatic ability. Wernicke, in whose style we trace Weise's influence, celebrates in his four idyls two deaths, one birth, and one betrothal in the conventional, allegorical manner.¹ The most realistic poet of his time was Christian Günther² (1695-1723), whose realism, however, often degenerates into coarseness. He also wrote a pastoral for a wedding, commemorates his old friends in a shepherd-poem, and in a conventional manner desires to have his epitaph cut in a tree.

Compared with those of Wernicke and Günther, the eclogues of B. Neukirch³ (1665-1729) show a retrogression towards the inflated style of Lohenstein. Yet Gottsched, in his *Critische Dichtkunst* (1730), calls Neukirch *Der deutsche Theokrit*, and in the 3d edition of *Crit. Dichtk.* (1742) he replaces his own model idyls by four of Neukirch's.⁴

¹ First printed 1701. See *N. Wernikens poetische Versuche in Ueberschriften, wie auch in Helden und Schäfergedichten* edited by J. J. Bodmer, Zürich 1749. This work was probably known to Gessner. As a sample may be given the synopsis of the 1st eclogue: Menalcas meeting Thyrsis, after some preliminary conversation, informs him of the death of Daphnis. Thyrsis exclaims: "Ist unser Daphnis todt? Denn gute Nacht Ihr Wälder," etc. (cf. Daphnis's farewell in Theocritus I). — They recall incidents of Daphnis's life, and decide to gather flowers for his grave. The influence of Vergil may be traced.

² "Der letzte Schlesier". — With him closes the long line of poets that began with Opitz.—Goethe thought highly of his songs and odes. See Tittman's Introduction to the works of J. C. Günther (1874). Cf. also O. Netoliczka; *Schäferdichtung u. Poetik im 18:ten Jahrhundert*, in *Viertel-Jahrschrift für Litt.-Gesch.* II. 2, 1889, p. 5.

³ The following shows to what extremes of absurdity he could go; in one of his poems we are told: "Die um Sylviens Busen spielende Hand wird vor Liebesbrand schwarz, Sylvia aber will ihr eine Gunst missgönnen, die sie den Flöhen nicht versagt." (Ehrich Schmidt in *Allg. Deut. Biog.*) In Neukirch's *Grosse Anthologie* (p. 577) a wedding pastoral oddly compares the bride to the sheep, the bridegroom to the shepherd, who loves not her wool, the golden fleece, but her heart. Netoliczka, p. 7.

⁴ In the edition of 1751, p. 593, Gottsched says: "Hier kann ich also keinen

In the revolt against bombast and affectation, Brockes and Haller led the way in turning to the contemplation of nature which had for so long a time been neglected.

Literature Many authors followed in their footsteps. This
Descriptive of literature, descriptive of nature, also set its stamp
Nature; Brockes, upon the idyls of Gessner.

Haller and Brockes¹ produced nine volumes of purely de-
Kleist. scriptive poetry, the title of which describes its
character: *Irdisches Vergnügen in Gott*² (1721-1748). He delineates all kinds of scenes on land and sea, plants, animals, the seasons, the various parts of the day, the heavens, the mental capacities of man, and a thousand other objects. These poems are usually too minute and detailed, and hence afford no good general survey of the object or scene described. As an artist of no mean merit, he sought to bring his poetry as much as possible under the rules of the arts of music and painting. Though this implied a gross misunderstanding of the rules of literary composition, yet by this very mistake he made a great advance in *form* and in *subject-matter* over his predecessors. His descriptions display fine perception; his great fault is that he always depicts *lifeless* nature. There is no action, as he was unable to people his world with appropriate inhabitants. He made his poems didactic, his views of the creation being teleological: God in nature, and purpose in everything created was ever his theme.

bessern nennen, als *Neukirchen*, der uns etliche schöne Proben (von Eklogen) gegeben hat, und also unser deutscher *Theokrit* zu heissen verdient." Yet in this edition Gottsched shows the good sense of omitting Neukirch's idyls, and even ventures to criticise them.

¹ Barthold Heinrich Brockes 1680—1747. His *Irdisches Vergnügen in Gott* was greatly admired by his contemporaries, the first volume going through seven editions.

² S. Gessner (in *Brief über die Landschaftsmalerei*, Frey's ed. in *Deu Nat. Lit.* p. 288 ff.) speaks of Brockes's minute descriptions of nature and adds: "Oft zu weitschweifig, oft zu erkünstelt, sind seine Gedichte ein Magazin von Gemälden u. Bildern, die gerade aus der Natur genommen sind."

Haller was greatly influenced by Brockes,¹ and like him considered the didactic and descriptive element to be the main purpose of poetry. But he made an improvement upon Brockes, both in his descriptions of nature, and especially by peopling it with real characters. By combining these two elements, human characters and a natural background, he produced literature that was idyllic in its nature.

These first notes of a realistic idyl in Germany were heard in Haller's *Alpen*. In 1728 Haller,² who ardently loved his native country, Switzerland, made a journey through the Alps, the impressions of which he describes in *Die Alpen* (published 1732). Other poets (as Brockes) had sung the beauty of the plain, the forest, the meadow, and the quiet river. But never before had the grand scenery of the mountains been described. Haller first grasped them poetically, and in his vigorous and rhetorical verse called the attention of his contemporaries to the beauty which before had aroused more awe than admiration.

In accordance with the taste of the times and following Brockes, Haller enters into a doubtful contest with the flower and the landscape painter.³ But instead of bringing in the ever-recurring reflections of Brockes on the goodness and wisdom of God and the purpose of creation, Haller combined with his descriptions pictures of human life standing in the very closest relation to the nature he depicts. Haller sketches before our eyes the natural beauties of the Alps, the seasons, the pursuits and festivals of the people, in general: simple, contented and happy life in the mountains. Here are the beginnings of the genuine idyl.⁴ Yet this best and most characteristic part of the poem failed to attract the attention of his contemporaries. Even his countryman Gess-

¹ See Julian Schmidt; *Gesch d. deut. Lit.* I 176.

² See *Albrecht von Hallers Gedichte*, edited by Dr. Ludwig Hirzel, Frauenfeld 1882.

³ Lessing in his *Laokoon XVII.* deals the death blow to merely *descriptive* poetry. He quotes *Die Alpen*, verses 381-400, which minutely describes the flora of the Alps, and shows its unsatisfactory character.

⁴ See Koberstein, *Deu. Nat. Lit.* V; 53, 1.

ner follows Haller's example in only *one* idyl, where he describes a real human character with the Alps as background. Not till we come to the works of Müller and Voss do we again hear idyllic notes of such clearness and beauty as Haller's.

Haller was also the first poet who gave expression to the feeling of hostility against society and civilization ("Kulturfeindliche Stimmung") in German poetry; the sentiment which later found its best expression in Rousseau with his theory of a return to nature.¹

In imitation of Brockes and Haller there appeared a great number of works descriptive of nature. Foremost of these is Ewald von Kleist's² *Frühling* (1749), in which he describes the impressions he had received during a walk on a beautiful spring day.³ It is based upon Brockes' paraphrased translation of Thomson's *Seasons*. Compared with Haller's *Alpen* it shows a retrogression in the idyllic elements, while the descriptions⁴ are more vigorous.⁵

The germs of a genuine idyl, especially as found in Haller, were not to bear fruit till almost half a century later. Most prominent among the influences which interrupted its development was that of Gottsched. This reactionary effect he accomplished mainly by two of his works which he published at the beginning of his "autocratic rule" in German literature, *Critische Dichtkunst* and *Atalanta*. *Critische Dichtkunst*⁶ (1730), and the shepherd-play *Atalanta* (1741). By the former he deter-

¹ See p. 40.

² Ewald Christian v. Kleist (1715-1759) also wrote many poems of an idyllic nature (See *Deut. Nat. Lit.*; *Anakreontiker*); among others *Sehnsucht nach Ruhe* 1744 (p. 134); *An Wilhelmina* (p. 131), *Das Landleben* 1745 (p. 140) *Menalk* (p. 142).

³ Gottsched and his followers condemned it; but it was hailed with joy by Klopstock and the Swiss, and strengthened not a little the influence of descriptive poetry in Gessner's idylls. (See *Deut. Nat. Lit.*, *Anakreontiker* II. 109.)

⁴ Lessing's *Laokoon* XVIII. passes sentence on descriptive poetry; *Der Frühling* is also mentioned as coming under this doom, since it is "eine mit Empfindungen sparsam durchwebten Reihe von Bildern."

⁵ See Julian Schmidt; *Gesch. d. deut. Lit.* I 226.

⁶ The references on the following pages are to the edition of 1751.

mined the theory of the idyl, as well as other forms of literature, till after Gessner's appearance; and his shepherd-play *Atalanta* was followed by such a mushroom growth of pastoral dramas as is seen nowhere else in literature.

Gottsched's *Critische Dichtkunst* is the first complete treatment of literary forms that I could find after Birken's *Dichtkunst* (1679). It shows an utter lack of originality, treating the subject-matter in a superficial and conventional manner and does not at all make any advance in the theory of literary forms. As to idyllic literature, he merely accepts the verdict of French critics, especially Fontenelle.¹ It is only a re-statement of the traditional theories of the seventeenth century as we see them in Opitz and Birken.² Gottsched again repeats the old theory that pastoral literature was the oldest in the world,³ that it ought to describe an ideal existence in a Golden age,⁴ since the present shepherd-life is unsuitable for poetic treatment; the only passion to be described is love, but such love must be of an innocent nature;⁵ the shepherds of Theocritus are too "grob und plump," Vergil was "artiger," though his shepherds were not always virtuous enough; fisher-idyls are not in good taste, as a fisherman's work is too laborious; vintagers, however, are proper subjects for idyllic description.

Only in one point did Gottsched show any advance on Fonte-

¹ "Herr von Fontenelle, dem ich diese Anmerkungen mehrertheils abborge." *Crit. Dichtk.* p. 589.

² Cf. *Von der deutschen Poeterey* by Opitz (Breslau 1624) pp. 23, 33. Also Birken's *Teutsche Redebind- und Dichtkunst* (Nürnberg 1679), especially the *Zuschrift* and *Vorrede*.

³ P. 581: Man kann gewissermassen sagen, dass diese Gattung (Idyllen) die allerälteste sey." — To defend this statement he adds: "Die allerersten Poesien sind nicht bis auf unsre Zeiten gekommen."

⁴ P. 582, Gottsched says: "Poetisch wurde ich sagen es (ein gutes Schäfergedicht) sey eine Abschilderung des güldenen Weltalters; auf christliche Art zu reden aber eine Vorstellung des Standes der Unschuld, oder doch wenigstens der patriarchalischen Zeit, vor und nach der Sündfluth.

⁵ P. 585: "Kurz, die unschuldige Schäferliebe muss von allen Lastern frey seyn, die sich durch die Bosheit der Menschen allmählich eingeschlichen haben." The shepherd, he adds, must be "ganz tugendhaft und vergnügt."

nelle in the direction of naturalness; for he criticises Fontenelle for having made his shepherds "witty Parisians clad in satin."¹

The extreme development, however, in the theory of the idyl² appears in J. A. Schlegel's satire *Vom Natürlichen in Schäfergedichten*,³ published 1746. He intended this essay as a satire upon Gottsched and his followers; yet his theory does not fundamentally differ from Gottsched's view of the idyl as expressed in *Critische Dichtkunst*. But it goes beyond Gottsched, and shows the extreme of the rococo taste in excluding everything that at all smacked of realism. Sickness, sweat, ordinary labor of any kind ("What have the Muses to do with household work?") must be utterly excluded.⁴ Gessner's fastidious shepherds show that this theory also influenced him.

It is interesting to notice that *The Guardian*,⁵ translated from the English by Frau Gottsched (1749), contains the first beginnings of a sound realistic conception of the idyl. Especially does it oppose the traditional cult of Vergil, and points out the genuineness of feeling which is displayed by the shepherds of Theocritus, as compared with the rhetorical tone of Vergil's. Gess-

¹ Gottsched himself probably felt the unreal character of this kind of poetry, as is shown by J. J. Schwabe's preface to Gottsched's *Gedichte* (1736), his eclogues being omitted in this edition. Schwabe says (after calling the reader's attention to the fact that there are no shepherd-poems in this edition); "Wo ist die güldene Freiheit, die reine Liebe, und die tugendhafte Einfalt, die das Wesen derselben sind? — jetzt verzeih uns nur, dass wir euch mit keinem Hirngeburten unterhalten, denen ihr doch nicht ähnlich sein wollt." See Gottsched's *Gedichte* 1751, pp. 20, 21.

² Among others who discussed pastoral literature was Christlob Mylius, Lessing's cousin, in an article on *Schäfer Poesie*, 1745. He makes the absurd proposition that "ein vollkommener Kenner des Charakters aller Arten von Schäfergedichten nach dem Inhalt der Muster der guten alten und neuen Schäfergedichten eine Geschichte von Arkadien als Richtschnur für die Poeten verfertigen und herausgeben solle." See Netoliczka p. 56.

³ *Vom natürlichen in Schäfergedichten*, wider die Verfasser der Bremischen neuen Beyträge verfertiget vom Nisus einem Schäfer in den Kohlgärten einem Dorfe vor Leipzig. Von Hanns Jörgen gleichfalls einem Schäfer, Zürich, 1746. Nisus was J. A. Schlegel, Jörgen Bodmer.

⁴ Gleim's *Blöder Schäfer* is criticised for making mention of "Heu und Erbsenstroh." See Körte: *Gleim's Leben*, p. 41.

⁵ See page 59, Netoliczka.

ner, too, in spite of his unreal and conventional shepherds, claimed that Theocritus was his model. Whether he was at all influenced by said article, I do not know.

Ever since Opitz had introduced the Opera into Germany through his translation of *Dafne*, with its mythological and pastoral character, the opera had been a favorite form of entertainment, first at court-festivities,¹ later in some of the large cities, especially Hamburg, Braunschweig, and Dresden, and grew to be exceedingly popular. Ballets, pantomimes, and masquerades were introduced into these operas, whence the music and display became all-important, while the text was utterly disregarded.

When Gottsched began his reforms of the German stage, he found the stage occupied by this form of opera, which he heartily despised.² Wishing to drive the opera off the stage, he proposed to substitute for it the shepherd-play to be *spoken*, not sung, and wrote his *Atalanta* (published 1741) with this purpose in view.³ He succeeded, too, beyond his expectations; German literature was literally deluged by imitations of Gottsched's play. During the ten years immediately following the publication of *Atalanta* more than thirty shepherd-dramas appeared, seven being published in the year 1746 alone.

In *Atalanta* and these plays which it called into existence there is no individual characterization; all allusions to the ordinary occupations of life are carefully avoided. The shepherds are mere conventional types, puppets without life and reality; the writers do not give any motives for the entrance or exit of the actors,

¹ As a good example of these operas may be mentioned Johann von Besser's *Singspiele*, 1707, ("mit mythologischem Prunk ausstaffiert"), page 563 of *Des Herrn von Besser Schriften* 1732.

² "Wenn nicht die Regeln der ganzen Poesie übereinander fallen sollen, so muss ich mit dem St. Evremond sagen: *Die Oper sei das ungereimteste Werk, der menschliche Verstand jemals erfunden hat*" *Krit. Dichtk.* p. 369.

³ See *Das deutsche Schäferspiel des 18. Jahrhunderts* (Inaugural Dissertation), Halle a. S., 1885, by Friedrich Rühle. In this he sets forth the importance of Gottsched's *Atalanta* in the development of the pastoral drama.

wherefore these plays lack all unity of dramatic action.¹ No real advance can be traced in these dramas;² on the contrary, a tendency towards shallow and sensual triviality manifested itself, so that Gleim laments the deterioration of the literary taste, and calls these plays "*Schweinhirten-spiele*."³

The importance of these plays in their influence upon the idyl lies in this, that they filled Germany with the atmosphere of this unreal pastoral world. Hence it seemed necessary to the first writers of idyls to retain this ideal hazy shepherd-life in their works in order to make them acceptable to their contemporaries.

A protest against these *Schweinhirten-spiele* and a return to an *innocent* ideal world is seen in the many works of the time

which went back to the patriarchal age of the Bible for their motives. These "*Patriarchaden*," usually epic in form, may be traced to the influence of Klopstock and even to Milton.⁴ The works emanated from the circle that was opposed to Gottsched,⁵ and exerted great influence upon Gessner. This "seraphic poetry," as Julian Schmidt calls it, suffers from the common fault of the period, vagueness and lack of characterization.

The earliest and best written idyls of the period immediately

¹ Bodmer's pastoral drama *Cimon* (written 1747) is noticeable by its giving reasons for the entrance and exit of the actors, and by its having a definite locality, "zum ersten und einzigen Mal in einem Schäferspiel" (Netoliczka, p. 68).— Yet even Bodmer was unable to imbue his characters with any life or reality.

² See Netoliczka p. 19.

³ In the year 1746 Gleim writes to Uz as follows: "Nach meiner Meinung hat in Deutschland nie ein so schlimmer Geschmack geherrscht als jetzt.— Man macht Schäferspiele, die man mit Recht Schweinhirten-spiele nennen kann." See *Gleims Leben* by Körte (1811) p. 43.

⁴ Milton's *Paradise Lost* was translated by J. J. Bodmer 1732, revised edition 1742; this as is well known greatly influenced Klopstock's *Messias*, three books of which were published 1748.

⁵ Bodmer's "*Patriarchaden*" were a weak imitation of Klopstock's *Messias*; they were: *Noah* 1750, *Jacob and Joseph* 1751, *Jacob and Rachel* 1752; Klopstock in turn followed his example in *Der Tod Adams* 1757, which work Gessner imitated in *Der Tod Abels* 1758; Maler Müller showed the influence of his predecessors in *Der erschlagene Abel* 1775, and *Adams erstes Erwachen und erste selige Nächte* 1778.

preceding Gessner are Johann Christoph Rost's *Schäfererzählungen*.¹ Both in style and contents they show a reaction against the conventional French taste of Gottsched, and contain many anacreontic elements. He abandoned the idea of an innocent Arcadian existence, and employs the form of the idyl for presenting the grossest sensual descriptions, though written in exceedingly light and pleasing style. Rost's lasciviousness was imitated only by C. N. Naumann, whose work is merely vulgar, as he lacked Rost's ability.

As Gessner was closely associated with Hagedorn and the "Hallenser" circle, they exerted great influence upon his style. Hagedorn's *Fabeln und Erzählungen* (1738) gave models for the epic treatment of bucolic material. From the "Hallenser" circle (Gleim, Uz, Götz, etc.) emanated a species of poetry which combined anacreontic and pastoral elements.³ The idyls of J. N. Götz⁴ were added to his book of poems: *Die Oden Anakreons in reimlosen Versen* (1746). These idyls are written in rhymed verse, and, like the works of all these anacreontic writers, are very light and charming in style. From these authors Gessner acquired much of his pleasing and graceful style, and the anacreontic element also enters into his idyls.⁵

In the idyls of Chr. Fr. Zernitz appears the tendency of again turning to an innocent pastoral world. However, his work, *Versuch in moralischen und Schäfergedichten*, 1748, written in strophic form, is wholly worthless.⁶

¹ See *Versuch von Schäfergedichten und andern poetischen Ausarbeitungen* 1760 (name of author and publisher not given on title page). The popularity of this work is attested by the fact that it went through eleven editions. Of similar nature is Rost's *Die schönste Nacht*, Berlin, 1763, one of the most famous poems of German erotic literature.

² *Sieben Hirtengedichte vom Schoch dem jüngern aus Sachsen*-1743.-See Netoliczka, p. 19.

³ See *Anakreontiker* in *Deut. Nat. Lit.*

⁴ See Koberstein V. 56, and Netoliczka, p. 62.

⁵ See Scherer's *Deut. Lit. Gesch.* p. 430.

⁶ See Koberstein V. 56, and Netoliczka 57.

None of these idyllic writers preceding Gessner had struck the note that suited the visionary, sentimental mood of their time.¹ Their work is of importance mainly as calling the attention of their contemporaries to this literary form. The sentimentality of the time was now to find its best expression in the idyls of Gessner.

CHAPTER IV.

GESSNER AND THE CULMINATION OF THE PASTORAL IDYL.

Gessner gathered together all the threads of pastoral poetry running through the literature of the period at the end of which he stood, and wove these into his idyls. Hence in his works we find all the elements of weakness as well as of excellence, characteristic of the rococo eighteenth century.

Solomon Gessner was born in 1730 at Zürich, where he spent most of his life, thus coming directly under the influence of the Swiss school and of Klopstock. Early in his youth he was attracted to the descriptive poetry of Brockes, for which he entertained a predilection all through life. When nineteen years old he went to Berlin to learn his father's trade, that of book-dealer, but soon turned to the study of drawing and painting. At Berlin he made the acquaintance of Ramler, to whom he showed his first poetical efforts, and who exerted a lasting influence upon his literary development. From 1751 on he resided at Zürich. Unable

¹ Of other writers of idyls I may also mention K. A. Schmidt.- See Koberstein V. 56. *Hirtenlieder und Gedichte* was published at Halle, 1753, by an anonymous writer. See Netoliczka p. 63.- Concerning F. W. Zachariä's *Phaeton* 1754. Gervinus says it could not be called anything but an idyl, if it did not smack of being a parody on Ovid's *Phaeton*. See Gervinus IV. 22.

to earn his living by his literary labors, he took up painting as his calling. After the death of his father he assumed control of the book-shop. Meanwhile his works had made him famous, so that he was honored by his townsmen with many positions of trust until his death in 1787.

Before he came to write the idyls upon which his fame chiefly rests, he tried his apprentice hand upon other works. His first poems were anacreontic,¹ in imitation of Hagedorn and Gleim. The next step towards the idyl was the pastoral romance *Daphnis* (1754), suggested to him by a chance reading of a translation of *Daphnis and Chloe* by Longos, which has been the great model for so many works of this nature. Gessner's *Daphnis* lacks action and reality as compared with the original. The story is full of tenderness and delicacy, but these qualities do not make up for what it lacks in strength and variety.

In the short sketch of *Genrebild* Gessner found the literary form for which his talent best fitted him. His first idyls, twenty in number, were published in 1756, followed by his *Neue Idyllen*, twenty-two in number, in 1772. The later idyls are to a great extent a reflection of the best parts of the first collection. Yet though they lack the freshness of the first idyls, the style and language show an advance in being less diffuse.

These idyls, especially the first edition, suited as no other had done, the "sweetish" sentimentality of the time, and were hailed with joy. In what did this feeling consist?

The tendency of German poetry to turn to a visionary world of imaginary innocence and happiness, away from the conditions of surrounding distress, is one of the most marked characteristics of the time.² The peasants and shepherds were almost without

¹ See Frey's *Gessner*, Introduction, p. 10.

Frey in his introduction to Gessner's works, page 18, says: "Haller's prophetische Strafrede, Gessner's liebliche Idylle, Lessing's *Emilia Galotti*, Goethe's *Götz* und Schiller's Jugenddramen — sie liegen hier alle in einer Linie; die Sehnsucht der Idylle wendet sich seufzend von ihrer Zeit ab, der Zorn der stürmischen Dramen stöszt diese um."

exception so poor and oppressed, that a realistic portrayal of their condition would have attracted no attention. As Gessner puts it: "Was soll der Schäfer mit der Wirklichkeit wo der Bauer mit saurer Arbeit unterthänig Fürsten und Städten den Überfluss liefern muss, wo Armuth und Unterdrückung ihn ungesittet, schlau, und niederträchtig gemacht haben?"¹

But this feeling of aversion was directed not only against pastoral or peasant life; civilization as a whole was blamed for having produced all the crime and unhappiness in the world. This common sentiment found its best expression in the works of Rousseau. Even in his first great works,² which appeared before the idyls of Gessner, Rousseau appears as the great apostle of freedom from the restraints of civilization, and in tones which re-echoed throughout the world, preaches a return to nature.

Gessner, in common with his contemporaries, turned away from the present state of the world and of civilization, which seemed all wrong, to an ideal world which was thought of either as wholly imaginary or as having existed in the past. Such periods they found in an ideal Arcadia, and also in the patriarchal times as pictured in the Bible stories treating of the periods before and after the deluge. Especially did Klopstock and the Swiss turn with religious fervor to depicting the Patriarchal Age.³ Gessner and his contemporaries entertained an unshakable belief and assurance that such an ideal world had actually existed.⁴ Was not the Bible narrative in itself absolute proof that this earth had

¹ Gessner's Introduction to the idyls, p. 64.

² In 1750 appeared *Discours sur les sciences et les arts*, which shows Rousseau's "Kulturfeindliche Stimmung;" it appears still more forcibly in his *Discours sur l'inégalité parmi les hommes* 1755, translated by Moses Mendelssohn in the following year.

³ Gervinus IV, 174, says: "Dass wir die Idyllen von Salomon Gessner aus Zürich auf eine Linie mit diesen Patriarchaden stellen, wird niemand wundern, der die Geschichtlichen Verhältnisse beachtet hat. Er ging aus Klopstock hervor, wie Thomson aus Milton,"

⁴ Gessner writes: "Kurz, sie (die Ekloge) schildert uns ein goldnes Weltalter, das gewiss einmal da gewesen ist, denn davon kann uns die Geschichte der Patriarchen überzeugen, und die Einfalt der Sitten, die uns Homer schildert."

seen an age of innocence and perfect happiness, when pastoral occupation was the most important? And was not the legend of the Golden Age, which had come down from classic authors corroborative evidence? In this ideal shepherd-world, too, all poetry had its origin and source, and to this era of perfection man must always go for his noblest ideals and highest aspirations. Gessner tried to depict this era as he imagined it had really existed,¹ and ardently hoped that it might again bless the earth and usher in a new age of innocence and happiness.

In Gessner's idyls description of nature occupies the most prominent place. Of the forty-two idyls of Gessner, twenty lack dialogue altogether, and are purely descriptive or narrative; and of the dialogues, fifteen or more come in this same category, leaving but a few in which the descriptive element is of minor importance. A Swiss and a painter, he seems to have been doubly qualified for describing the grand nature of his native country; but not even Haller's *Alpen* had opened his eyes to the beauty and grandeur of the mountains. On the contrary, nature in his works is too conventional and overadorned, like the ornamental French gardening of the rococo period.

Gessner intentionally made the descriptive element so prominent, following the examples of Haller and Kleist, and more especially of their predecessor Brockes, whose minute vapid descriptions had charmed him in his youth. In common with these great descriptive authors Gessner still labored under the theory that poetry could and should vie with the landscape painter, and in his idyls he entered into this unequal contest. In his *Brief über die Landschaftsmalerei* he says: "Die Dichtkunst ist die wahre Schwester der Malerkunst. — Wie mancher Künstler würde mit mehr Geschmack edlere Gegenstände wählen, wie mancher Dichter würde in seinen Gemälden mehr Wahrheit, mehr Malendes im

¹ Gessner says: "Diese Dichtungsart bekommt daher einen besondern Vortheil, wenn man die Scenen in ein entferntes Weltalter setzt; sie erhalten dadurch einen höhern Grad der Wahrscheinlichkeit."

Ausdruck haben, wenn sie die Kenntniss beider Stücke mehr verbänden."¹ This tendency naturally developed much *Kleinmalerei*. In his *Brief über die Landschaftsmalerei* Gessner characterizes his early work as a painter; this criticism is also the best characteristic of his literary productions, including the idyl. He writes: "Meine Neigung ging vorzüglich auf die Landschaft. Das Beste und der Hauptendzweck ist doch immer die Natur. So dacht' ich und zeichnete nach der Natur. Aber ich wollte der Natur allzugenau folgen und sah mich in Kleinigkeiten des Detail verwickelt, die den Effekt des Ganzen störten; und fast immer fehlte mir die Manier, die den Gegenständen der Natur ihren wahren Charakter beibehält."²

Just as the grand nature of the Alps finds no reflection in Gessner's idyls, he also fails to imitate Haller in introducing actual idyllic life of the mountain people who dwelled in almost patriarchal simplicity. However, Gessner did people his beautified nature with inhabitants: shepherds, satyrs, fauns, and zephyrs. Even though the former are more natural than Fontenelle's shepherds ("courtiers clad in silk"), yet two causes contributed to make the characters represented seem unreal and lifeless. In the first place they were only of minor importance as compared with the scenery of which they were intended to be the ornaments and decorations. In the second place, the scenes are laid in an ideal Arcadia, an innocent Golden Age, and in consequence the characters are vague and unreal, too innocent and virtuous to be really human. This Arcadian innocence and goodness makes the characters all of one general type; it was always the same shepherd in different situations. This poverty of character-types is all the more noticeable as there is hardly any action in the idyls. In twenty

¹ Continuing, Gessner writes: "Der Landschafts-maler muss sehr zu beklagen sein, den z. B. die Gemälde eines Thomson nicht begeistern können. Ich habe in diesem grossen Meister viele Gemälde gefunden, die aus den besten Werken der grössesten Maler genommen scheinen, und die der Künstler ganz auf sein Tuch übertragen konnte." Brockes is also mentioned. p. 288.

² See *Brief über die Landschaftsmalerei* in *Gessners Werke (Deut. Nat. Lit.)* p. 282.

of the forty-two idyls no dialogue occurs at all, and what dialogue there is, is lacking in dramatic life, being either descriptive or narrative. The conversation of the shepherds which ought to bring out the difference of character only shows how exactly alike they are,¹ most of what is said would be equally appropriate in the mouth of either shepherd. This sameness is necessarily fatal to any continued interest in the characters. Their calm dialogue cannot move us even when it, as in the idyl *Der Sturm*, describes a storm at sea and a shipwreck. As Goethe says: "Voltaire kann zu Lausanne aus seinem Bette dem Sturm des Genfer Sees im Spiegel nicht ruhiger zugesehen haben als die Leute auf dem Felsen, um die das Wetter wüthet, sich vice versa detailliren was sie beide sehen."

Two of Gessners idyls, however, deserve special mention as differing from the others, and showing an approach toward realism.

Der Faun (idyl 20) has some of the spirit of Theocritus, and excellently characterizes two different types; the love-sick Faun, whose suit has been rejected, gives way to despair, while his friend banters him on account of his passion and eventually induces him to join the merry procession in honor of Lyaeus.

In only one idyl does Gessner leave the dream-world of an Arcadian existence and descend to *terra firma*; in only one does he foreshadow the realistic idyl, which was so soon to appear, describing characters and scenes of the native soil. *Das hölzerne Bein, eine Schweizer-idylle* portrays in the old invalid soldier a characteristic figure with the grand mountains of Switzerland as a background. The veteran describes in animated words to an

¹ Goethe says: "Zeigt das nicht den grössten Mangel dichterischer Empfindung, dass in keiner einzigen dieser Idyllen die handelnden Personen wahres Interesse an und mit einander haben? Entweder ist es kalter, erzählender Monolog oder was eben so schlimm ist, Erzählung und ein Vertrauter der seine paar Pfennige quer hinein dialogisiert, und wenn denn einmal zwei was zusammen finden, empfindet's einer wie der andre, und da ist's vor wie nach." See Goethe's excellent review of *Moralische Erzählungen und Idyllen von Diderot und S. Gessner* in *Frankfurter Gelehrte Anzeigen* 8, 273 (1772).

admiring young shepherd one of the severe battles fought for the independence of Switzerland. But even this idyl Gessner overloads by bringing in an account of the shepherd's subsequent visit to the soldier's home, and his marriage with the soldier's daughter. Of the first part of this idyl Goethe says: "Wie ich anfang, sie zu lesen, rief ich aus: O, hätt' er nichts, als Schweizer-idyllen gemacht! Dieser treuherzige Ton, diese muntre Wendung des Gesprächs, das National-interesse! Das hölzerne Bein ist mir lieber als ein Dutzend elfenbeinerne Nymphenfüsschen!"¹

The hexameter would have been the most natural form for Gessner to adopt in his idyls after the example set by Klopstock and Kleist, and by Bodmer in his *Patriarchaden*, especially as that is also the meter of the classic idyls. But at the advice of Ramler he began to write in a rhythmical prose,² which together with a poetic and elevated style he adopted in nearly all his works. Everywhere occur fragments of iambic³ or dactylic verse, occasionally even a whole hexameter line.⁴ This rhythmical prose appears in the works of many of the immediate imitators of Gessner, especially writers of idyls, some of whom tried to hide their inability to put their weak products into a strict poetical form, and hence chose this easier rhythmical form.

The idyl or *Genre-bild* suited Gessner's peculiar talent. But with success came the ambition to produce some greater work. Under the influence of Klopstock and the Patriarchal epics of the Swiss, he wrote *Der Tod Abels* which was considered by his

¹ In *Frankf. Gel. Anz.*, 1772.

² Later Ramler became possessed with the mania to "improve" the works of his friends. Among other "improvements" he turned Gessner's prose idyls into verse and published them under the title: *Gessner's auserlesene Idyllen in Verse gebracht* (Berlin 1787).

³ So in idyl I there are long iambic passages; e. g. "Die, Daphne! dies allein, belohne meine Lieder, dies sei mein Ruhm, dass mir an deiner Seite, aus deinem holden Auge Beifall lächle."

⁴ E. g., in Gessner's wellknown idyl *Mirtil* (No. 5), we meet the following dactylic prose, the latter part of it constituting an hexameter line:

"Itzt schwieg er und sah mit thranendem Aug' auf den Greisen;
Wie er lächelnd da liegt und schlummert! sprach er itzt schluchzend."

contemporaries, especially in France, as his best work. He describes in it the same idyllic world as in his idyls, with the same lack of action, and inability to characterize. Abel is the embodiment of good, Cain of evil, but as Gessner could create no genuine human villain, there is no real climax. *Der erste Schiffer* (1762), altogether pastoral in its character, is considered Gessner's best work both as to the plot and style.¹

Gessner informs us, that in his idyls he took Theocritus for his model. He says: "Ich habe den Theokrit immer für das beste

*Gessner and
Theocritus.*

Muster in dieser Art Gedichte gehalten. — Ich habe meine Regeln in diesem Muster gesucht." And outwardly he did imitate Theocritus and the ancients in

choosing their shepherd-names, as Daphnis and Daphne, Amyntas and Alexis, Damon and Thyrsis, Phillis and Chloe, Tityrus and Menalkas; further, by the introduction of satyrs and fauns, by the use of songs and refrains, and by referring to the ordinary occupations of shepherd-life. Yet there is a wide difference between the two: Gessner described a beautified nature which he adorned with Dresden China shepherds. Theocritus described human characters to whom he gave an appropriate natural background. Seemingly Gessner himself did not appreciate in all its extent the difference between himself and Theocritus. This self-deception may to some extent be explained by Gessner's inability to read Greek; it is possible that the French translation of Theocritus, which he used, may have blurred the distinctness and vigor of the original outlines. So in the introduction to his idyls Gessner several times speaks of the *unverdorbene Herzen* and *sanfte Miene der Unschuld ihrer Liebe* of the shepherds of Theocritus, as if they, too, belonged to an innocent Arcadia. By omitting such realistic features as seemed to him inappropriate according to his standard,² he

¹ Frey says in his introduction to Gessner's works: "Über dem ganzen Werkchen ist ein unendlicher Zauber süßser Sehnsucht und nirgends schimmert Gessner's traumhafte Welt in solchem Glanze, wie hier." Cf. Koberstein V. 57, 11.

² "Zwar weiss ich wohl dass einige wenige Ausdrücke und Bilder in Theokrit bei so sehr abgeänderten Sitten uns verächtlich worden sind; dergleichen Um-

thought that he could produce a world which was as real as that of Theocritus, without the latter's seeming coarseness, not appreciating that it is just the combination of all these small touches in Theocritus which give color and life to his characters and to his poetry.

Though Gessner himself challenges a comparison of his idyls with those of Theocritus, we cannot judge them by the same standard, but must always remember, that the aim and purpose of the two poets was altogether different.¹ It was Gessner's aim to describe a Golden Age, in which piety and virtue and calm happiness reigned supreme; it was his aim to portray a nature beautiful and perfect, like the paradise of the Bible. Besides this there was the *moral purpose*: Gessner wished to strengthen in his readers the desire to lead a life of virtue and contentment, and wished to arouse a deep appreciation of the beauties of nature. And who would deny that Gessner has accomplished this his purpose to a remarkable degree? He must ever be honored on account of the tenderness of his feelings, the purity of his thought, the grace of his presentation, and the harmony of his language.

Even though Gessner misunderstood the character of Theocritus's idyls, yet by turning to them for his models he called the attention of his contemporaries and successors to Theocritus. The need of a greater realism began to make itself felt and gave an impulse towards the later realistic development of the idyl.

If you wish briefly to sum up the characteristics of Gessner's idyls, it can be best done in the words of Goethe: "Malender Dichter! — Dazu charakterisiert sich Gessner selbst, und wer mit Lesingen der ganzen Gattung ungünstig wäre, würde hier wenig zu loben finden: Mit dem empfindlichsten Auge für die Schönheiten der Natur hat G. reizende Gegenden durchwandelt, in seiner Einbildungskraft zusammengesetzt, verschönert — und so standen

ständig hab ich zu vermeiden getrachtet." See Introduction to Gessner's Idyls, p. 65.

¹ Concerning the character of the idyls of Theocritus, see page 11.

paradiesische Landschaften vor seiner Seele. Ohne Figuren ist eine Landschaft todt; er schuf sich also Gestalten aus seiner schmachtenden Empfindung und erhöhten Phantasie, staffierte sein Gemälde damit, und so wurden seine Idyllen. Und in diesem Geiste lese man sie! und man wird über seine Meisterschaft erstaunen."¹

Gessner's ideal pastoral idyl is the culmination of the pastoral literature which has been introduced into Germany at the beginning of the seventeenth century. But this culmination also brought with it a surfeit and a reaction, by which the unreal elements of this literature were thrown off, just as Goethe overcame his sentimental Werther-mood by giving expression to it in *Werther's Leiden*. After Gessner the notes of the shepherd's pipe, which had been heard on every hillside, were soon to die away in German literature. His strains were not the beginning of a new era. They were the swan's song of one about to end.

Most of the immediate imitators of Gessner in their desire to be original substituted fishermen and gardeners for the shepherds.

The imitators of Gessner. Yet we discern no real advance in the works of these imitators; their atmosphere and setting is the same innocent and perfect Arcadia which we find in Gessner; the characters represented are Gessner's shepherds in the garb of fishermen. These idyls are not only narrative and descriptive, but the moral and religious element occupies a most prominent position. The authors who persisted in clinging to this ideal world of innocent Arcadian existence thereby showed that they were untouched by the re-awakening influence which began to dominate German literature, and that they retained the phantom ideal, which others had already cast aside. Hence much of the work of these imitators is of a very low order of merit; in fact, Julian Schmidt places it among the least enjoyable literary products of the time. Two of the imitators of Gessner, Kleist and Bronner, rise above the others in ability and mastery of form.

¹ See *Frankf. Gel. Anz.* 1772.

Ewald Christian v. Kleist who had exerted a great influence upon Gessner by his descriptive poem *Der Frühling*¹ is now in turn led by Gessner's works to try his hand at writing idyls.² Even in his earliest idyllic works³ written before Gessner's idyls he shows a tendency to turn away from the world of shepherds. So in *Amynt* (1751) and in other poems the shepherd element has almost vanished. Now when Gessner's example led him to write idyls, he endeavors to enlarge their scope. In the introduction to his *Neue Gedichte* (1758) he says, that the French by taking the subject matter for the idyl from shepherd-life only, had made the limits of the idyl altogether too narrow; Kleist thought that other phases of country life were equally suitable for idyllic treatment. However, as Kleist's aim was moral and religious, he insisted that only pure and pleasing pictures should be given, trivial and unenjoyable traits were to be carefully removed. In his *Milon und Iris* and *Irin* he contributed a gardener-idyl and a fisher-idyl. These, like all his works, are full of pious sentiment; pray to God, rely upon him; He directs the world for the best; He will bestow a lasting happiness upon all who obey His will.⁴ The idyls of J. Chr. Blum,⁵ though written in a pleasing

¹ See page 32.

² In imitation of Gessner Kleist wrote the gardener-idyl *Milon und Iris* 1758 and his fisher-idyl *Irin* 1758.

³ See note 2, p. 32.

⁴ So in *Irin* the son admires the beauty of the sea and shore, but the most important part of the idyl are the moral precepts of the father:

"O bleib der Tugend immer Treu
Und weine mit den weinenden
Und gieb von deinem Vorrat gern
Den Armen."

In order to complete the *moral*, even though it makes the idyl as such less perfect, the death of *Irin* is mentioned, and that the son

"folgete
Stets diesen Lehren. Segen kam
Auf ihn. Sein langes Leben dünkt
Ihm auch ein Frühlingstag zu sein."

⁵ See Koberstein V. 60. Several of Blum's idyls written in blank verse had been printed in the Göttinger Musenalmanach, before they were collected and published in the year 1773.

form, are unimportant in themselves and in the influence they exerted.

Kleist wrote only one fisher-idyl, His example was followed by one whose name is inseparably connected with idyls dealing exclusively with the life of fishermen, Franz Xaver Bronner¹ (1758—1850). In his youth he had been a most ardent reader and admirer of Gessner, and early tried his hand at translating idyls from the Greek. From the window of his cell in a Benedictine convent he had a fine view of the Danube and of a fisher-village, so that he at all times saw fishermen plying their trade among the small islands that dotted the water. This sight aroused his interest in the village-life, and led him to the composition of his first fisher-idyls. Diffident of his own powers he did not venture to publish these idyls, until after his flight from the convent to Switzerland. Here he met Gessner who encouraged him in his writing of fisher-idyls, and introduced his first volume to the public in 1787.² Re-assured by the success which greeted this publication he issued his *Neue Fischergedichte und Erzählungen* in 1794.

With little originality Bronner everywhere shows the influence of the models whom he followed. In all his idyls he adopted the rhythmical and lofty prose of Gessner and the moralizing tone of

¹ See Bronner's Introd. to Vol. II. 24, where he makes special mention of Kleist's *Irin* "eine der lieblichsten versificierten Fischeridyllen. Wer hört nicht gern den frommen Vater zu, der seinem Sohne beym Reusenlegen die schönsten Lehren ertheilt? Und wer fühlt sich nicht sanft gerührt, wenn er den Schluss liest, aus dem ein so feiner Ton süsßer Wehmuth lispelt?— Möchten nur die folgenden Fischergedichte auch so allgemein gefallen, als Kleist's *Irin*." See Gervinus IV, 188.

² *Fischergedichten und Erzählungen* mit einem Vorwort von Gessner, 1787. — Among other things Gessner says: "Der Verfasser hat diese Gedichte in einsamen Stunden der Musse verfertigt; vom Fenster seiner Kloster-zelle, wo er die Jahre seiner Jugend auch unter ernstern Studien der Mathematik und Naturkunde hinbrachte, hatte er die ausgebreitete Aussicht auf einen Flusse, und seine schattenreichen Ufer, und auf die anmuthigen Inseln, die er umschwamm. Bey der Lektur des Theokrit, Virgil und Sannazar staunte er diese Scenen an, beobachtete die mannigfaltigen Schönheiten, die vor ihm lagen und die Bewohner der Gegend, deren meiste Beschäftigung der Fischfang ist, ward begeistert, und schrieb so, was er sah, was ihn rührte, und so entstanden seine ersten Fischergedichte." See p. 3.

Kleist. *Die erste Fischerin* is an evident and weak imitation of Gessner's *Der erste Schiffer*, and the idyl *Der Bad* seems to be based upon the bathing scene in Thomson's *Seasons*.

In the introduction to his idyls Bronner justifies his selection of fishermen for the actors in his descriptive idyllic poems by citing the example of classic authors, of Sannazaro and of Kleist, and claims that fishermen are fully as capable of idealized treatment as are shepherds;¹ furthermore, the fisheridyl had the advantage of not being worn threadbare.² And he was acquainted with the life of the fisherfolk; for years had he studied and observed their ways and habits, their daily work and pleasures. He says himself: "Erinnern Sie sich nur, dass ich, sieben Jahre lang, täglich ein Fischerdorf mit aller seiner Geschäftigkeit vor Augen hatte; dann werden Sie es ganz begreiflich finden, wie sich meine Phantasie allmählich mit Fischern bevölkern konnte."³

In spite of this fact, that Bronner's idyls are based on personal observation and actual acquaintance, and ought therefore to contain real human characters, we feel at once that it is not the fresh and invigorating sea-air which pervades them, but the perfumed atmosphere of conventionality and idealization. And even Bronner himself appreciated that his characters are not men of flesh and blood. On the contrary, his very definition of fisheridyl indicates his purpose to describe an idealized and innocent world.⁴ The fisherman's garb was but a mask for ideal characters, in some of whom he even expected his friends to recognize themselves.⁵ The very names he gives his fishermen show their un-

¹ Introd. to Vol. II., p. 9 of Bronner's works.

² Introd. to Vol. II., 9.

³ Introd. to Vol. I., 10.

⁴ Bronner defines the fisher-idyl as "einzelne den sanften Gefühlen Schmeichelnde Bilder. Handlungen und kleine Scenen aus dem Fischerleben." Later he adds: "Ihre Charaktere dürfen und sollen veredelt sein, wie man sie vielleicht nirgend antrifft, aber wie man sie doch anzutreffen hoffen kann." See Introd. to Vol. II., pp. 6, 8.

⁵ "Meine Bekannten werden sich, bey der Durchlesung derselben, wohl selbst erkennen." See Introd. Vol. I., 12.

real character and their kinship to Gessner's shepherds: *Clinias* and hardly astonished at meeting a mythological incident, as when a Naiad transforms the drowning Calmus into a water-plant. The *Theone*, *Palemon* and *Myrson*, *Asphalion* and *Lyde*. The time of the idyls is laid in a remote and hazy antiquity, wherefore we are characters all belong to the innocent Golden Age; if at any time a fisherman does commit any wrong, no motive is assigned for his action, and he immediately repents.¹ Dramatic dialogue is lacking and the action is stifled by the long descriptions and more especially by the moralizing reflections.² The very titles are often suggestive of sermons: *Geniess im Stillen*, *Mässigung*, *Die wahren Reichen*, etc.

Real fishermen of his day Bronner did attempt to introduce into two of his idyls, but with little success. He thinks it necessary, however, to preface the first of these idyls with an apology to the reader for thus rudely taking him away from the pleasing illusion of a "better world", an illusion so necessary to idyllic poetry.³ But even in this idyl, *Der Fischer bey Hofe, ein modernes Fischergespräch*, the purpose is didactic, the fisher-element disappears, and the idyl becomes a satire, in which *Veit* describes to *Hans* his impression of a visit at court. The second attempt at a realistic idyl again shows Gessner's influence; just as Gessner had closed his idyls with *eine Schweizer-idylle*, in which the soldier with the

¹ So e. g. the idyl *Die Rache des Redlichen*.

² That Bronner considered these moralizing reflections an important ingredient of his idyls we see by his own statement: "Vermögen die eingestreuten moralischen Züge, hier und da, eine schönere Empfindung in unverdorbenen Herzen zu wecken, so halte ich mich doppelt für meine Arbeit belohnt." See Introd. to Vol. I., 12.

³ Bronner's apology which also shows the character of his work is as follows: "Ich mende hier unter Gedichte, deren handelnde Personen alle in ein enferntes Zeitalter zurückgesetzt sind, ein Fischergespräch aus neueren Zeiten. Zwar muss ich fürchten meine Leser dadurch auf eine unangenehme Weise aus dem Traume zu wecken, in den ich sie gern eingewiegt hätte, um ihnen desto bequemer Bilder aus einer bessern Welt vormahlen zu können. Allein ich hoffe doch, das kleine Stück, eben weil es modern ist, werde so viel Interesse haben, dass man mir die gefissentliche Aufhebung einer dieser Dichtungsart so vortheilhaftes Täuschung zu gut halten wird." See Bronner Vol. I. 98.

wooden leg describes a battle, so Bronner makes a ballad celebrating the Swiss struggle for liberty the chief element of his last idyl, *Schwanau, ein Schweizerisches Fischergedicht*.

Other writers of little or no original powers imitated Gessner and Kleist in their idyls, losing themselves in reflections and vague descriptions of an idealized and hazy world of innocence. Of these authors Brückner is of importance only in so far as he in no small degree influenced the first idyls of Voss, with whom he was intimately associated. Brückner's *Idyllen aus einer Unschuldswelt* appeared 1774—5 in the *Göttinger Musenalmanach*,¹ of which Voss was editor. These idyls also contain descriptions of innocent precocious child-life (as *Die Unschuld, Jesus als Kind*) later published under the title of *Kinderidyllen*. — Brückner's *Unschuldswelt* together with works of a similar nature, Wilmsen's *Sammlung für Geist und Herz*, and Breitenbauch's *Jüdische Schäfergedichte* mark the lowest ebb which German literature of this period reached.²

Meanwhile the new and vigorous era of a literary re-awakening had begun in Germany; literature became a genuine reflection of actual conditions and real life. The decaying literature descriptive of an imaginary Golden Age, heard its doom from every side, best expressed in the words with which Gryphius closes his *Schwärmer Schaffer*:

“Aus Nymfen! Schäffer aus! Aus mit der Schäfferey!
Man kehre aufs Schloss! Last Kleid und Hirtenstab heim senden
Weil Lysis nun entbäumt, ist dieses Spiel zu Enden.”

¹ Sauer in *Göttinger Dichterbund (Deut. Nat. Lit.)* p. 31 says: “Es macht keinen erfreulichen Eindruck dass dieser Almanach der mit Klopstock so kräftig einsetzte, mit Brückner so schwächlich endet.”

² See Julian Schmidt *Gesch. d. Deut. Lit.*

CHAPTER V.

THE REALISTIC IDYL.

With the middle of the eighteenth century the day of a new literary era began to dawn upon Germany. The foreign forms and materials which had dominated German literature for centuries were overthrown by destructive criticism and by the impetuous onsets of the Storm and Stress period, whereupon followed the most remarkable development of a classic national literature which modern times have witnessed. In the idyl we can see the same successive stages which German literature as a whole passed through, namely: 1. the theory of the idyl perfected in the era of criticism; 2. the rough naturalistic idyl in the Storm and Stress period represented by Maler Müller; 3. the idyl in its German classic perfection, at least as to form, in the works of Voss.

The critics immediately following Gessner, especially Schlegel¹ and Ramler,² find only words of approbation for Gessner, considering his style and conception of the idyl almost perfect. But with quickening literary life in Germany, men began to doubt whether the idyl in Germany had been developed along right lines. Was this idealized description of a Golden Age the highest possible devel-

¹ A. J. Schlegel in his edition of Batteux, 1751, still characterizes *Schäferdichtung* as follows: "Ihr wesentlicher Inhalt sind die sanften Empfindungen eines glückseligen Lebens, die vermittelt einer einfachen weder heroischen noch lächerlichen, sondern natürlichen Handlung entwickelt werden, und in der für sie gehörigen Scene, in der reizenden Scene der Natur, aufgestellt werden." He lays stress, then, upon action as the essence of the pastoral, but action that includes no ordinary labor. In the second edition, 1759, however, in the article *Von dem eigentlichen Gegenstande des Schäfergedichts* he accepts and approves of Gessner's descriptive idyls with their moral reflections as a new kind of pastoral.

² In the second edition of Ramler's Batteux, 1762, Ramler says that Gessner had written in the true spirit of Theocritus: "Man findet hier gleich Süssigkeit,

opment of this literary form? Could the unreal, hazy characters of Gessner's idyls be ranked with the real shepherds of Theocritus?¹

The review of Schlegel's treatise by Mendelssohn in *Briefe die neueste Literatur betreffend*, Berlin (1762) marks the first important advance in theory. He defines the idyl as "*der sinnlichste Ausdruck der höchst verschönerten Leidenschaften und Empfindungen solcher Menschen, die in kleineren Gesellschaften leben.*" Mendelssohn defends local coloring in the idyl as over against the conventional background which Schlegel demanded, and advocates the introduction of more complex action and motives than an innocent Arcadia could offer. Mendelssohn claims that the peasant of the time, with some degree of idealization to be sure, could well be made the subject of idyllic treatment. In laying down this principle Mendelssohn made a great advance, for he thus brings the idyl back to the actual life of the immediate present. But Mendelssohn places Theocritus, Vergil and Gessner in one and the same category of idyllic writers, and thereby shows that he did not carefully distinguish genuine naive feeling from sentimentality.

It was reserved for Herder,² as he was the pioneer in the theory of all modern German poetry and culture, to lay down the principle governing realistic idyllic poetry. In his *Fragmente* he points out for the first time the impassable chasm which separated Theocritus and Gessner. The emotions and passions of Gessner's

gleiche Naivetät, gleiche Unschuld in den Sitten. Seine Empfindungen sind mannigfaltig, seine Plane regelmässig, nichts ist schöner als seine Colorit. Er hat zwar nur in Prosa gesungen, allein seine Prosa ist so wohlklingend, dass wir den Klang des Theokritischen Verses nur wenig vermissen."

¹ Koberstein V. 59, states that the first testimony of this change of feeling which he could find occurs in a letter from Abbt to Mendelssohn in the year 1762. Abbt writes (see *vermischte Werke* 3, 60): "Dieser Tage las ich etwas von Idyllen, fieng an darüber nachzudenken, dass sie für unsere Zeiten und für unsere Länder immer sehr ungeschmackt sein müssten, weil weder Natur noch Staat die Originalien dazu geben können."

² See Herder's *Fragmente über die neuere deutsche Litteratur*, the chapter headed *Theokrit und Gessner*, 1767.

are made so pure and ethereal that they cease to be passions, while Theocritus stands on the soil of real nature, his shepherds have really human passions; their innocence is the naive innocence of the child, while Gessner's shepherds do not give the impression of being artless and ingenuous. In the words of Herder: "Wenn Ramler sagt, man finde bei Gessner eine gleiche Süßigkeit wie bei Theokrit, so ist die Süßigkeit des Griechen noch ein klarer Wassertrank aus dem pierischen Quell der Musen, der Trank des deutschen dagegen ist verzuckert."

Herder wished that idyllic literature should no longer be a mere conventional presentation of ideal life, but should become a plant of native growth and development, grounded in the rich soil of actual popular life. This principle he laid down in the following words: "*Nicht nachahmen sondern im Sinne des eigenen Geistes nachschaffen.*" This return of idyllic poetry to the actual present excluded from the idyl the conventional, virtuous and perfect characters, which were so utterly unreal. Only by representing human characters, with all their weaknesses as well as excellences, could the idyl attain its best and highest form. Herder states his ideal of the purpose of the idyl as follows: "Wenn man Empfindungen und Leidenschaften der Menschen in kleinen Gesellschaften so sinnlich zeigt, dass wir auf den Augenblick mit ihnen Schäfer werden, und so weit verschönert zeigt, dass wir es für den Augenblick werden wollen: *Kurz bis zu Illusion und zum höchsten Wohlgefallen erhebt sich der Zweck der Idylle, nicht aber bis zum Ausdruck der Vollkommenheit oder zur moralischen Besserung.*" Under Herder's influence *poetic beauty* was no longer confounded with *moral perfection*, and thus a return to depicting real life was made possible. Furthermore, Lessing had given the death blow to purely descriptive poetry in his *Laokoon* (1766), that famous analysis of the difference between the plastic arts and poetry, where he claims that *action* constitutes the essence of poetry.

Thus criticism cleared the ground and prepared the soil for the wonderful growth which was so soon to burst forth. Men turned away with a feeling of surfeit from the old literary forms and

subject-matter, and rejoiced to behold the dawning glory of classic German literature. In this great German renaissance the idyl, too, was regenerated; the principles which Herder had laid down were crystallized into form in the realistic idyls of two authors of superior merit, Maler Müller and Voss.

Fredrich Müller (1749—1825), one of the most fruitful poets of the Storm and Stress period, was born in the Rhenish Palatinate, which he has celebrated in his best idyls.

Maler Müller.

He early showed artistic talent, and for some time was in the service of a Prince of the Palatinate as a painter and engraver. When 21 years old he came to Mannheim where he spent his happiest and most productive years in a congenial literary circle, assuming the pen-name of *ein junger Maler*, later *Maler Müller*. Through the recommendation of Goethe he obtained a pension to go to Italy to continue his studies as an artist. He spent the remainder of his rather unhappy life at Rome without accomplishing much further.¹ The very name he assumed, *Maler Müller*, indicates how his efforts were divided between painting and literature, a distraction of interests fatal to the highest success in either.

Müller won the favor of the public of the Storm and Stress period by his idyls,² since he, as hardly any one else felt and gave expression to the various forces which were at work in this period of fermentation and transition. It is interesting to notice how the old and the new influences struggled for the mastery in his mind and in his works, a reflection of a struggle which was going

¹ He died at Rome in 1825. His wellknown epitaph, written by himself reads as follows;

“Wenig gekannt und wenig geschätzt, hab’ ich beim Wirken.

Nach dem Wahren gestrebt, und mein höchster Genuss.

War die Erkenntniß des Schönen und Grossen — *ich habe gelebet!*

Dass Fortuna mich nie geliebet, verzeih ich ihr gern.”

² The idyls of Maler Müller in the order of publication are: in 1775 appeared *Der erschlagene Abel, Bacchidon und Milon, Der Satyr Mopsus, Der Faun, Die Schaafschur*; in 1778 *Adams erstes Erwachen und erste selige Nächte. Das Nusskernen* and *Ulrich von Kossheim* were not published till 1811, but must have been written much earlier.

on all over Germany in all phases of literary and intellectual life. Müller, however, never emerged from his period of Storm and Stress. Although in his idyls he passed from the imitation of Klopstock and Gessner to a natural and naive presentation of life, yet his works from beginning to end bear the stamp of Storm and Stress, and are throughout characterized by a rough naturalism and an entire lack of restraint. We obtain the best view of the influences affecting Müller by considering his idyls in three groups:

1. Those depicting the Patriarchal Age;
2. The faun and satyr idyls, based upon classic models;
3. The idyls describing the village-life of his own home near the Rhine.

Klopstock and Gessner exerted a great influence upon young Müller; their example led him to select Biblical subjects as material for his idyls. His *Der erschlagene Abel* is an imitation of Gessner's *Der Tod Abels*. An episode in the latter work Müller expands into the idyllic romance *Adams erstes Erwachen und erste selige Nächte*. Yet though Müller in these works adopts Gessner's rhythmical prose and still makes his characters too sentimental, we at once notice an improvement upon Gessner's in characterization; instead of Gessner's vague, paradisaical forms Müller has produced characters with real human feelings and passions. The different persons appear sharply outlined against the background of an idealized nature. For instance, in Müller's idyl Cain is a real villain who, however, succeeds in arousing our sympathy. The style is lively and vigorous.¹

In the faun and satyr idyls Müller frees himself still more from Gessner's influence. The satyr *Mopsus*, *Bacchidon und Milton*, and *Der Faun* (1775), even though sometimes coarse and burlesque, are instinct with life and action, and are written in that vigorous language which betrays the dramatist of the Storm and Stress

¹ See Hettner's edition of Maler Müller p. VI.

period. They are also full of sparkling humor of which we find no trace in Gessner.¹ In *Mopsus*, the counterpart of Polyphemus of Theocritus, how ludicrous is the lament of the deformed satyr, whom the nymph Persina, pretending to answer his suit with favor, had decoyed into the brambles! The most humorous, however, of his idyls is the second, describing the youthful eagerness of Milon to read his poem to Bacchidon, whose attention he had to buy by offering him wine. The garrulous old man with his unquenchable thirst continually interrupts him with:

“Halt ein, Milon, keine Silbe weiter! Hierauf muss erst getrunken sein!”

When the reading is ended and the wine, too, is gone, how droll is Bacchidon's elegy² to the empty wine-flask!³

The third idyl of this group possesses the proper brevity for an idyl, while the previous ones are too diffuse. It tells of the lament of Molon at the funeral-pyre of his wife. His rough, wild nature, his genuine emotion, his love for the wine-flask from which he drinks repeatedly between his sighs and lamentations, is all set forth in vigorous and choppy language thoroughly characteristic of the uncouth character depicted.

The third group of idyls, *volkstümlich-deutsche*, Müller treats in a manner wholly independent and original. Here he describes peasant life of his home in the Palatinate (*Die Schaafschor* and

¹ Though Bronner, in his introduction to his idyls, states that in private life Gessner was exceedingly witty.

² “Todt, runzlicht, entstellt liegst du, zuvor so angespannter Schlauch! Gern, herzlichster Schlauch, wollt' ich länger bei deiner Leiche weinen, stünde nur, wie sich's gebührt', neben deiner Bahre ein wohlgezogenes junges vollbackiges Schläuchlein, dein Sohn oder Enkel, der mir hernach mit seinem Balsam wieder abwüschte meiner Thränen Salz. Aber wehe mir Trauermann! Der erblichene war eine Waise. — Leer! zu früh leer! Ach armer Weinschlauch!” Hettner's *Müller*, p. 83.

³ The review in *Allgemeine Deutsche Bibliothek* (XXXI. I 222) says: Die Beschreibung der ganzen Scene, der Ausdruck der rohen ungeschminkten Natur in der Trauerklage des Alten und des Kleinen hat etwas so Wahres, Charakteristisches, Eindringendes, dass es Herz und Sinn rührt. Die Sprache ist hart, verstümmelt, hingeworfen, wie es für seine Faunen, die er einmal als ehrliche Wilde bildet, geziemt.”

Das Nusskernen) or goes back to the chivalry of the Middle Ages for his material (*Ulrich von Kossheim*). Never before in German literature had the simple life of the common people been depicted with such force and vigor, with such faithful adherence to reality, as here in Müller's idyls descriptive of his Rhenish home. In the German poetry of the Middle Ages we see the beginnings of a *Dorfgeschichte*; but this phase of life had for centuries remained entirely disregarded, until *Das Schaafschur* again taught men to appreciate actual simple life of the present, and thereby gave renewed impulse to the *Dorfgeschichte* which in the modern novel has proven to be such a rich and productive field.¹ Müller's descriptions are so true to life and full of vigor, so full of small traits of everyday occurrences that these idyls seem almost photographic representations of the life of his native village. His love for folksong and folk-tales crops out everywhere in the many selections from these sources which he introduces. But unfortunately, satirical and polemical elements directed against pedantic critics and conventionality, interesting as they are from a literary point of view, weaken the poetic effect of these idyls.²

Maler Müller put his idyls on the basis of reality. But there is a certain wildness in his scenes and characterization, a roughness in his prose, which shows that he had not overcome the

¹ "Wir dürfen eine begünstigte Gattung unseres Jahrhunderts, die Dorfgeschichte, auf Müllers Versuche zurückleiten." See Müllers Werke in *Deut. Nat. Lit.* edited by August Sauer, p. V.

² The following passage illustrates both the vigorous style and polemical tendency of Müllers writings. In *Die Schaafschur* one of the characters, Walter, in speaking of ideal shepherds virtually attacks Gessner and his followers. Walter says: "Der Schulmeister bringt mir weiss der Kukuk was für ein Buch, heisst Idyllen, Gedrucktes, so von Schäfern; schreit, lärmt und jubiliert und gaudirt sich wegen des Zeugs, so drinnen steht; liest mir dann auch hin und wieder etliches vor. — Ei freilich, sagt ich; wo giebt's denn Schäfer wie diese? Das Schäfer? Das sind mir curiose Leute, die weiss der Henker wie leben; fühlen nicht, wie wir andere Menschen, Hitze oder Kälte: hungern oder dursten nicht; leben nur von Rosenthau und Blumen und was des schönen süssen Zeugs noch mehr ist, das sie bei jeder Gelegenheit einem so widerlich entgegenplaudern, dass es einem mein Seel' wider den Mann geht. — Das Pack da ist nicht von Herzen lustig, nicht von Herzen traurig, alles im Traume nur." etc. See Hettner's *Müller* p. 87.

Storm and Stress period, and attained classic calmness and self-control.

Between the two extremes, the pleasing form and unreal world of Gessner and the rough naturalism of Müller, stands Voss.

While Gessner marked the culmination of the *pastoral* idyl, descriptive of an *ideal* state of existence, in Voss the *realistic* idyl of the classical period of German literature reached its highest development. He wished to describe in his idyl actual simple life as it existed in Germany, and to do this in the *spirit* of Theocritus. We are told that the idyls of Theocritus had their roots in Homer. The study of Homer, too, greatly influenced the character of the idyls of Voss. And so after various deviations and wanderings the idyl comes back to the form and spirit of the idyls of Theocritus, and the circle is complete.

*Johann Heinrich Voss*¹ (1751—1826) was born and lived in Northern Germany, and it is the natural scenery and the life of Northern Germany which is reflected in his works, especially in his idyls. While struggling along in poverty as a private tutor he sent some poems to *Göttinger Musenalmanach* (1772), and thus began a correspondence with the editor Boie (afterwards his brother-in-law), which led to his going to Göttingen in the same year. He and some associates of similar bent of mind founded the well-known *Göttinger Dichterbund* (*Hainbund*), a circle of poets of no small importance in the history of literary Germany. He also assumed the editorship of the *Musenalmanach* in which most of his idyls first appeared. From 1775—1802 he again lived in Northern Germany, (at Wandsbeck, Otterndorf and Eutin), most of the time as teacher and rector at a *Gymnasium*. These years were the happiest and most productive years of his life: now he wrote his idyls, carried on his classical studies, especially in Homer, and produced his incomparable translation of the *Odyssey*

¹ See *Johan Heinrich Voss* in *Göttinger Dichterbund* of *Deut. Nat. Lit.*, edited by August Sauer.- Also *Johann Heinrich Voss* by Wilhelm Herbst, 3 vols., 1872—1876.

(1780). In 1802 he moved to Jena where he was in close intercourse with the Weimar circle, especially with Goethe. But soon an advantageous offer induced him to go to Heidelberg (1805). Here during his last years he busied himself with collecting and filing his earlier poems.

Voss shows in his works that he, too, was carried away by the influences which dominated his contemporaries. The whole period was characterized by a longing to flee from the artificial and overtrained culture of the so-called "Zopfzeit" back to simplicity of life and manners, — and this feeling is the very soul of all idyllic poetry. We see this feeling manifested in the extravagant joy with which men hailed Rousseau's attack upon civilization and his theory of a return to a state of nature, in the deep and universal appreciation of nature and country life, in the growing respect and admiration for the folksong, and in the revolt from Neo-classicism in literature. The age went back to the classic Greek literature for its inspiration; for now men were able to understand and appreciate Greek art and literature with a deeper and fuller sense of its beauty and greatness.

Early in his youth Voss's attention had been called to the idyl by his bosom friend *Brückner*, a devout admirer and imitator of Gessner in his *Idyllen aus einer Unschuldswelt*.¹ Gessner and Klopstock also charmed the receptive mind of young Voss.² At Göttingen, however, he at once showed a predilection for classical studies; especially did ancient Hellas attract him, after Herder's writings had opened his eyes to the grandness and beauty of Homer. He also made Theocritus and the bucolic poets an object of thorough study. Notes were collected for a future edition of Bion and Moschus, and he had in mind to write a long treatise on

¹ See page 52; also Herbst's *Voss* II. 84.

² At the end of 1774 Voss wrote to Brückner: "Gessner ist so leicht als Gellert und doch ein Dichter, ein grosser Dichter." — But only a few months later he speaks of how Gessner had imitated the Italians and filled his world with Arcadian inhabitants. "Was gibt du mir," he adds, "wenn ich dir zeige, dass er nur da vortrefflich ist, wo er wirkliche Natur hat".

ancient pastoral poetry. The study of the Greek literature, especially of Theocritus and Homer, determined both the form and the character of his idyls.

One reason why the idyl attracted Voss was the sense of his poetic limitations. He felt that he did not possess the originality and the creative power to produce great masterpieces in epic or dramatic poetry. Least of all was he a lyric poet. But if any one of these forms by itself was beyond his poetic powers, might he not accomplish something of value and of *lasting* value in the less pretentious idyl, into which he might introduce elements from all these forms of poetry?

Through the study of Theocritus and Homer, Voss came to the conclusion, that the hexameter was best fitted to give dignity and stateliness to his poetry.¹ But of greater consequence was their influence on Voss in his choice of subject-matter. Like Theocritus he wished to depict reality, not an imaginary shepherd-world.² But his was not a slavish imitation; in the *spirit* of Theocritus he embodied in poetic form the idyllic features of his own time and of his native country with their local coloring and in their definite forms. He studied conditions about him, in order to depict them truthfully. So in March, 1775, he wrote to Ernestine Boie that he intended to visit Dithmarschen "um Studien zu Dietmarscher Idylle zu machen." He adds: "Ich gläube dass diese Dich-

¹ Klopstock's hexameters were from a technical point of view very halting; many of them can hardly be scanned. It is Voss's great merit that he first reduced the German hexameter to sound metrical rules and fully naturalized it in German poetry. The metrical diletanteism of Goethe and Schiller advanced under Voss's influence to a mastery of this form of which Herbst says: "Unsere neuere Kunstpoesie in charakterischen Hauptzweigen hat sich recht eigentlich am Hexameter, dem *Culturvers im eminenten Sinn*, aufgerichtet." (Herbst's *Voss*, II. 88).

"Wer eine wahre Form erschafft," says W. von Humboldt with reference to Voss, "der ist der Dauer seiner Arbeit gewiss."

² In a letter to Brückner written while at Göttingen he says: "Ich habe vieles über die Idylle mit dir zu reden. Theokrit hat mich zuerst auf die eigentliche Bestimmung dieser Dichtungsart aufmerksam gemacht. Man sieht bei ihm nichts von idealischer Welt und verfeinerten Schäfern. Er hat sicilische Natur und sicilische Schäfer, die oft so pöbelhaft sprechen, wie unsere Bauern." See Koberstein V. 63.

tungsart grossen Einfluss auf die Menschen haben kann, denn sie ist die einzige, in die die jetzigen *Menschen* (d. h. Landsleute und die niedern Stände die nichts mit der grossen Welt zu schaffen haben) völlig hineinpassen."

The idyls of Voss¹ clearly reveal how for a long time he kept groping about seeking for proper idyllic material. They show a gradual improvement in choice and treatment of the subject-matter, until he finally found the proper sphere in which he accomplished his best work. Most of his idyls are based on real life, such as had come within his own experience, wherefore they have the effect of an autobiography. In his very first productions he celebrates the theme, which like a thread runs through so many of his later idyls, and finds its highest expression in *Luise*, namely his love for Ernestine Boie. In *Der Morgen*² and *Selmas Geburtstag* behind the names Selma and Selino we at once recognize Voss and his betrothed. But the immaturity of the beginner and the beginner's tendency to follow extraneous influence, are

¹ The Idyls of Voss most naturally fall into four groups, corresponding to Voss's residence at Göttingen, Wandsbeck, Otterndorf and Eutin. These idyls appeared first in various periodicals. They are as follows:

1. The Göttingen period 1774—5: *Der Morgen; Selmas Geburtstag, Die Leibeignen* (in two parts).

2. The Wandsbeck period 1776—8: *Die Bleicherin, De Winterawend, Die Elbfahrt, Der Bettler; De Geldhapers, Das Ständchen, Der Riesenhügel; Der Abendschmaus, Der Hagestolz.*

3. The Otterndorf period 1780: *Der bezauberte Teufel, Die Kirschenpflückerin, Der siebenzigste Geburtstag.*

4. The Eutin Period;

<i>Der Geburtstag</i> 1782	} Combined in	
<i>Der Bräutigams Besuch</i> 1783		<i>Luise</i> 1795.
<i>Luise</i> 1784.		

Die Heumad 1784, *Philamon und Baucis*, 1785, *Die Erleichterten* 1800, *Fragment einer Fischeridylle* (language indicates a late date).

The first important publication of Voss works was *Johann Heinrich Voss, vermischte Gedichte und prosaische Aufsätze*, Frankfurt und Leipzig, 1784.

² In *Der Morgen* the sentimental lyrical element is unduly prominent, and Klopstock's angels haunt the poem. So Selma's guardian angel flies to console the absent Selino:

"Und ihr Seraph entflog auf goldnen ätherischen Schwingen
Hin zum fernen Selino."

still noticeable and to a marked degree, especially in the pompous style and the introduction of the "seraphic" element of Klopstock's *Messias*. The angels Sulamith and Thirza, sent to assist at the birth of Selma, sing a responsive cradlesong to the music of the golden harp, in sonorous hexameters out of keeping with their thoughts.¹

With *Die Leibeigenschaft* Voss begins a long series of idyls which have properly been called *Tendenz-Stücke*. As he wrote these idyls with the express purpose of instituting social reform by holding up to view certain social wrongs of the period,² he consciously or unconsciously imbued many of these idyls with the bitterness of satire.³ This bitterness introduced an element which necessarily injured the idyllic atmosphere. Voss was descended from serfs; narratives of his father and others, together with what he himself had actually seen of the curse of bondservice as it still existed in parts of Northern Germany had filled his soul with hatred and indignation against the tyranny of the nobility. His soul burned with a desire to bring about an amelioration in the condition of these peasants. This indignation and reformatory desire prompted the idyls *Die Pferde-*

¹ They even decide to inform her future lover of her birth:
"Meld ihm des Kindes Geburt, du Genius, dem er vertraut ward,
Dass ihm die Ahndung das Herz erläutere würdig zu sein."

² The whole era of the Storm and Stress is characterized by restiveness under restraint and a desire to break the bonds and shackles of tyranny under whatever form they existed (we remember Goethe's "Tyrannen-blut trinken"). This revolutionary tendency also manifested itself in the *Göttinger Bund*, and in many of their poems took the form of a tirade against those whom they considered responsible for the social inequalities which existed. Later while at Wandsbeck when the ardor of youth was somewhat allayed, Voss's tendency became *didactic*; he writes himself, that the work of a poet is "die Sitten des Volks zu bessern und besonders dem verachteten Landmann feinere Begriffe und ein regeres Gefühl seiner Würde beizubringen." See Sauer's *Göttinger Dichterbund*, p. 16. Also Herbst's *Voss* 1. 190.

³ Boie writes to Voss in March 1777: "Ihr Talent liegt in der Idylle. — Sie werden auch unser Juvenal werden, wenn Sie wollen."

knechte and *Der Ährenkranz*, which in parts are characterized by a tone almost savage.¹

This didactic and to some extent satiric element appears in almost all the idyls Voss wrote while at Göttingen and Wandsbeck. *Der Bettler* declaims most bitterly against intolerance; it is based on an actual incident which had come under Voss's immediate observation: a rationalistic and liberalminded minister has been persecuted and deposed by his more orthodox superior. We hear Voss's own indignation when the idyl tells us that the deposed minister is now supported by *Der Bettler*, the cripple Tiess,² and is often obliged to starve, "weil er nur, was Gott gesagt, nicht Menschensatzung, lehrt." Jürgen, the shepherd, is but the mouth-piece of the poet, when he bursts forth: "Kopfhänger ihr, ihr Wolf' in Schafsgestalt." However we feel as if the moralizing element went a little too far when Jürgen adds:

Doch Gott sei euer Richter! Tiess und du
Habt mich so weich gemacht, dass mir so ist,
Sonntag, will's Gott, zum Abendmahl zu gehen."

¹ Michel describes how his uncle in a dream had seen the noblemen feasting in hell:

"Statt der Musik erschallt aus den Wänden ein Heulen und Winseln.
Drauf wird die Tafel gedeckt. Ganz oben setzt sich der Stamherr
Vom hochadligen Haus', ein Strassenräuber. Sein Beinkleid,
Wams und Bienenkapp' ist glühendes Eisen. Sie fressen
Blutiges Menschenfleisch, und trinken siedende Thränen."

² The lame Tiess is probably modelled after the soldier in Hölty's *Das Feuer im Walde* which in turn was a copy of Gessner's *Schweizer-idylle*. Ludwig Hölty (1748—1776) an intimate friend of Voss, wrote several idyls; *Das Feuer im Walde* being by far the best one. He gained entrance into the *Göttingerbund* by a translation of *The Rape of Europa* from the Greek of Moschus, 1770. We trace the influence of Voss's idyls depicting the life of northern Germany in Hölty's *Christel und Hannechen, eine Schnitteridylle*, 1774. Just before Hölty was carried away by consumption he wrote *Der Arme Wilhelm*, in which idyl Wilhelm mourns the premature death of his love and expresses a presentiment that he too soon will die.

J. M. Miller, also of the Göttingen circle, wrote a couple of unimportant idyls (*Daphnis und Daphne, Wilhelm und Lischen*, 1773).

In like manner Voss in the form of the idyl attacks many other real or imagined vices of his times: so he declaims against avarice in *De Geldhapers*, against superstition in *Der Riesenhügel*, against bachelorhood in *Das Ständchen*, against gluttony in *Der Abend-schmaus*. These may be compared to the modern social story or novel which preaches some special social reform.

Yet even in these idyls Voss considered the satirical and didactic element less important than the idyllic. He wished to make the idyl the reflection of life about him, with which he was perfectly familiar, of the manners and customs of his home. The very names he gives to his characters, Hans, Michel, Henning, etc., the introduction of popular sayings, and the outspoken language colored with provincialisms show that he had abandoned entirely the "Frauen- und Unschuldswelt" of Gessner and Brückner, and placed himself on the soil of reality. More and more he drops the satirical tendency in his idyls, and turns to the delineation of the sweet joys of legitimate love and of home life.

The idyls *De Winterawend* and *De Geldhapers*¹ are two excellent *Genrebilder* from peasant life written in Low German dialect.² In these idyls as well as in the ones immediately following them the influence of Theocritus becomes more and more apparent.

¹ Claudius (the editor of *Wandsbecker Bote*) considered *De Winterawend* as Voss's most perfect idyl. Although the dialect to one not thoroughly used to it conceals the excellence of the poem somewhat, yet one can appreciate the following charming song in praise of country life, sung while the members of the family are gathered around the fireplace of a winter-evening. When Peter urges Krischen:

"Sing du, ik groele dato, und im Schorsteen orgelt die Ostwind,"
the latter sings:

Wat ist doch voär en quadlig Ding,
In Wall und Muhr to läwen!
Drum hew ik mi ok vix und vlink
Wol up dat Land begäwen.
As Landmann, läw ik gans gewiss
Vergnögter, as de Kaiser is."

² "Voss hat den Schritt bis zur voller Anwendung des Dialekts gewagt, und so der reichen Dialektdichtung der nachklassischen Zeit den Weg gebahnt." See Sauer's *Introd. to Maler Müller* p. 5.

Voss himself defends his use of dialect by referring to Theocritus's *The Syracusan Women*, which idyl evidently was in his mind when he wrote *De Geldhapers*. The two women of Syracuse force their way through the crowd at the Adonis festival, as the two peasants in Voss's poem press through the crowd of wagons and people on the market place. The former admire the royal horses-of-state, the splendid carpets and Adonis on the silver couch, as the latter the Danish hussars with the bright sabres. Dramatic movement and excellent characterization distinguish this idyl above all others. Sauer claims¹ that were it not for the unusual dialect of the idyls, they would be more popular in Germany than the "still-life" picture of *Der siebzigste Geburtstag*.²

The most perfect of all the idyls in which Voss used the dramatic form combined with lyrical elements, as we find in Theocritus, is *Die Kirschenpflückerin*. The whole idyl is pervaded by the calm and balmy atmosphere of the orchard on a summer's day. How charming is the roguish Rebecka who takes away the ladder from the tree in which Hedewig is picking cherries! The unwilling prisoner is not released, until she has sung a song composed by her lover.³

But the peasant life of the North offered a rather unyielding material for poetic treatment, and besides was too remote from the interest and sympathy of the majority of Voss's readers. Not until Voss in his idyls described scenes and conditions, in which the simplicity of the country and the culture of the city were reconciled and united in perfect harmony, did he fully charm the hearts of his audience. This union of lowly life with high intel-

¹ See Sauer's Introd. to Voss in *Göttinger Dichterbund* (*Deut. Nat. Lit.*) p. LIII.

² Other less important idyls based upon Greek models are *Das Ständchen* (an imitation of Theocritus's *Cyclops*) with its rather forced humor, and *Der Riesenhügel* (imitation of Theocritus's *Magician*, Idyl II.) with the strange refrain in the song of the witch:

"Trommle, trommle den Riesen zum Leichnam, Abrakadabra!"

³ Voss writes in a letter to Gleim to whom he dedicated the idyl: "Es ist ein Versuch, wie weit man die Denkart der Landmädchen veredeln kann."

tual interests Voss found in the country school-house and parsonage, and his choice and treatment of just this field revealed genuine poetic discrimination and even creative power on his part. Here, too, Voss felt perfectly at home. His father had taught school and his wife Luise was the daughter of a country parson. The happiest experiences of his life had come to him in this harbor of peace, upon whose secluded shore the ocean-waves of the troubled world beat only with gentle murmur.

This attractive sphere Voss has depicted in *Der Siebzigste Geburtstag*, and the three idyls which eventually were united into the idyllic epic *Luise*. In *Der siebzigste Geburtstag* Voss has erected a beautiful monument to his parents. He himself is the expected son who brings Ernestine to visit the old home. This poem marks Voss's highest power as a writer of idyls, "eine Perle unserer Litteratur", as Julian Schmidt says. It is replete with the atmosphere of love and restfulness, in its simplicity and brevity it is the most perfect panegyric of happy family life. With what art does the poet describe the mother's busy preparations for the reception of the son and the daughter-in-law who were coming to join in the birthday celebration of the aged father! With what loving minuteness does Voss refer to every detail of his childhood home!¹ With what grace does the young wife on her arrival, when she sees the slumbering father, awaken him with a kiss!² — Voss wrote no other idyl of equal power and objectivity.³

¹ See Voss p. 137, lines 21—30 in *Deut. Nat. Lit.*

² The fine closing lines are: (The mother)

“Öffnete leise die Klink' und liess die Kinder hineingehn.
Aber die junge Frau mit schönem lächelndem Antlitz
Hüpfte hinzu und küsste des Greises Wange. Erschrocken
Sah er empor und hing in seiner Kinder Umarmung.”

³ When Voss for the first time collected and published these idyls in his *Vermischte Gedichte*, we can see by Wieland's review in *Der deutsche Merkur*, August 1785, how they were received by Voss's contemporaries. Wieland says: "Seine Idyllen sind nicht *Kopieen*, nicht idealisierte Nachahmungen des griechischen Hirtendichters: es sind wahre Theokritische Gedichte, nicht bloss in seiner *Manier* sondern mit seinem *Geiste* gedichtet, der durch Idealempychose in unsern Landsmann übergangen zu sein scheint. Gerade so, denke ich . . . würde

When Voss composed *Der siebzigste Geburtstag* he was just completing his translation of the *Odyssey* (1780). Not only did the translation charm all Germany with its beauty and freshness, so that Schiller could say: "Und die Sonne Homers siehe, sie lächelt auch uns", but the *Odyssey* also sets its stamp upon the later idyls of Voss. From now on he employs altogether the epic form, no lyrical elements are introduced, and the conversation is drawn into the epic narrative. Furthermore the minute descriptions of household furniture, of preparations for meals and other duties, point to similar descriptions in the *Odyssey* as the model.

The epic form Voss employed and developed in the idyls *Des Bräutigams Besuch* (1783), *Der Geburtstag*, and *Luise* (1784), each in its brevity and conciseness affording a charming picture of the calm idyllic life in a German country parsonage.¹ All that can be said in praise of *Der siebzigste Geburtstag* is equally true of these idyls. The happiness of ideal home-life is the theme, which Voss describes with all the affection of his heart. And how could it be otherwise? "Die rosenwangige Jungfrau" "die freundliche schöne Luise" is to Voss his own Ernestine, "der ehrwürdige Pfarrer von Grünau" and "die alte verständige Hausfrau" her parents, in whose home he had spent the sunniest days of his life. True, there is a lack of psychological depth in these

Theokrit oder *Homer* selbst diese Natur und Dorfszenen aus unsrer heutigen Welt behandelt und geschildert haben, wenn er in unserer Zeit gelebt, und (wie unser deutscher Theokrit) in der Lage gewesen wäre, die Natur von dieser Seite belauschen und studieren zu können." Furthermore, Wieland praises in these idyls the *Neuheit, Wahrheit, Reichthum der Bilder, Poesie des Styles, Versification, Auswahl der Umstände, Natur und Landleben* and *Rusticität*.

¹ In the words of a critic (in *Neue Bibliothek der schönen Wissenschaften*, vol. 56, 261): "Schon der Kreis, aus dem die handelnden Personen gewählt sind, ist so beschaffen, dass er der Phantasie des Dichters einen günstigen Spielraum eröffnet und den Leser in einen anziehenden Standpunkt versetzt. Wo lassen sich Tugend und Unschuld, Gutherzigkeit und Zufriedenheit mer erwarten, als in der Familie eines würdigen und biedern Landpfarrers, oder, wo wird der gebildete Mann lieber einkehren und sich besser und glücklicher fühlen, wenn er auf dem Lande des Gewühls und Getümmels der Stadt vergessen will."

characters, a lack of individuality in the poetic treatment, a lack of action in the whole plot, but in spite of this or perhaps, in consequence of it, we feel at once soothed, calmed and at home in this peaceful atmosphere and in the presence of these attractive people, whom we after all would not care to have otherwise. Goethe often read these idyls to his circle in Weimar, and we are told that certain passages moved him to tears, and he would close the book with the words: "Eine heilige Stelle."

In these idyls Voss like Homer describes family life, furniture, the kitchen utensils, and household duties. The description of nature occupies a much more prominent place than in either Homer or Theocritus, as might be expected in modern poetry with its deeper feeling for and appreciation of nature in all its moods. But the description is not too prominent in these idyls, for we feel that it is an essential element of the poem: these surroundings are a fitting and necessary background to these characters.

At the advice of Gleim, Voss changed these three idyls and combined them into one, publishing the whole in 1795, under the title of *Luise, ein ländliches Gedicht in drei Idyllen*. This change and amalgamation made of the unpretentious idyls a pretentious epic poem.¹ What in the idyl had been minor shortcomings, (such as the comparative lack of action and of individual characterization) in the larger epic strikes the reader as gross blemishes. Furthermore, the simple natural tone has given way to one more pretentious and pompous.² The old realistic parson speaks and moralizes much more than in the original idyls, he has become the main figure, as the poet wished to express his own philosophy

¹ The original idyls had been increased by 468 verses (from 1392 to 1860) to form the epic. And with every new edition Voss showed a misguided desire to improve his work by adding to their length, and by changing the simple tone to one more stilted. In the final edition, the *Luise* had been increased to 2825 verses, one quarter of the length of the *Odyssey*! In almost every case the original form is the more simple, natural, and pleasing.

² The "*Kaffee*" of the original had become "*Trank der Levant*," etc. See Sauer's *Voss*, p. 56.

of life by the mouth of the parson. The didactic elements suffocate the idyllic.

Yet the *Luise* does mark a great advance and deepened in Voss's contemporaries the appreciation and the respect for the dignity and worth of simple idyllic life such as we find here represented. Schiller felt this when he says: "Die Luise ist ein recht poetisches Werk, mit welchem Voss unsere deutsche Litteratur nicht bloss bereichert, sondern auch wahrhaft erweitert hat."¹ And Goethe writes to Voss immediately after the publication of *Luise*:² "Für das was Sie an Luisen aufs neue gethan haben, danke ich Ihnen, als wenn Sie für eine meiner Schwestern oder für eine alte Geliebte gesorgt hätten. Ich habe besonders die dritte Idylle, seitdem sie in Merkur stand, so oft vorgelesen und repetiert, dass ich sie mir ganz zu eigen gemacht habe, und so wie es jetzt zusammensteht ist es eben so national als eigen reizend, und das deutsche Wesen nimmt sich darin zu seinem grössten Vorteil aus."

But the *Luise* is not only a great poem in itself, but rendered a most important service to German literature by directly suggesting the idyllic epos *Hermann und Dorothea*.³ The wonderful and fertile mind of Goethe seized upon the ideas and underlying principles in Voss's poem, they grew and developed into *Hermann und Dorothea* the most perfect *bürgerliche Epos* ever written. No longer an idyl, this idyllic epic is yet the direct offspring and most perfect fruit of idyllic literature. And Goethe himself was the first to acknowledge his indebtedness to Voss.⁴

¹ In a note to his treatise: "*Über naive und sentimentalische Dichtung*."

² July 6th, 1795, — See *Goethe Jahrbuch V. 41*. Goethe's famous and sympathetic review of Voss's works (1802) was published in *Jenaische Allg. Lit. Zeit* in April, 1804.

³ A. W. Schlegel in his review of *Hermann und Dorothea* says: "Bei der Nachwelt wird es Luisen empfehlen können, dass sie Dorotheen zu Taufe gehalten hat." See Koberstein IV. 460.

⁴ Goethe writes to Schiller, February 28, 1798: "Ich bin mir noch recht gut des reinen Enthusiasmus bewusst, mit dem ich den Pfarrer von Grünau aufnahm, als er sich zuerst im Merkur sehen liess, wie oft ich ihn vorlas, so dass ich einen grossen Theil davon noch auswendig weiss, und ich habe mich sehr gut dabei gefunden, denn diese Freude ist am Ende doch produktiv bei mir geworden, sie hat mich in diese Gattung gelockt, den Hermann erzeugt, und wer weiss, was noch daraus entstehen kann."

When *Hermann and Dorothea* was about to appear, he wrote in a letter to Voss: "Ich werde nicht verschweigen, wie ich bei dieser Arbeit unserm Volke und Ihnen schuldig bin, Sie haben mir den Weg gezeigt und es mir Mut gemacht." And the public acknowledgement did not fail to appear. It occurs in the beautiful *Elegie*, the prologue to Goethe's epos:

"Uns begleiche des Dichters Geist, der seine Luise
Rasch dem würdigen Freund unz zu entzücken verband."

With the discussion of the idyls of Voss, and their development into the idyllic epos, we have arrived at the end of our study. From now on idyllic literature in Germany as elsewhere seeks a wider channel in which to flow, namely the *Dorfgeschichte* or peasant novel, of which Gosse, in discussing a work of this nature by Björnson, says that it "is a recrudescence of the idyl in its most primitive form, a recapture of the early charm of bucolic poetry."

TABLE NO. 1.

NUMBER OF WORKS PUBLISHED IN GERMANY DURING THE 17TH AND 18TH CENTURIES CONTAINING PASTORAL AND IDYLLIC ELEMENTS.

	1620-29	1630-39	1640-49	1650-59	1660-69	1670-79	1680-89	1690-99	1700-09	1710-19	1720-29	1730-39	1740-49	1750-59	1760-69	1770-79	1780-89	1790-99
Romances	1	5	6		2	1					1							
Drama	2	1	4	4	2	4	3		1	1		3	28	8	4	5	1	
Pastorals (many difficult to classify)			9	16	16	9	4	2	4		5	4	10	15	14	11	4	2
Praise of Nature		2	1	2	1		1			1		2	7	9	12	6	1	
Idyls & Eclogues			3	1					1			2	2	7	10	22	10	5
Critical												1	5	2	4			2

See page page 15. The flood of pastoral literature may be represented by two waves, the latter very much larger than the former.

TABLE NO. 2.

Works of pastoral and idyllic nature published in Germany from Hesus to Voss.
(1500—1795).

(Also including works which greatly influenced idyllic literature.)

Date of first appearance.	Title of Work.	Author.	Place of publication and date of later editions.
1509	Das Bucolicon (12 idyls)	Eobanus Hesus	Erfurt
1528	Das Bucolicon (17 idyls)	Hesus	Hagenau
1530	Theokritus transl. into Latin verse	Hesus	Hagenau
1567	Virgilio Bucolica (Transl.)	Stephan Riccius	1573, 1580
1576	Der Weingärtner (a play)	Nicodemus Frischlin	
1579	Lob des Landlustes (Beatus ille)	Johann Fischardt	Strassburg 1580, 1600
1580	Virgilio Bucolica et Georgica paraphrasi. Introduction De vita rustica	Frischlin	Frankfurt 1602, 8
1595	Bergeries de Juliette (Montreux)	durch F. C. V. B.	Mümpelgart
1600 (about)	Contarinis Schäfergedicht (transl.)	Elizabeth of Hessen	
1605	Longos (soon after transl. by Joh. Brieger)	Jungermann	
1619	Guarinis Pastor Fido (transl.)	Eilgerum Mannlich,	Mühlhausen
1619	D'Urfe's Astree (transl.)	J. B. B. V. B.	Mümpelgart
1625	Lob des Feldt-lebens (based on Fischarts 1579)	Martin Opitz	
1627, 4	Dafne (first opera in Germany)	Opitz	(Torgau) Breslau
1629	Sidney's Arcadia, (transl.)	Opitz	Frankfurt a. M. 1638, 1642, 1643, 1659
1630, 4	Schäfferey von der Nimfen Hercinie	Opitz	Brieg
1630	Lentz oder Frühling	Andres Findischen	Gera
1630, 8	Theatrum Amoris, III part von der Liebe Endymionis des Schäfers in Caria (Roman)		Frankfurt
1631	Frühlings-Hochzeit Gedichte	Paul Fleming	Leipzig
1632, 8	Schäfferey oder keusche Liebesbeschreibung der verliebten nimfen Amoena u. d. lobw. Schäfer Amandus (Roman)	SS. D. D.	Leipzig, 1635 1641, 1642 1645, 1652 1659, 1661
1632	Reu und Leid uber die Liebe der Schäferin Dieromene	Zacharias Lund	(Autograph in Kopenhagen)
1636, 8	Wintertags Schäfferey d. Schönen Coelinden u. ders. ergeb. Schäfer Corimbo (Roman)	Friedr. V. Drachsen- dorf	Leipzig

Date.	Title.	Author.	Place.
1638	(Drama) Daphnis u. Chrysilla neben einem anmutigen Auftrage vom Schafe-Dieb.	Herm. Heim. Schere	Hamburg (das zwischen-spiel meist Platt deutsch)
1640	Lamentatio Germaniae expirantis. der nunmehr hinsterbende Nymphen Germaniae elendeste Todesklage	Just. Ge. Schottelius. F. G., P. ¹	Braunschweig
1640	Hirt Filamon u. Schäfernymfe Belliflora. Schäfer-roman	Georg Neumark	Hamburg 1648
1641	Pegnesisches Schäfergedicht (von Strefon u. Clajus)	Geo. Philipp Harsdörffer & Johann Klaj	Nürnberg
1641	Idyl (first)	Georg Rudolf Weckherlin	
	Ein Hirten-geräthe eines Christlichen Hirten, der seine Schafe in der Fremde weidet	Joh. Brzetislaw Mislick	(no date)
1642	Des Daphnis aus Cimbrien Galathee	Johann Rist, P., F. G., E. O.	Hamburg 1646
1642	Poetischer Rosen-wälder Vorschmack oder Götter und Nymphen Lust von einer Nymphen entworfen.	Philipp Zesen, D. G.	Hamburg
1642	Früling	Andreas Tscherning	
1642. 8	Die verwüstete u. verödete Schäfferey. Leoriander betrogen von d. Schäferin Perelina (Roman). (Two) Hirtenoden	Kaspar Hertranfft	Dresden (no date) printed in Lappenberg's Fleming
1643	Tragico-Comoedia Von der verliebten Schäfferin Dulcimunda	Ernst Cristoph Homburg	Jehna, 1645, 8
1644	Schäfferey (from the French of Montchrestien), one for each season (Roman)	Aug. Augspurger	Dresden
1644	Weihnachts-Lied (Ecloge)	Johann Klaj (Birkens Redekunst page 297)	Wittenbergk
1644	Des edeln Daphnis aus Cimbrien Besungene Florabella	Rist	Hamburg
1645	Fortsetzung der Pegnitz Schäfferey	von Birken u. Klaj, P.	Nürnberg

¹ F. G. means member of the *Fruchtbringende Gesellschaft*; P. member of the Nürnberg *Pegnitzschäfer*; E. O. member of *Elbschwanen-orden*.

Date.	Title.	Author.	Place.
1646	Montemayors Diana (transl.)	Harsdörffer	Nürnberg 1661—1663
1646, 8	Roselieb d. i. Waldspiel in Reimloser Rede. Fast nach Tassens Amintas	Zesen	Hamburg
1647	Die vier Tage eines Newen und Lustigen Schäfferey von d. Schönen Coelinden u. derselb. ergebene Schäfer Corimbo	Christian Brehme (says he describes his friends)	Dresden
1647	Das Friede wünschende Teutschland	Rist	1647, 1648 1649
1648, 4	Pegnesisches Schaeferdicht in den Nordgauer Gefilden	Klaj	Nürnberg
1648	Idyls (six)	Weckherlin	Amsterdam
1649	Vergils Bucolics (in Alexandrines) also ein absonderlich Hirtengespräch eines Fürstl. Person zu ehren gemacht.	Oswald Beling	Schleswig
1649	Hirtenliedchen zur Vermehrung d. Hochzeitl. Ehrenfreuden Herrn Joh. Fauljoch	Simon Dach	Königsberg
1650	Der Elmen-Nymphen Immergrünendes Lust-Gebäu nach Art eines Schäfergedichtes. (In honor of the house of Brunswick)	Enoch Glaeser	Wolffenbüttel
1650	Die Nympe Noris in zweyen Tagzeiten (mit Gedichte, Rätseln, Sinn-u. Reimenbildern duch artigen Gebäuden.)	Joh. Helwig, P.	Nürnberg
1650	Deutsche Poetische Gedichte (containing idyllic description)	Sibylla Schwarz	Danzig
1650	Teutschlands Kriegs Beschluss u. Friedenskuss vom Schäfer Florian	v. Birken	Nürnberg
1650.12	Die Geistl. Schäfferey Dem Hirten aller Hirten		München
1651	Margenis, das vergnügte, bekriegte und wieder befriedigte Teutschland	v. Birken	Nürnberg
1651, 4	Hirtenambt d. Geistl. Schäfferey aller Hirten	Joann Khuen	München
1652	Des Königl. Printzens Erofilos Hirtenliebe (after the Dutch author Cats)	Joh. Geo. Albini	Leipzig
1652	Hirtengesang (zur Hochzeit Schöpplings)	Julius Bruning	Königsberg

Date.	Title.	Author.	Place.
1653	Der Getreue Hürte. Arkadischer Hürten-Aufzug. (Am Namenstag einiger Prinzen)	Ernst Geller	Dresden
1653	Das Friede jauchzende Teutschland	Rist	Nürnberg 1653
1653	Pastor Fido presented at Dresden		
1653, 4	Der Grund aller Hochzeiten oder Beschreibung d. erst. Hochzeit zw. Adam u. Eva	Georg Greffinger, E. O.	Hamburg
1653	(Drama) Rosetta Schäfferey	Heinr. Elmenhorst	Leipzig
1655	Aengelens Der verständige Gärtner über die 12 Monate d. Jahres (Transl.)	Greffinger	Hamburg 10 ed. to 1692
1655	Vortrag des Sommers	Tscherning	Rostock
1655, 4	Ein Hirtenlied (zur Hochzeit d. cand. Fuchs)	Joh. Wedemeyer	Riga
1655, 12	Schäfferfreud .d. Geistl. Schäfferey. Dem Hirten aller Hirten		München
1656	Über den Schäfferischen Namen abgesehene Ode	David Schirmer	Dresden
1656	Eclogé. Florelle oder Lob- und Trost-Schallendes Hirtengespräch beim Tode Eleonora Krausen, gest. 16 Sept., 1655 in Weimar	Neumark	Jena
1656	Wandlungslust welche in allerhand Anbindungs- Hochzeit- Neu-Jahres- u. Liebes- Schäffereien besteht	Jac. Schwieger	Hamburg
1657	Musik- poet. Lustwald, also cont. zu keuscher Ehrenliebe dienende Schäferlieder	Neumark	Jehna
1658, 4	Schäfergedicht u. Schützensgeschichte	Cristoph Frank, P.	Nürnberg
1659	Virgil, Bucolica oder Hirtenlieder (transl.)	Chr. H. Lübeck	
1659	Adeliche Rose welche den Getreuen Schäfer Siegreich u. d. wankelm. Adelmucht vorstellet	Jacob Schwiger	Glückstadt
1660	Die Verführte Schäferin Cynthie durch listiges Nachstellen d. Floridan	Schwiger	Glückstadt
1660, 8	Verliebtes Gespenste, Die Geliebte Dorn-roose (Bauerstücke in honor of wedding of Prince Geo. of Glogau)	Andreas Gryphius	Breslau
1660, 12	Schäffer- Hirten- Liebes- und Tugend Lieder	Joh. Geo. Schoch	Leipzig

Date.	Title.	Author.	Place.
1661	Dess Elbischen Schwanen- Schäfers Hyphantos Poetische Muser, über die himmelschöne Rabelle, treuverliebte Karylisis, falsche Florinde	Geo. Heinrich Weber	Glückstadt
1663	Monte- Mayors Diana (transl.)	G. P. H.	Nürnberg
1663	Neu-erfundene Philyrenische Kriegs- und Friedens Schäfferey, das ist: Kurtze Chronologische Verfassung aller vornehmster Gesch. d. Stadt Leipzig	Schoch	Jena
1664	(In Octobert the author speaks of his) Hirtenlieder	Wolfg. Helmhard, F. G.	Erfurt
1665	Pegnesische Gespriespiel- Gesellschaft von Nymfen u. Hirten bey einem Hochgräfl. Beylager	v. Birken	Nürnberg
1665	Altaniens werthester Hirtenknabe Filareto unter e. Schäf. spiel u. Sanglust	Const. Chris. Dede- kind	Dresden
1667	Ergötzliche Frühlings-freude in einem Pastorell.	Martin Kempe	Königsberg
1667	Schäferspiel der ehre des Ruhm- seligsten Spielenden durch die Pegnitz Hirten	v. Birken	Nürnberg
1668	Schäfergedicht: Ohne Gott. u. d. ges. Vernunft vorg. u. von vielen beg. Thorheit d. Verliebten (Roman)		
1668, 8	Klarin, Klariminde u. Magdalis, oder Poetischer Myrthenwald	Henning Gross- court	Helmstadt
1669, 4	Weinachts-Schäfferey zu Ehren d. Geburt Jesu Christi	J. Hagen	Baireuth
1669, 4	Die in der Flucht siegende Daphne	Seb. Seelman	Regensb.
1669, 5	Jauchtzende Cupido. Schäferspiel beim Namensfeste eines Prinzen	Wilh. Cronpusch	Görlitz
1670, 4	Der Herculische Palmenbaum (Schäfergedichte)	S. Seelmann	Regensburg
1670	Kundegis, eine Teutsche Schäfferey	Heinrich Tolle	Göttingen
1670	Wahrgilt, eine Teutsche Schäfferey	Heinrich Tolle	Göttingen
1672, 8	Die Königl. Schäferin Aspasia. Am Geburtstage Herrn Augusti		Halle
1673	Willbald, Teutsche Schäfferey	Tolle	Göttingen
1673, 8	Der Bekehrte Schäfer (Roman)	Maria Cath. Stockfleth	Nürnberg
1673, 9	Pegnesis: oder der Pegnitz Blumen- genoss Schäfer Feld Gedichte in 9 Tagzeiten	mostly by v. Birken	Nürnberg

Date.	Title.	Author.	Place.
1673,12	Des Blumenengenossen Lilidans geküsste Lysis	Joh. Tepelius, P	Giessen
1674	Trauer Hirtenspiel (über e. verstorb. Markgraf)	Michael Korgehl	Cölln
1674	Die Betrübte und getröstete Galathee (Schäferlich mythologisch Sangspiel)	Christian Weise (the only one by him cont. past. el.)	(Leipzig)
1675,4	Das verletzte, benetzte und wieder ergetzte Schäfflein, ein Feldgedicht	Joh. Lud. Faber, P	
1677	Corydons auss Arcadien Viessirliches und gar erbauliche Narrenbossen oder Spannene Grabschriften (Satire)		
1678	Adam und Eva, oder Singspiel v. d. gefallne u. wieder aufgerichtete Mensch. (Transl. fr. Ital. Opera)	Christian Richter	Hamburg
1678,8	Guarinis Pastor Fido (Transl.)	Hofmann v. Hoffmanswaldau	Göttingen 1679, 1681. repr. 15 times till 1730
1679	Teutsche Rede- bind u. Dichtkunst- mit einem Hirtengedichte	v. Birken	Nürnberg
1679	Schäferspiel	Joh. Bapt. Renz	(Göttingen)
1680	Eine Geistliche Schäfferei in Rosen- Lilien- und Negelchen Thale an- dächtigt betrachtet	K. H. Viebing	Helmstadt
1681, 8	Lob des Landlebens	Ernst Stockman	Jena
1682	Der unglückselige Hirt (From the French) (Roman)	P. v. M.	Regensburg
1682	Mirantisches Flötlein: oder Geistliche Schäfferey. In welcher Christus under dem Namen Daphnis die in dem Sündenschlaß vertieffte Seel Clorinda zu einem bessern Leben aufferwecket.	Laurentius v. Schnifis	Constanz 1694, 95, 1711 1735, 39
1684	Schäfferspiele (No. 1 Pastorell)	Joh. Christ. Hall- man	1750 Augsburg
1684, 8	Die betrübte Pegnesis- von dem Wandel des sel. Floridans- mit Gesps. Ged . . . durch einen Blumenhirten (of v. Birken)	Martin Limburger	Nürnberg
1686, 6	Der unbleglückte Schäfer Corydon, welcher mit Zuhilfe der Cypris, in Annehmung der himml. Rosibeilen in einem Fortunato verkehrt worden, bey einer bürgerlichen	Jac. Reich	Königsberg

Date.	Title.	Author.	Place.
	Hochzeit in einem Pastorell abgebildet.		
1689, 4	Cain u. Abel oder d. Brudermörder (Opera)	Christn. Heinr. Postel	Hamburg
1690	Von dem Hof-, Stadt- und Landleben	Canitz	Publ. 1700 and later
1692	Vorzug des Landlebens	Canitz	
1692	Mirantische Mayen-Pfeiff oder Marianische Lobverfassung. In welcher Chorus, ein Hirt, der Mutter Gottes Schönheit besingt	Laurentius v. Schnifis	Dellingen
1699	Die Wiederkehr der Güldenen Zeit (Opera)	F. C. Bressand	Hamburg
1701	Etliche Schäffer-Gedichte (in vier Eklogen besingt er zwei Todesfälle, eine Geburt u. eine Vermählung)	Christian Wernicke	Hamburg 1704, 1749
1702	Geistliche Hirtenlieder, der in ihrem Jesum verliebten	Joh. Scheffler (called Angelus Silesius)	Berlin
1702, 4	Der Tod d. Grossen Pans, oder Herrn Schotten (Opera)	Christian Hein. Postel	Hamburg
1705	Der Getreue Treu-Bruch (Schäferspiel)	F. C. Bressand	Braunschweig
1708	Daphne (Opera) (Music by Händel)	Heinrich Hinsch	Hamburg
1712	Die geheime Liebe d. Diana. In einem Pastoral auf d. Schauplatz	Joh. Ulr. v. Koenig	Hamburg
1714, 10	L'inganno fedele, oder der getreue Betrug, ein heroischer Schäferspiel (Opera)	Joh. Ulr. v. Koenig	Hamburg
1716	Feld und Landleben	Helmhard 1688	Nürnberg
1718-20	B. Neukirch's grosse Anthologie. (Much of it Schäferliche Gelegenheitsdichtung)	Collected by B. Neukirch	Halle
1721	Irdisches Vergnügen in Gott	Brockes	Hamburg
1722	Isaac u. Rebecca oder die Kluge Vorsichtigkeit		Frankfurt a. d. O.
1724	Hochzeit-fest (ein Pastorel) Schäfergedicht. (In memory of his friends)	Joh. Chr. Günther 1723	Frkf. u. Leipzig
1725	Cupido auf seinem Thron	Vocativo	Friestadt
1726	Fontenelle's Endymion (Trans)	Gottsched	
1727	Ird. Verg. in Gott, II Theil (Spring and winter)	Brockes	Hamburg
1727	Gelegenheits Eklogen (In part VII of Hoffmannswaldau's works) by upper Saxon poets	by G. F. W. Juncker	

Date.	Title.	Author.	Place.
1729	Extract from Longus's Daphnis & Chloe in Zeitschr. der Biedermann	Gottsched	Leipzig
1730	Schäfergedicht: Das Neubeglückte Sachsen (durch die Geburt eines Printsens, auf d. Schauplatz vorgestellt)	Joh. Ulr. v. Koenig	Dresden
1730, 8	Critische Dichtkunst (cont. 4 Idyls of Gottsched)	Joh. Cristoph Gottsched	Leipzig 1737 1742, 51 etc.
1732	Phillis, Schäfergedicht	Fried v. Hagedorn	
1732	Vergils Eclogues transl. (theils in Hoch-, teils in Nieder-Sächsische Verse)	Caspar Abel	Gosslar
1732	Die Alpen (written 1729)	Albrecht v. Haller	Bern
1733	Daphnis, ein Hirtengedicht	Brockes	Hamburg
1733	Sottises Champêtres oder Schäfergedicht des Prof. Philippi	Chr. Ludw. Liscow	Leipzig
1738	Fabeln u. Erzählungen	Friedr. v. Hagedorn	Hamburg
1738	Das Lob d. Zakenflusses u. s. Umzirks auf d. Schles. Riesengebirgen	Lindner	Hirschberg
1739, 12	Hirtengedichte auf die Geburt Jesu Christi	Lindner	Hirschberg
1740	Ode auf die Geburt Christi, nebst der Priorischen Ekloga Messias (Aus dem Engl.)	Elias Kaspar Reichard	
1740	Critische Dichtkunst	Breitinger	Zürich
1741	An Friedrich II im Namen d. Nympe Hercynie	Kaspar Gottlieb Lindner	Hirschberg 1742
1741, 8	Atalanta oder die bezwungene Sprödigkeit (written 1740)	Gottsched	Leipzig 1745
1742, 8	Amyntas, Hirtengedicht d. Tassi (Transl.)	Joh. H. Kirchhoff	Hannover
1742	Four eclogues as models in Gottsched's Crit. Dichtk. 3rd ed. Schäfergedanken bey einer Jagd seiner Königl. Maj. in Preussen	Benj. Neukirch Benj. Neukirch	
1742	Schäfererzählungen ("gefällig, aber auch lüsterlich") (8 Erzähl.)	Joh. Cristoph Rost	Berlin 1744, 48, 51, 56, 60, 64, 67, 68, 78
1742	Die gelernte Liebe, oder der versteckte Hammel, Schäfersp. (1 act)	Joh. Cristoph Rost	
1743?	Hirtencantate (Belustigungen)	J. E. Schlegel	
1743	Sieben Hirtengedichte von Schoch dem Jüngeren	Naumann	
1743	Corydon, der Bräutigam ohne Braut, Sylvia, die Braut ohne Bräutigam	Kopenhagener Anonymus	Frkf. u. Lpz. 1746

Date.	Title.	Author.	Place.
1743	Landleben in Ritzebüttel	B. H. Brockes	Hamburg
1744	Oden und Schäfergedichte	Joh. Fried. Grafe	Leipzig
1744	Das Band, ein Schäferspiel, 1 act	Chr. Gellert	Leipzig
1744, 8	Das angenehme Huhn. In versen besungenes Landgut d. Herrn v. Stocken.	Hinr. Jansen	Bremen
1744	Elisie. Schäferspiel	Ad. Gottfr. Uhlich	Leipzig 1749
1744, 8	Die geprüfte Treue. Schäferspiel	Karl Chr. Gärtner	Bremen
1745, 8	Sylvia, ein Schäferspiel	Gellert	Leipzig
1745	Der Inselberg besungen von einem Meistersänger	Chr. Euseb. Suppius	Gotha
1745	Hinterbergens Winter u. Sommer- lust mit physik. u. moral. Betracht.	J. B. v. Fischer	Riga
1745, 4	Der blöde Schäfer (ein Lustspiel)	Joh. Wilh. Ludw. Gleim	Berlin 1746 1752, '63, '67
1745	Ein Aufsatz uber die Schäferpoesie	Christlob Mylius	
1745	Thomson's Jahreszeiten (Trans. fr. Engl.) ("breit umschreibend")	Brockes	Hamburg
1745, 8	Die Martinsgans, Schäfersp.	Chr. Nik. Naumann	
1745	Der faule Bauer, ein Nachspiel	A. G. Uhlich	Hamburg u. Leipzig
1746	Idyls (in die oden Anacreons in Reimlosen Versen)	Joh. Nik. Götz	Frankfurt u. Leipzig
1746, 8	Die versöhnliche Liebe. Die zufriede- dene Liebe	Joh. Dav. Herr- mann	Leipzig
1746	Die Kirms (Sperontes)	Joh. Sig. Scholze	Leipzig
1746	Kätzchen	Joh. Sig. Scholze	Leipzig
1746	Der plauderhafte Schäfer (Lustsp.)	Ad. Gottfr. Uhlich	Danz. u. Leipzig
1746	Vom Natürlichen in Schäfergedich- ten etc. (bes. gegen Gottsched)	Joh. Ad. Schlegel	Zürich
1746	Die beste Wahl. (Schäfersp.)		Erlangen
1746, 8	Critische Briefe	Bodmer u. Breitin- ger	Zürich
1747	Ein Schäferspiel ohne Liebe	J. W. Jelpken	Braunschweig
1747	Der Leichtsinige (von Drymantes)	Fr. Wilh. Eichholtz	Hamburg
1747	Die Glückliche Eifersucht. Schsp. Metastasios Königl. Schäfer (transl. fr. Ital.)		Jena Wien
1748, 4	Die Spröde, ein Schäferspiel	J. F. Löwen	Helmstaedt.
1748, 8	Der Herbst.	Frhr. Bachoff v. Echt	
1748, 8	Die Landlust	Frhr. Bachoff v. Echt	
1748, 8	Versuch in moralischen und Schä- fergedichten (resembles Haller) (ed. by Uhlich) ("Ganz werthlos" Kob.)	Chr. Fr. Zernitz 1745	Hamburg u. Leipzig

Date.	Title.	Author.	Place.
1748. 8	Galathee u. Alcides. musik. Schäferspiel		Potsdam
1748. 8	Der Kuss ganz neu musik. Schäferspiel	Christlob Mylius	Frkf. u. Leipzig
1749	Der Frühling. ein Gedicht	Ewald Chr. v. Kleist	Berlin, 10 ed. to 1804
1749	Der grossmüthige Entschluss, 3 acts		Frkf. u. Leipzig
1749	(An article from) Guardian (conc. Theor. and pastoral poet., transl.)	Frau Gottsched	Leipzig
1749	Die Schäferinsel. Lustp. in 3 Aufz.	Christlob Mylius	Wien
1749	Die unschuldige Diebe. Schäferspiel	Joh. Jac. Dusch	Hannover
1749. 8	Neue Critische Briefe	Bodmer u. Breitinger	Zürich 1763
1749	Die glückliche Eifersucht		
1750	Die Liebe oder Thyrsis u. Doris. (Ein Schäfergedicht in 3 Gesängen)	“Keineswegs ein gewöhnliches Gelegenheits-dichtung”. (Netoliczka.)	Eisenach 2nd ed.
1750	Empfindungen d. Frühlings		
1750. 8	Noah (Jacob u. Joseph 1751—Jacob u. Rachel 1752)	Bodmer	Zürich
1750	Discours sur les Sciences et les Arts (attacks civilization)	Rousseau	
1751	Hirten- Gespräche	Suppius	Gotha
1751	Der Betrug bei der Schäferey (Schäferspiel)	(Seleontes)	Langensalza
1752. 4	Poetische Blicke ins Landleben (ed. by Bodmer)	E. F. v. Gemmingen	Zürich
1752	Doris oder die zärtliche Schäferin. 1 act		Dresden 1759
1752	Der Winter. ein moral. Ged.	Georg Joach. Mark	Rost u. Wismar
1752	Der Fröhling (transl into French 1770)	Cristoph M. Wieland	1752
1752. 8	Das Urtheil des Paris. music. Schäferspiel (Ital. u. Deut.)		Berlin
1753	Hirtenlieder u. Gedichte (Following rules of Batteux and his transl.)	Anonymous (“The song Myrtill belongs to the best of the time”)	Halle
1753	Das Schäferfest oder die Herbstfreude. Lustspiel in versen am Namenstage Maria Theresa aufgeführt.	Carolina Neuberin	Wien. 1753. 4
1753. 8	Die Nacht	Sal. Gessner	Zürich
1754	Damon und Damoetas. Ekloge.	Mich. Dietr. Blohm	Altona

Date.	Title.	Author.	Place.
1754	Der Tausch	J. J. Dusch	Lübeck
1754	Versuch eines Gedichtes über die Landlust	Fried. Dan. Behn	.
1754	Die Schöne Nacht	Joh. Cristoph Rost	Berlin 1763, 9
1754, 8	Daphnis an Silen	Anonymous	Halle
1754, 8	Der Stand der Unschuld und Fall des Menschen, Schäferspiel von Dryden (transl.)		Frankf.
1754?	Trilogie (after Prior's Despairing Shepherd) ("Sterbeblau senti- mental")	Joh. Arnold Ebert	Braunschweig
1754, 8	Daphnis	S. Gessner	Zrch. 1760, 65
1755, 4	Die Tageszeiten, ein Gedicht in 4 Büchern	Just Fr. Wilh. Zachariac	Rostock
1755	Der beste Vater. Schäfersp.	Joh. Ad. Pantke	
1755	Discours sur l'inegalité parmi les hommes	Rousseau	
1755, 8	Doris oder die zärtliche Schäferin (Schäfsp.)	Joh. Cristoph Rost	Frankf. u. Leipzig
1755, 8	Gartengedanken. Ein reimfreis Gedicht	Ernst Gottl. Wol- tersdorf	Breslau
1756, 8	Idyllen	Sal. Gessner	Zrch. 1760, 65
1756, 8	Von der Ursprung der Ungleichheit unter d. Menschen (trans.)	Moses Mendelssohn	Berlin
1756, 58	Batteux. Einl. in die schönen Wissenschaften (mit Zusätzen von-----)	C. W. Ramler	Leipzig., 1762, 69, 74, 85, 1802
1757	Der Tod Adams	Fr. Gottl. Klop- stock	Leipzig u. Kopenhagen Many ed.
1757	Die Idyllen Theokrits, Moschus u. Bion (transl.)	Chr. Gottl. Lieber- kühn	Berlin
1757	Poet. Gemählde u. Empf. aus d. heil. Gesch. (ecloga sacra)	Jac. Fried. Schmidt	
1757, 8	Die dankbare Treue. Ein Schäfersp.	Joachim Chr. Grot	Hamburg
1757-60	Schilderungen aus dem Reiche der Natur u. d. Sittenlehre für alle Monate des Jahres	Joh. Jac. Dusch	Hamburg u. Leipzig
1758	Neue Gedichte (including Idyls) (one fisher-idyl)	Ewald Chr. v. Kleist	Berlin
1758, 4	Thomson's Jahreszeiten (transl.)	Joh. Franz v. Palthen	Rostock
1758, 4	Der Mai, eine musik. Idylle.	Karl Wilh. Ramler	Berlin 1764
1758, 8	John Gay's Fabeln (transl.)	Joh. Franz v. Palthen	Hamburg

Date.	Title.	Author.	Place.
1758, 8	Der Tod Abels	Gessner	Zürich 1760, 60, 65, 67, 73
1758, 8	Die Hirtengedichte des Virgilius	Chr. Gottl. Lieber- kühn	Berlin
1758, 8	Die Hirten bei der Krippe zu Bethl. (musik. Ged.)	Karl Wilh. Ramler	Berlin
1759	Lyrische Muse an der Saale (Con- tains Hirtengedichte) (in one "wetteifert mit Rosts Schamlo- sigkeit")		Jena
1759	J. Gay's Schäfertrauerspiel Dione. Transl. from Engl.		Berlin u. Leipzig
1759	Das Ochsenfest	Paul Aug. Schrader	Braunschweig
1759	Schäfergedichte (A. d. Engl. u. Ital. übers.)	Joh. Geo. Phil. Muchler	Berlin u. Leipzig
1760	Der Morgen, in Prosa	H.	
1760	Lied der Nymphe Persanteis	Ramler	Kolberg
1760, 8	Das Dorf, ein Gedicht	Joh. Jac. Dusch	Altona
1761, 8	Der Schatz. Ein Schäfersp. in 1 akt. (in Alexandrinern)	Gottl. Konr. Pfeffel	Frankfort
1761, 8	Idyllen	Jac. Fr. Schmidt	
1762	Kritik der Schlegelschen Abh. (an advance in idea of idyl)	Mendelssohn	Berlin
1762	Die Schäferspiele: Evander u. Erast. Der erste Schiffer (his best work)	S. Gessner	Zürich 1765, 67, 70, 75
1762, 4	Hirtenliedern des Virgils u. Pope	Joh. Heinrich Smid	Aurich
1762, 8	Die Schöpfung der Natur. Ein Gedicht	Benj. Chr. Hein. Giesebrecht	Halle
1762, 8	Damoet u. Phillis. Eine Schäferey	Joh. Sigm. Manso	Bielsfeld
1763	Bukolische Erzählungen	Geo. Aug. v. Breitenbauch	Frkf. u. Leipzig
1763, 4	Elmine und Ernst. Eine Idylle	Joh. Dan. Glum- mert	Danzig
1763, 8	Menalk in der Schäferstunde	C. E. Suppius	
1763, 8	Philemon u. Baucis, Schausp. in versen. 1 Akt.	G. K. Pfeffel	Strassburg
1763, 8	Moses in Midian, ein poet. Gemälde	Joh. Chr. Lossius	Erfurt
1764	Lieder auf die vier Tagszeiten	Joh. Matth. Stoll	Hildb.
1764	Der Sommertag in 4 poet. Be- trachtungen	(Graf) Alex. Christiani	Wien
1764, 8	Lob des Landlebens	Gleim	Berlin
1764, 8	Idyllen oder Klagen über die Flüchtige Zeit	Karl Heim. Höffer	Leipzig
1765	Der Brudermord des Kains. Ein prosaiches Trauerspiel	Lud. Fried Hude- mann	Wismar

Date.	Title.	Author.	Place.
1765?	(Allegorische Alexandriner) Ekloge	Joh. Elias Schlegel	Leipzig
1765, 8	Jüdische Schäfergedichte	Breitenbauch	Leipzig
1765, 8	Abwechselungen wider die Lange- weile	H. A. J.	
1765, 8	Lob des Landlebens		
1766	Laokoon	Lessing	Berlin
1766, 4	Lucas od. der erhörte Schäfer. Eine Idylle	Joh. Dan. Glum- mert	Danzig
1766, 4	Die süsse Dienstbarkeit, ein landl. Singgedicht.	Joh. Dan. Glum- mert	Danzig
1766, 8	Thomson's Jahreszeiten; also Gem- malde von der Weinlese	Johannes Tobler	Zürich 1774
1766, 8	Die Abendzeiten in 4 Meisterge- sängen		Quedlinburg 1773
1767, 8	Die Ruhe auf dem Lande	Gottl. Cristopher Schmaling	Gotha
1767	Bion u. Moschus: Idyllen (transl.)	Fr. Grillo	Berlin
1767	Der Wartberg bei Heilbronn. 12 Gesänge	Cristoph L. Pfeiffer	Heilbronn
1767	Abhandlung vom Schäfergedichte	Jos. (Freyherr) v. Penkler	Augsburg
1767	Theokrit u. Gessner (in Fragmen- ten über neu. deu. Lit.)	Herder	
1767, 8	Das Landleben ("Kleinmalerei")	Chr. Cai. Lorenz Hirschfeld	Leipzig 1768, 71, 76, 1828
1768, 8	Idylle auf die Abreise Marien Char- lotten, Erzherz. in Oesterr.	Joh. Cristoph Re- gelsperger	Wien
1769	Sieben kleine Gedicute der Venus gesungen. Also Idyls.	Abraham Jac. Penzel	Berlin
1769, 4	Paris auf Ida. Ein heroisches Pa- storale	Joh. Heinr. Weiss- mann	Rudrestadt
1769, 8	Der Winter (eine moralische Wo- chenschrift)	C. C. L. Hirschfeld	Leipzig 1775
1770, 4	Der glücl. Frühling. Ein Ged. auf d. Ankunft d. Mad. la Dauphine	Joh. Rautenstrauch	Strasburg
(Compd)	} Elegie eines Schäfers (Imitation of Kleists Amyntas)	Hölty	
1770			
1770, 8	W. Collins Orientalische Eklogen aus dem Engl.	S. Gessner	Zürich
1770	Einige Idyllen (in Vermischte Gedichte)	Joh. Gottf. Chr. Nonne	Jena
1771, 8	Versuche in Idyllen	Hektor W. (Frei- herr) v. Gunderode	Karlsruhe
1771, 8	Idyllen: Die Hügel bei Ratenau u. Rosalia u. Amyntas.	Joachim Cris. Blum	Berlin
1771	Idyllen	Karl Chr. Reckert	Münster

Date.	Title.	Author.	Place
1771, 8	Versuch eines poet. Gemäldes vom Herbst	Karl Sam. Slevogt	Eisenach
1771, 12	Theokritos Idyllen (Transl.)	Fr. Grillo	Halberstadt
1772	David, ein Trauerspiel	Klopstock	Hamburg
1772	Moral Erz. und Idyllen von Diderot	Gessner	Zürich
1772	Brief über die Lanschaftsmalerei	Sal. Gessner	Zürich 1772.
1772	Neue Idyllen		
1772	Idylls of Theokritus. Bion u. Moschus (prose)	Karl Aug. Kütner	Leipzig
1772, 8	Hirtenlieder. u. d. verklagte Amor.	Fr. Aug. Clem Werthes	Leipzig
1772-3	Idyllen	Joh. Heinr. Weissmann	Leipzig
1773	Cimon. Schäferspiel (written 1747) (After Bocc. Decamerone VI.)	Bodmer	
1773	Idyllen	Andreas Grader	Riga
1773	Amor und der Dichter	Joh. Sig. Manso	Bielefeldt
1773, 8	Der Hügel bei Kindleben	Heinr. Aug. Otto-kar Reichard	Gotha
1773, 8	Amors reise nach Fockzana zum Fried-Congress	J. G. C. Nonne	Jena
1773, 8	Idyllen	Blum	Berlin
1773, 8	Versuche von Schäfergedichten	Johannes Kraus	Maynz.
1774	Das Feuer in Walde	Cristoph L. H. Hölty	
1774	Gemälde aus einer Welt unschuldiger Menschen	Theo. Joh. Brückner	Mus. Alm.
1774, 8	Schäferspiele	Moses Dobruska	Prag u. Leip
1774, 8	Palämon, Schäfersp. mit Gesängen (2 acts)	Joh. Wolfg. And. Schöpfel	Frkf. u. Leip
1774, 8	Die Promenade in dem Grossen Garten	Hein. Aug. O. Reichard	Gotha
1774, 8	Die Christnacht unter den Schäfern (Dram. idylle)	Paul Georg Hagenbruch	Langensalza
1775	Idyllen	Brückner	Mus. Alm.
1775	Idyllen. Schnitteridylle u. d. Arme Wilh.	Hölty	
1775	Orpheus. Ein Singspiel	Werthes	Zürich
1775	Menalk u. Mopsus (after V eclogue of Vergil), Eclogen	Jak. Mich. Reinh. Lenz	Frk. u. Leipz
1775	Der Faun. Eine Idylle	Maler Müller	Mannheim
	Der erschlagene Abel. Eine Skizze		
	An den Frühling		
	Gemälde aus dem Sommer		
	Der Satyr Mopsus		
	Bacchidon u. Milon		

Date.	Title.	Author.	Place.		
1775	Die Schaafschur, eine Pfälzische Idylle	Maler Müller	Mannheim		
1775, 8	Idyllen	Joh. Heinr. Bücking	Maynz		
1775, 8	Einige Gedichte (Fikenscher) (coll. by Krausemark)	Joh. Geo. Em. Rosner	Bayreuth		
1775, 8	Apollo unter den Hirten (Musik. Schäfsp., 1 act)	Gottfried Uhlich	Wien		
1776, 8	Die Werbung für England. Ländliches Lustspiel	Joh. Christoph Krauseneck	Bayreuth		
1776, 8	Idyllen (9 versifizierte, Gessner's)	Klamer E. K. Schmidt	Leipzig		
1776	Der Morgen	} Voss			
	Die Leibeigenschaft				
	Die Pferdeknechte				
	Der Aehrenkranz				
	Selmas Geburtstag				
	Die Bleicherin				
1777	Der Bettler	} Traugott Benj. Berger	Leipzig		
	Die Elbfahrt				
	De Winter Awend				
1777	Liederchen u. Gedichte, Schäfer drama, etc.				
1777, 8	Idyllen u. Erzählungen			Karl Hein. Höffer	Leipzig
1777, 8	Eine ländliche Erzählung			P. E. Birkner	Helmstadt
1777, 8	Die Fürstenreise. Ein ländliches Lustsp. in 1 act.	J. C. Krauseneck	Bayreuth		
1777	Ein Kinderpastorale, aufzufüh. am Geb. tage s. Vaters	Heinr. Leopold Wagner	Strassburg		
1777, 8	Wintergemälde (2 Ausgaben)	Karl Chr. Reckert	Berlin		
1778	Adams erstes Erwachen und erste Seelige Nächte	Maler Müller	Mannheim 1779		
1778, 8	Das Steingebürge bei Adersach in Böhmen, ein Gedicht	Ernst Leberecht Semper	Bunzlau		
1778	Das Ständchen	} Voss			
	Der Hagestolz				
	Der Abendschmaus				
	Der Riesenhügel				
	De Geldhapers				
1779, 8	Es ist Friede. Ein ländliches Drama in 1 act	Joh. Chr. Bock	Leipzig		
1780, 8	Neue Idyllen eines Schweizers				
1780, 8	Jacob beim Brunnen, eine Schäferspiel aus d. Ital. des Lemene	Bodmer	Zürich		
1781	Homer's Odyssee	Voss	1801, 02, 24		
1781	Die Kirschenpflückerin	} Voss			
	Der bezauberte Teufel (Die Theoc. 10)				

Date.	Title.	Author.	Place.
1781	Der siebenzigste Geburtstag	Voss	
1782	Theokrit (9 Idyllen). Bion u. Moschus (3). transl.	Chr. Graf zu Stolberg	Hamburg
1782, 8	Das Harz. ein Gedicht in 7 Gesängen	Er. Chr. Hein. Dannenberg	Göttingen
1782	Das Adonis-fest (from Theocr.)	Voss	
1783	Des Bräutigams Besuch (afterwards 2nd part of Luise)		
1784	Luise (afterwards 1st part of Luise)		
1784	Idyllen u. Lieder	Traugott Christiana	Dresden
1785	Gedichte, vol. I Idyllen	Dor. Löberin	
1785	Hochzeitlied (afterwards in 3rd part of Luise)	Voss	
	Die Heumad		
1786	Philemon u. Baucis		
1786, 8	Idyllen (in his Gedichten)	Jac. Fr. Schmidt	Leipzig
1787	Ardinghello u. d. glückseligen Inseln. (Ital. 16 cent.)	Joh. Jac. Wilh. Heinsø	Lemgo
1787, 8	Alexis oder von dem goldnen Weltalter (transl. of Hemsterhuis)	Fr. Hein. Jacobi	Riga
1787, 8	Fischergedichte u. Erzählungen (introd. by Gessner)	Franz Xaver Bronner	Zürich
1787, 8	Damöt u. Phyllis. Eine Idylle	Karl Chr. Reckert	Berlin
1787, 8	Salomon Gessners auserlesene Idyllen in Verse gebracht	Ramler	Berlin
1788	Die Insel	Fr. Leop. Stolberg	Leipzig
1789, 8	Gessners ep Schäfergd. Der erste Schiffer in verse gebracht	Ramler	Berlin
1790, 8	Idylle. die glücl. Wiedergenesung des von Flotow	J. C. Krauseneck	Bayreuth
1790	Two idyls of Theocritus (Polyfem)	Voss	
1791	Sonntagsfreuden d. Landmanns	Fredrike Jul. (Gräfin) v. Revertlow	Kiel
1791, 8	Daphnis u. Chloe. Idylle mit Gesang	Karl Chr. Reckert	Berlin
1791, 8	Die ländliche Feier d. Fürstentages. ein Dorfgemälde in 1 Handl.	C Krauseneck	Bayreuth
1792	Das Mörsergericht (transl.)	Voss	
1793	Homer's Werke (Ilias neu-, Odysseus umarb.)	Voss	
1794	Neue Fischergedichte	Bronner	Zürich
1795	Der erste Frühling	Fr. Leop. Stolberg	
1795	Gesang d. Leibeignen beim Erntekranz (later in Die Erleichterten)	Voss	

Date.	Title.	Author.	Place.
1795	Luise	Voss	Königsberg
1795, 6	Über naive u. sent. Dichtung	Schiller	
1796	Gedichte (incl. Mörsergericht etc.)	} Voss	
1797	Vergils Eclogues (transl)		
1797	Alexis u. Dora. Eine Idylle	Goethe	
1797	Hermann u. Dorothea	Goethe	

TABLE NO. 3.

Idyls proper published in Germany during the 17th and 18th centuries.

Date.	Title.	Author.	Place.
1641	Idyl (First)	Geo. Rud. Weckherlin	
1648	Idyls (Six)	Geo. Rud. Weckherlin	Amsterdam
1656	Eclog. Florelle oder Lob und Trost Schallendes Hirtengespräch (beim Tode Eleonoren Krausen gest. 16 Sept. in Weimar)	Georg Neumark	Jena
1701	Etliche Schäffer-gedichte (in four ec- logues he celebrates two deaths, one birth and one betrothal)	Chr. Wernicke	Hamburg 1704, 1749
1718-20	B. Neukirch's grosse Anthologie (much of it pastoral Gelegen- heits-dichtung)	Coll. by B. Neukirch	Halle
1732	Die Alp n	Albr. v. Haller	Bern
1742	Schäfererzählungen	Joh. Christoph Rost	Berlin
1746	Idyllen (in Oden Anakreons in reim- losen Versen)	Joh. Nik. Götz	Frkft. u. Leipzig
1748, 8	Versuch in Moralischen und Schä- fergedichten (inclined toward Haller) Ed. by A. G. Uhlich	Chr. Fr. Zernitz 1745	Hamb. u. Leipzig
1750	Die Liebe oder Thyrsis und Doris		
1753, 8	Die Nacht	S. Gessner	Zürich
1753, 8	Hirtenlieder u. Gedichte (after Batteux)	Anonymus	Halle
1754, 8	Daphnis an Silen		Halle
1654, 8	Daphnis	S. Gessner	Zürich 1760, 60, 65
1754	Damon und Damoetas. Ekloge	Mich. Dietr. Blohm	Altona
1756, 8	Idyllen	Sal. Gessner	Zürich 1760, 60, 65
1758, 4	Der Mai, eine musik. Idylle	Karl Wilh. Ramler	Berlin 1764
1758	Neue Gedichte (including idyls)	Ewald Chr. v. Kleist	Berlin
1758, 8	Der Tod Abels (transl. into French 1759)	S. Gessner	Zürich 1760, 65, 67, 73
1760	Der Morgen in Pros. Sereibart	H.	
1761, 8	Idyllen	Jac. Fr. Schmidt	
1762	Der erste Schiffer	S. Gessner	Zürich
1763	Bukolische Eszählugen	Ge. Aug. v. Breitenbauch	Frft. u. Leipzig
1763, 4	Elmire und Ernst, Eine Idylle	Joh. Dan. Glummert	Danzig

Date.	Title.	Author.	Place.
1764, 8	Idyllen oder Klagen über die flüchtige Zeit.	Karl Hein. Hoffer	Leipzig
1765, 8	Jüdische Schäfergedichte	Ge. Aug. v. Breitenbauch	Leipzig
1766, 4	Lycas od. der erhörte Schäfer, eine Idylle		Danzig
1766, 8	Thomson's Jahreszeiten (including Gemählde von der Weinlese)	Johannes Tobler	Zürich 1774
1768, 8	Idylle auf die Abreise Marien Charl. Erzherz. in Oesterr. (He wrote many similar)	Joh. Cristoph Regelsperger	Wien
1769	Sieben Kleine Gedichte der Venus gesungen, also Idyls	Abraham Jak. Penzel	Berlin
1770, 8	W. Collin's orientalische Eklogen etc. aus. d. Engl.	S. Gessner	Zürich
1770	Einige Idyllen in Vermischte Gedichte	Joh. Gottf. Chr. Nonne	Jena
1771	Idyllen	Karl Chr. Reckert	Münster
1771, 8	Versuche in Idyllen	Hektor Wilh. (Freyherr) v. Günderode	Karlsruhe
1771, 8	Idyllen. die Hügel bei Ratenau, Rosalie und Amyntas	Joachim Cristoph Blum	Berlin
1771, 12	Theocritus: Idyllen (transl.)	Fr. Grillo	Halberstadt
1772	Moralische Erzähl. u. Idyllen v. Diderot	S. Gessner	Zürich
1772, 8	Neue Idyllen	Sal. Gessner	Zürich
1772, 8	Hirtenslieder u. d. verklagte Amor	Fr. Aug. Clem Werthes	Leipzig
1772, 73	Idyllen	Joh. Hein. Weissman	Leipzig
1773, 8	Idyllen	Blum	Berlin
1773	Idyllen	Andreas Grader	Riga
1773, 8	Versuche von Schäfergedichten	Johannes Kraus	Maynz
1775	Menalk u. Mopsus (after V. Ec. of Vergil), Eclogues	Lenz	Fkft. u. Leipzig
1775	Der Faun. Eine Idylle Der Erschlagene Abel. Eine Skizze Der Satyr Mopsus Bacchidon u. Milon Die Schaafschor, eine Pfalzische Idylle	Maler Müller	Mannheim
1775, 8	Idyllen	Joh. Heinr. Bücking	Frankfurt
1776, 8	(Anhang von) Idyllen (9 versificierte Gessner's)	Klamer E. K. Schmidt	Leipzig
1777, 8	Idyllen u. Erzählungen	Karl Heinr. Höffer	Leipzig

Date.	Title.	Author.	Place		
1776	Die Leibeigenschaft Die Pferdeknechte Der Aehrenkranz Selmas Geburtstag	Voss			
1777	Die Bleicherin Die Bettler Die Elbfahrt De Winterawend				
1778	Das Ständchen. Eine Junker Idylle De Geldhapers				
1779	Der Riesenhügel Der Abendschmaus Der Hagestolz				
1781	Die Kirschenpflückerin Der bezauberte Teufel Der siebzigste Geburtstag				
1781	Homer's Odyssee)				
1783	Des Bräutigams Besuch (later 2nd part of Luise)			Voss	
1784	Luise (later 1st part of Luise)				
1784	Idyllen u. Lieder			Traugott Christiana Dor. Löberin	Dresden
1785	Gedichte. vol. 1 Idyllen			Voss	1801, 2, 1824
1785	Hochzeitlied (later in 2nd part of Luise, Die Henmad	Voss			
1786	Philemon u. Baucis				
1787. 8	Damöt u. Phyllis. Eine Idylle	Karl Ch. Reckert	Berlin		
1787. 8	Gessner's Auserlesene Idyllen in Verse gebracht	Ramler	Berlin		
1789. 8	Gessner's Schäferged. Der erste Schiffer in Verse gebracht	Ramler	Berlin		
1790. 8	Idylle: die glückliche Wiedergene- sung des Cammerpres. von Flotow	J. C. Krauseneck	Bayreuth		
1791. 8	Daphnis u. Kloe. Idylle mit Gesang	Karl Chr. Reckert	Berlin		
1793	Homer's Werke (Ilias neu-, Odyssee umarbeitet)	Voss			
1795	Frühlings Gesang (later in 1st part of Luise,	Voss			
1796	Gesang d. Leibeignen beim Erntekranz (later in die Erleich- terten) Gedichte (contains Mörsergericht etc.)				
1795	Luise ein ländl. Ged. in drey Idyllen.				

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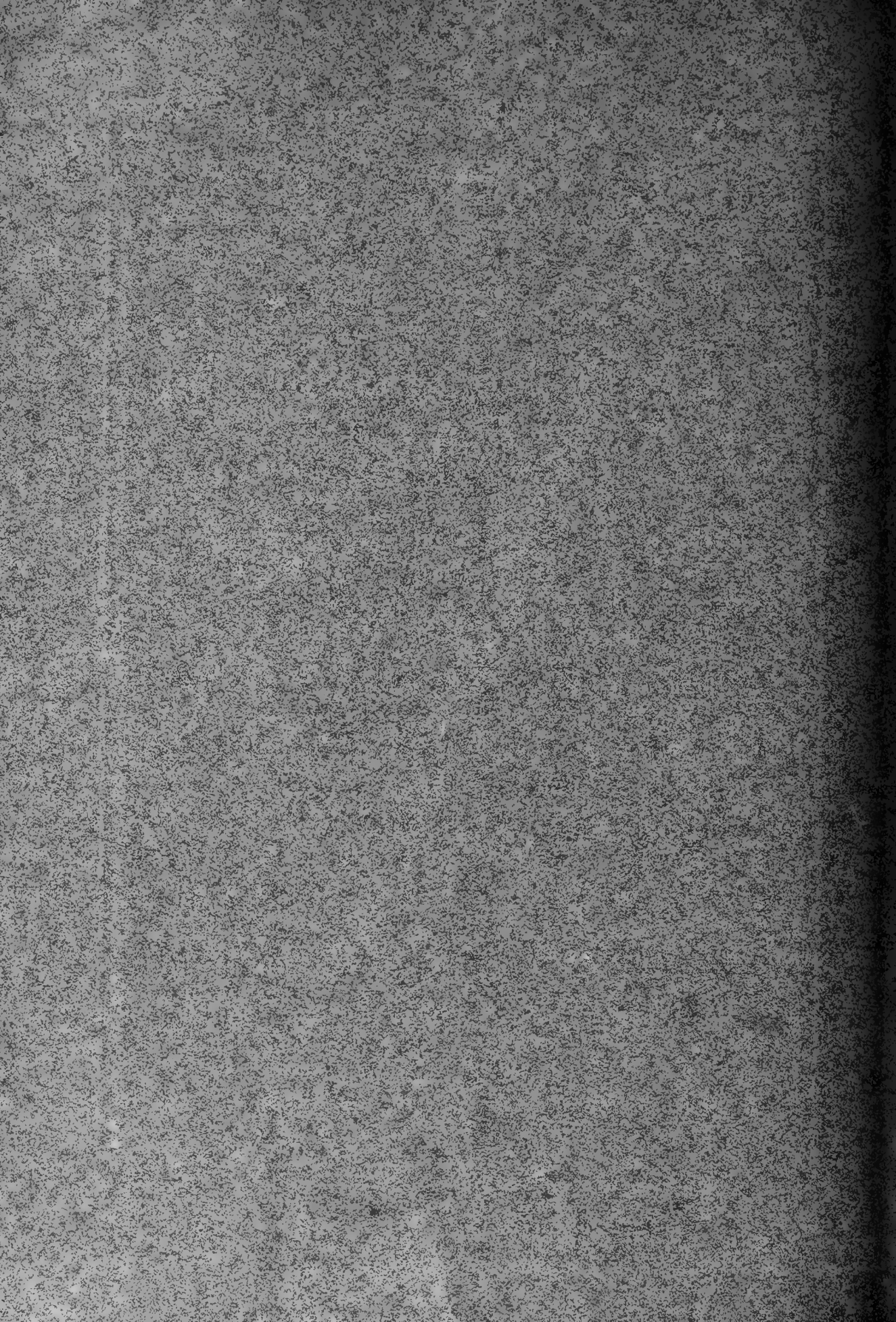
On the Cyclonic Distribution of Rainfall

BY

JOHAN AUGUST UDDEN

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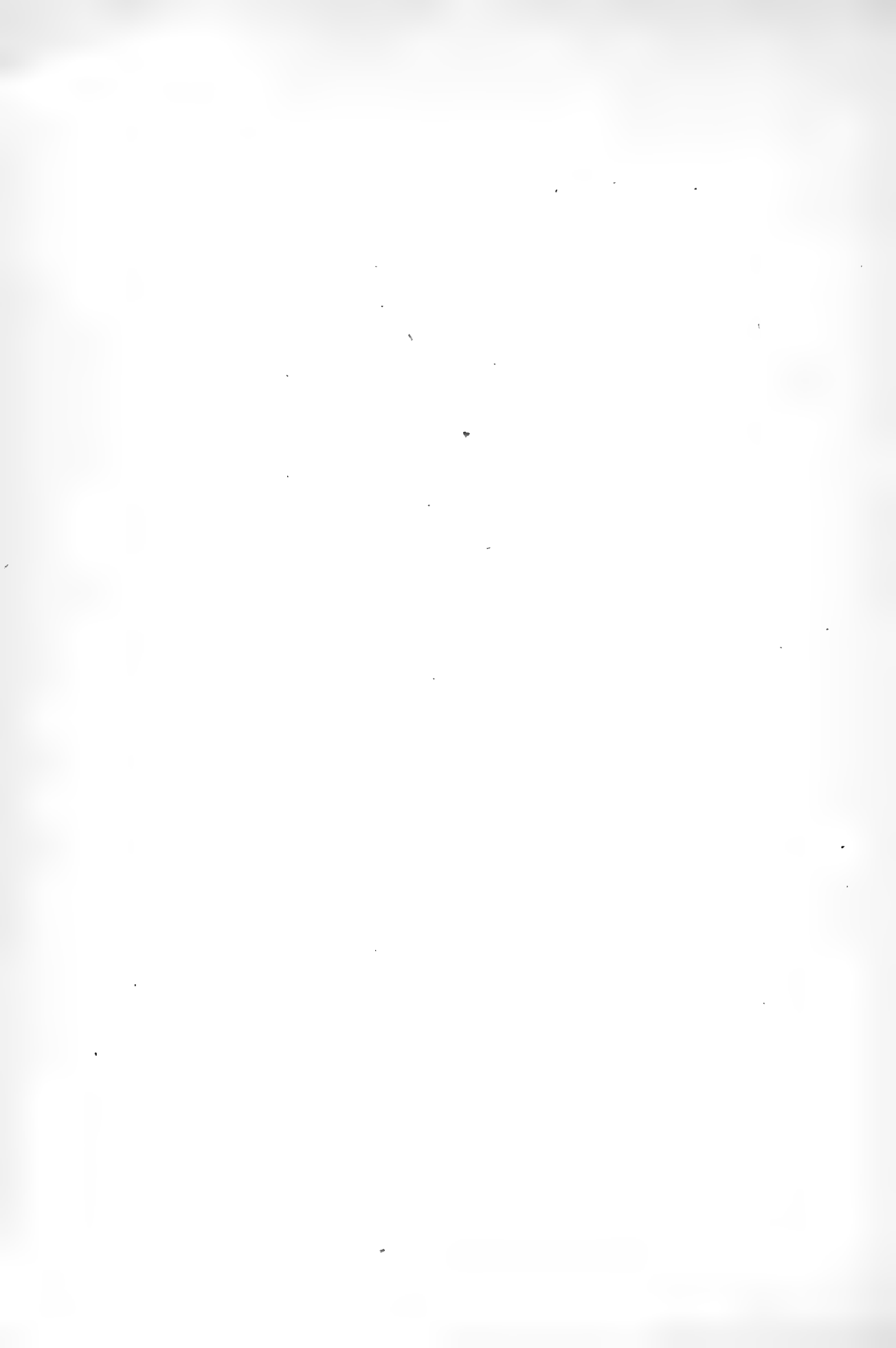
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DEDICATORY.

However inappropriate the occasion, the author of the following short paper cannot forego the pleasure of expressing a greeting of remembrance and affection to all of those earnest young men and women who have, with a truly scientific and unselfish interest, during several years in the past given time and thought to the work which was necessary for the extraction from the original documents of the data presented on the following few pages.

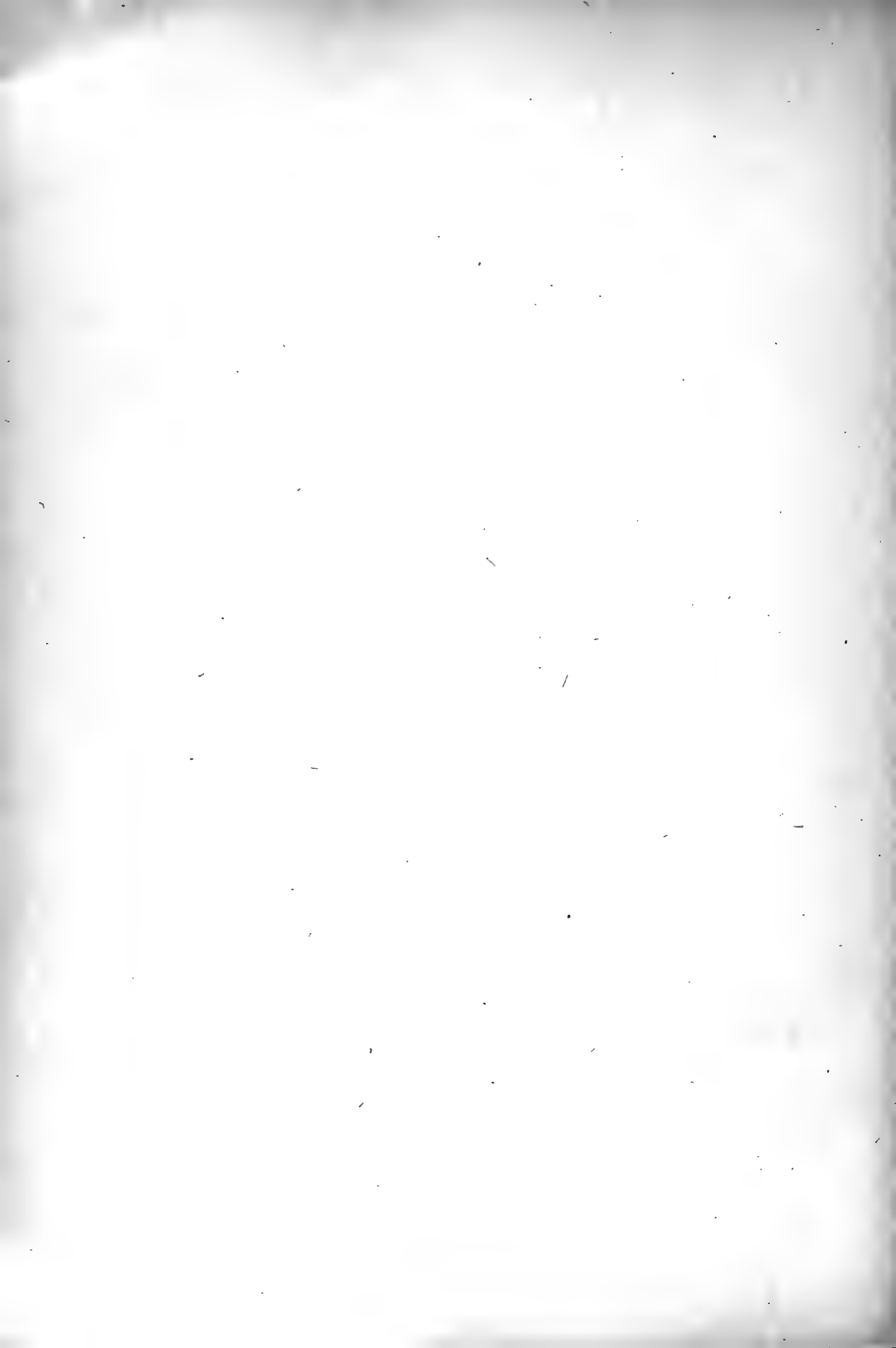
Ars longa, vita brevis.

Especially does life and its associations seem short to the man in the lecture room. It is his privilege to continually make new and most pleasant acquaintances with open and unbiased young minds and hearts, but it is also his fate to be compelled to part with them, as he feels, altogether too soon, often never to meet them again.

To each and every member of my former classes in Meteorology, and especially to the members of the Weather Club, I extend my thanks, and desire to present a copy of this paper.

J. A. UDDEN.

Augustana College, March 30, 1905.



ON THE CYCLONIC DISTRIBUTION OF RAINFALL.

Some years ago I had the pleasure of hearing a lecture on weather, given by one of the observers of the United States Weather Bureau. The lecturer discussed the distribution of weather in the extra tropical cyclones in America. He described the conditions which characterize the four quadrants of an area of low pressure. He especially emphasized the statement we often find in text-books, that the greatest precipitation occurs in the region which lies some distance to the southeast of the center of an area of low pressure.

A short time after hearing this lecture I had occasion to discuss weather prognostics with a gentleman whose occupation had led him for many years to closely watch the government's forecasts issued at Davenport, Iowa. This gentleman said he had found that storms would usually arrive from six to twenty hours behind the time they were due according to the local forecasts. Otherwise he regarded the predictions as quite reliable and valuable. "When a storm is announced", he said, "it will almost always come, but it is apt to be a little behind time." This statement corroborated an impression which I had myself received. It is the writer's belief that if a careful comparison were made of the forecasts referred to, and of the actual conditions of the weather at Davenport previous to 1896—since which time I have given less attention to the matter—it would be found that the forecasts more frequently missed by announcing storms too early, than too late.

It occurred to me that this delay of the expected storms might be due to some regional or local variation in the features of the passing cyclones, and that it would be desirable to determine, by some statistical method, the actual relation of weather conditions to different parts of the cyclone for this locality. For the purpose

of doing this, I made use of a simple device, which I have since had the satisfaction of seeing employed by others. By marking off eight radii in four concentric circles I plotted twenty-five areas in a figure, which could be used to represent definite separate tracts in a circular storm. The lengths of the radii of the successive circles had the ratios 1: 4: 7: 10 and were taken to represent the same number of hundreds of miles in a composite cyclone two thousand miles in diameter. The construction will be readily understood from the accompanying figures. The radii were drawn at angles of 45° , but were not extended into the inner circle. The figure was so oriented that the four points of the compass would bisect four alternate octants. There were thus three tracts marked off in each octant outside the smallest circle. With this representing the central region of a cyclone, the figure was used to delimit twenty-five fixed areas inside its extent. Tract "1" thus covers a central circle two hundred miles in diameter in the center of a cyclone. Tract "2" covers an area extending from one hundred to four hundred miles away from the center to the north, and lying between radii diverging $22\frac{1}{2}^\circ$ on either side. Tract "10" covers the area between the same two radii at a distance from four hundred to seven hundred miles from the centre. Tract "18" lies at a distance from seven hundred to one thousand miles from the centre, and so on, in the other octants.

My method was then simply to take a sufficient number of observations on the weather at Davenport, when this station lay in any one of the twenty-five corresponding tracts of an actual cyclone, and to average these for each tract separately and thus obtain for each separate percentages expressing frequency of certain weather conditions, such as precipitation and cloudiness, resultant wind directions, etc. I averaged these elements of the weather, as observed at S A M., during a period of about five years, taking the data from the daily weather maps. There were nearly a thousand observations in all. These were distributed among the twenty-five tracts somewhat unequally, but it is believed that the number of observations in each tract was large

enough to secure a fairly representative average. In other words: the number of times precipitation occurred or cloudiness prevailed was noted when Davenport was located in any one of the designated tracts with reference to the centre of a low area, and also the total number of times the opposite conditions prevailed. From these two figures percentages were obtained showing the comparative frequency of precipitation and cloudiness in each tract. It will be seen that this is only a very simple method of averaging weather conditions for different parts of an area of low pressure. The results can be plotted on a chart.

It was found that precipitation is most frequent at Davenport when the station lies in the tract numbered eight, which is on the west side of the central low. It was also found that precipitation is infrequent in the region to the southeast of the centre, decreasing very rapidly in that direction from the tract numbered eight. From this distribution of precipitation it is evident that if forecasts were made on the supposition that precipitation is greatest on the southeast side of the central low, a large percentage of the predictions would announce the stormy weather ahead of time. For it would often happen that the centre of the low would have to move east some two or three hundred miles before it would bring up that tract, where rains and snow are actually most frequent.

With the aid of some student friends the cyclonic conditions were averaged in a like manner for some more stations, representing four other climatic regions in the United States. It was found expedient to make use of data slightly different from those used in the Davenport cyclone. Thus we combined the observations taken at Amarillo, Dodge City, Wichita, and Oklahoma during the years 1894—1898, obtaining a chart which presumably is characteristic for the cyclonic conditions on the southwest plains. Other charts combined into like averages the observations at Helena, Miles City, Leander, and Boise City for 1899; those taken at nine stations in the Upper Missouri Valley in 1899; and those taken at Detroit and at Buffalo during the years 1900—1903.

The percentages of precipitation for the several cyclonic tracts in each of the five locations averaged, are given in Table no. 1, below, and in the same way the percentages of cloudiness are shown in Table no. 2 for the same locations, excepting Davenport. Cloudiness was averaged for this station also, but the figures are not now accessible. The same data are plotted in the accompanying figures.

TABLE NO. 1.

Showing percentages of precipitation in five composite cyclones in different parts of the United States.

Number of tract.	Davenport.	Amarillo, Dodge City, Wichita, and Oklahoma.	Helena, Miles City, Leander, and Boise City.	Missouri Valley Stations.	Detroit and Buffalo.
1	26	3	0	20	44
2	21	14	17	21	40
3	15	20	10	11	40
4	0	—	6	8	40
5	3	5	0	5	26
6	4	3	3	5	15
7	7	9	3	7	15
8	35	5	13	11	26
9	17	21	16	15	33
10	17	21	18	20	25
11	8	19	6	20	18
12	8	13	14	6	17
13	6	2	10	2	18
14	4	2	6	5	5
15	4	8	4	2	0
16	10	6	5	5	34
17	0	21	20	6	25
18	17	18	1	8	9
19	19	6	12	9	8
20	2	6	8	8	9
21	2	6	5	2	6
22	22	6	2	3	—
23	7	7	2	4	0
24	6	7	3	4	1
25	0	6	16	3	0

TABLE NO. 2.

Showing percentages of cloudiness in four composite cyclones in different parts of the United States.

Number of tract.	Amarillo, Dodge City, Wichita, and Oklahoma.	Helena, Miles City, Leander, and Boise City.	Missouri Valley Stations.	Detroit and Buffalo.
1	49	48	60	93
2	57	60	77	93
3	69	46	66	93
4	38	37	49	98
5	37	42	48	77
6	26	55	47	75
7	36	47	47	72
8	67	54	66	92
9	69	45	68	93
10	53	51	12	79
11	68	36	66	75
12	54	56	49	76
13	30	37	34	55
14	28	36	38	58
15	33	36	33	81
16	42	45	36	69
17	60	63	41	71
18	64	22	59	82
19	59	45	51	77
20	38	41	34	53
21	28	26	32	65
22	35	33	35	—
23	36	41	36	80
24	23	36	30	56
25	38	49	27	50

Although the data used for these different averages are not exactly of the same kind, it is believed that these tables and charts are quite comparable, and that they roughly indicate the cyclonic features which are characteristic for each region. They show clearly that the area of the greatest rain- and snowfall is not in the same position with regard to the centres of low areas in different climatic regions. In every case it is eccentric and lies to the

west, northwest, north or northeast, in the cases studied, but in no instance to the southeast.

Several features shown in these charts suggest further inquiries. In the two charts for the semi-arid regions in the southwest and the west, precipitation is most frequent in a crescentic tract on the north side of the central low pressure. To what extent is this characteristic of the cyclones in the west?

In the two charts representing conditions in the region of the northern part of the central plains, the area of the greatest precipitation has a sigmoid shape. Is this a constant feature for the region, and, if so, what is its cause?

In the Davenport charts precipitation as well as cloudiness is unexpectedly high in the southernmost tract. Rain and snow are almost as frequent when a low centres three hundred miles north of Lake Superior, as when it lies at Davenport. A study of the conditions which bring about this unexpected precipitation may throw some new light on cyclonic conditions in the interior.

The purpose of this paper is merely to call attention to the method of averaging. It is a truly statistical method which promises a more accurate knowledge of cyclonic conditions than we have had before. Its application will involve a great deal of work. The averages given here pertain only to the conditions for the morning hour. If similar averages could be made for an afternoon or for an evening hour, for the same places and periods, it is not unlikely that differences would appear. Again, it is to be expected that summer and winter cyclones are unlike, and it is believed that there are differences among the cyclones coming along different paths. If this is true, it ought to be shown in such averages as those presented in the above tables.

A study of all regional, seasonal, and other differences by some such accurate method of averaging can hardly fail to add some important items to our knowledge of cyclonic disturbances. It may be used for any of the elements of the weather. Thus, in the charts which follow, the prevailing wind directions are indicated

by arrows, and the relative persistence of the given direction is indicated by the relative length of these arrows.

NOTE: In the figures numbered 2, 3, 4, 5 and 6, the shading represents different percentages of precipitation as follows:

Solid black,	40% and above.
Crossed parallel lines,	30-39%
Parallel lines,	20-29%
Interrupted parallel lines,	10-19%
No shading, less than	10%

and in the figures numbered 7, 8, 9 and 10 percentages of cloudiness are indicated thus:

Parallel lines,	75% and above.
Interrupted parallel lines,	50-74%
No shading, less than	50%

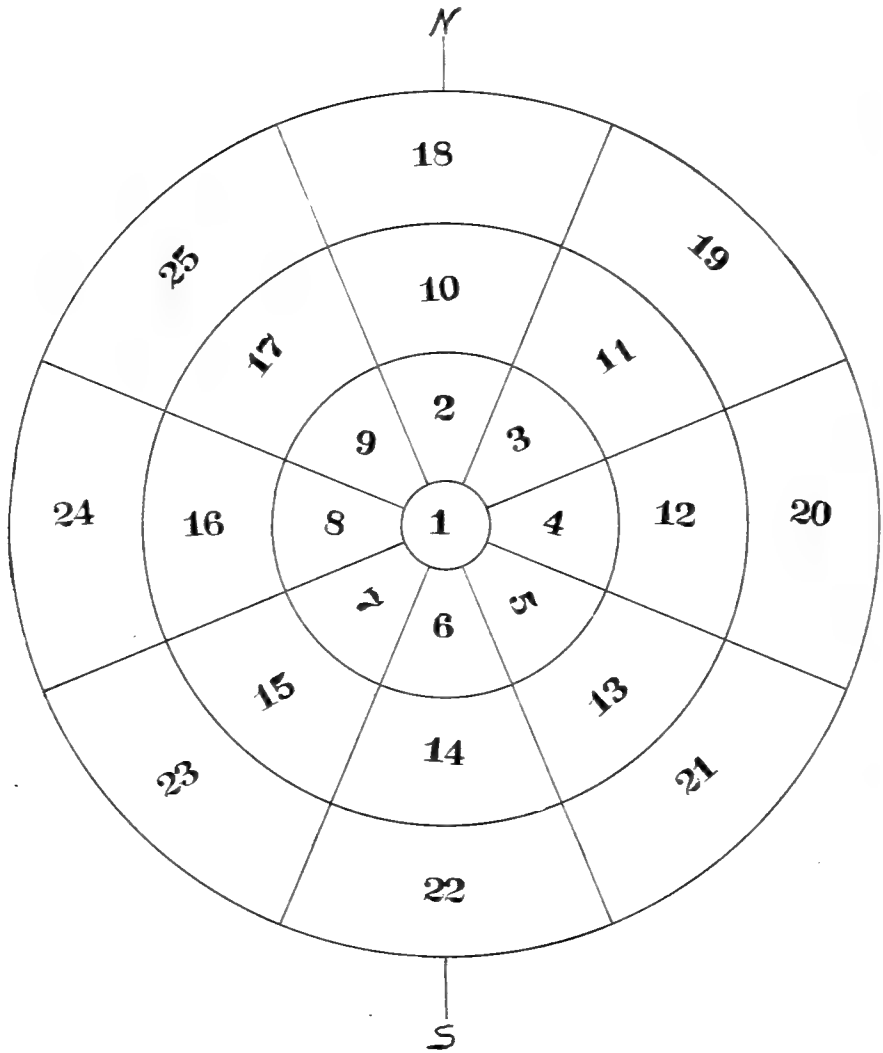


Fig. 1. Showing the location of each of the twenty-five tracts as averaged in each cyclonic area. The numbers are those given under the columns "number of tracts" in the preceding tables.

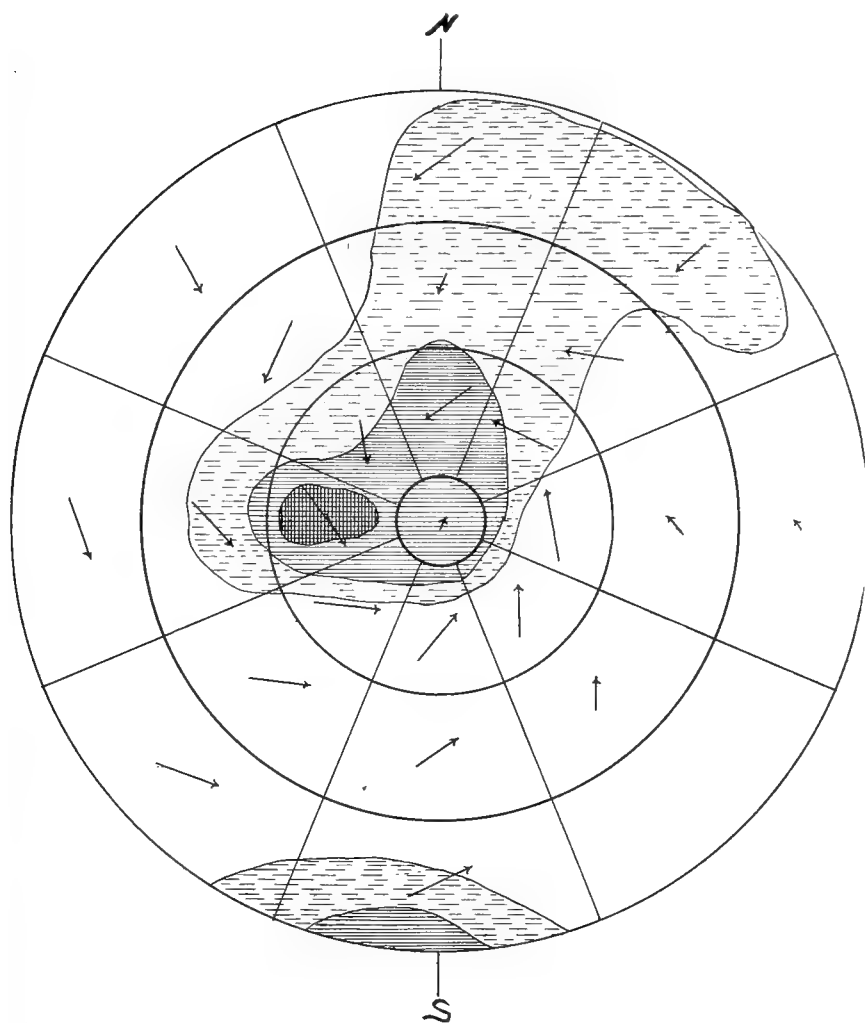


Fig. 2. Showing the distribution of precipitation and wind directions in a composite cyclone, based on the 8 A. M. observations taken at Davenport during the years 1893—1897.

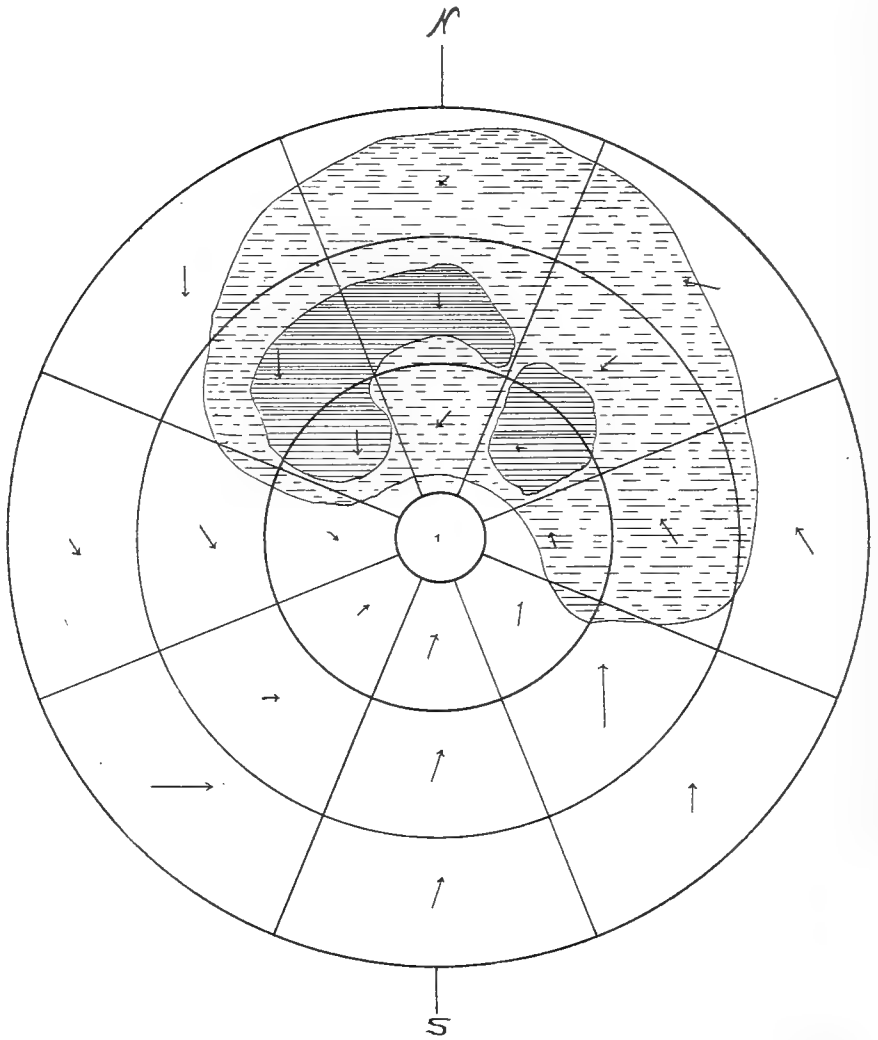


Fig. 3. Showing the distribution of precipitation and wind directions in a composite cyclone, based upon the 8 A. M. observations taken at Amarillo, Dodge City, Wichita and Oklahoma during the years 1894—1898.

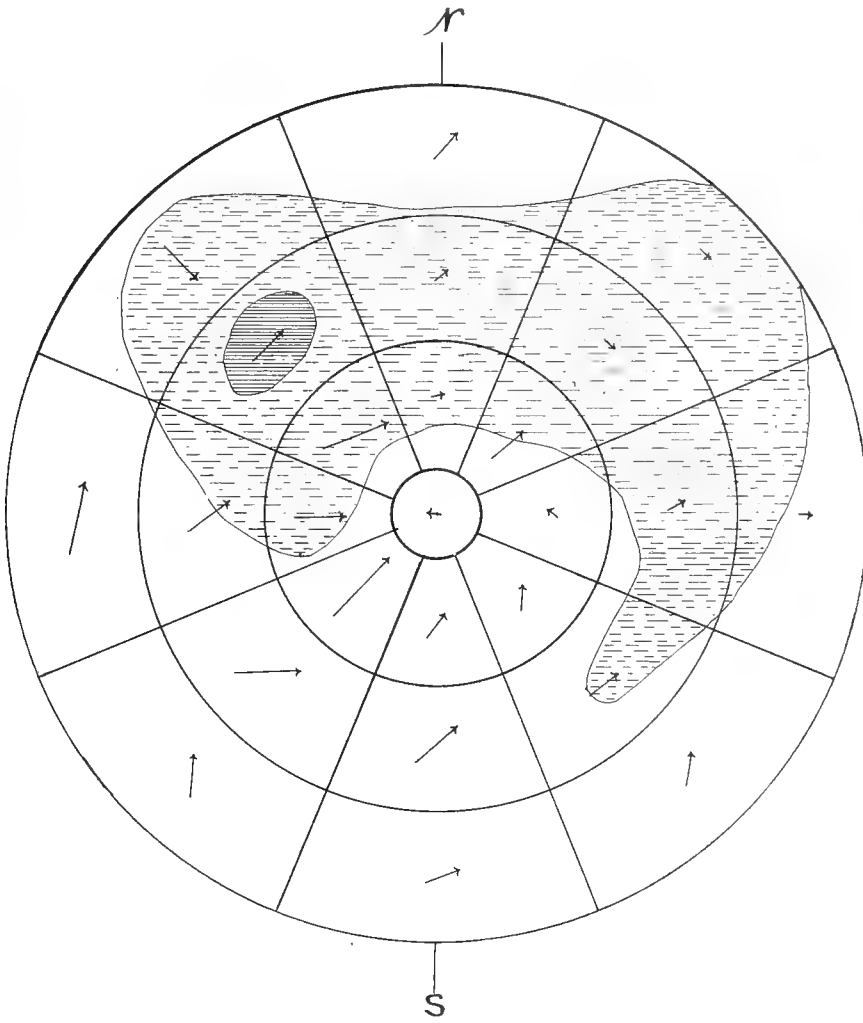


Fig. 4. Showing the distribution of precipitation and wind directions in a composite cyclone, based upon the 8 A. M. observations taken at Helena, Miles City, Leander and Boise City in 1899.

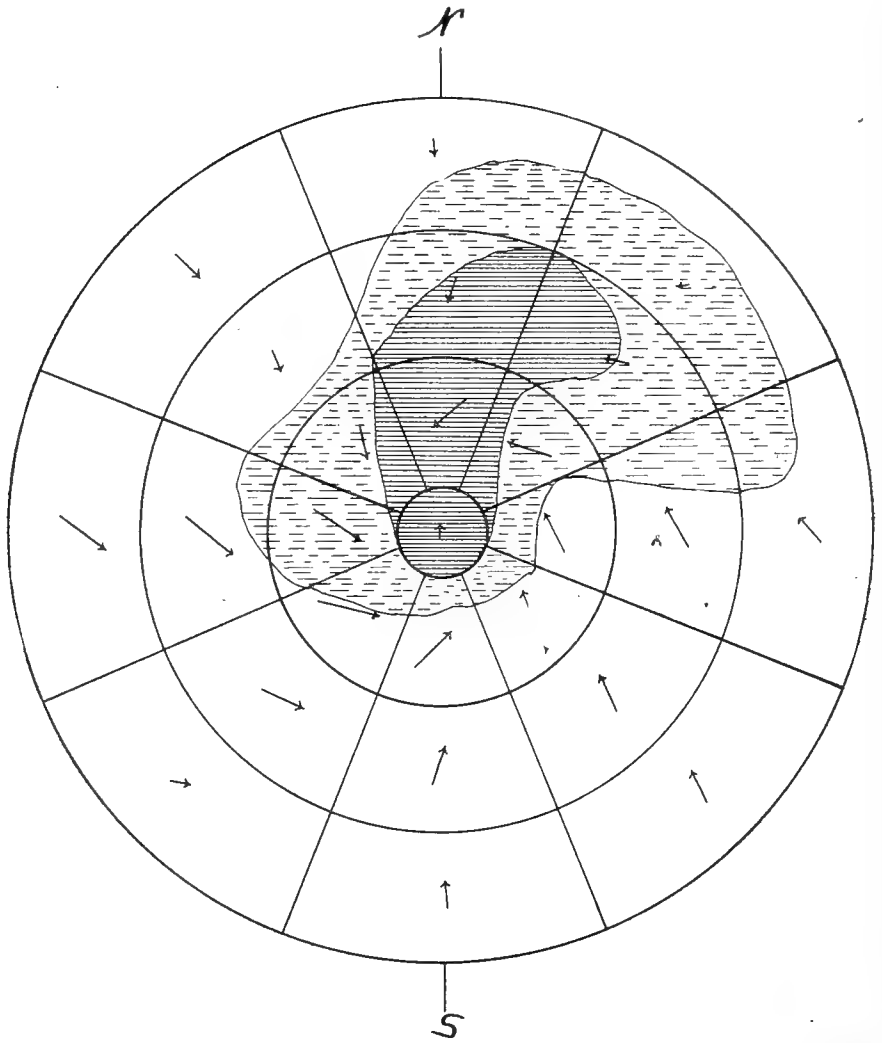


Fig. 5. Showing the distribution of precipitation and wind direction in a composite cyclone, based upon the 8 A. M. observations taken at all the stations in the Upper Missouri Valley during 1899.

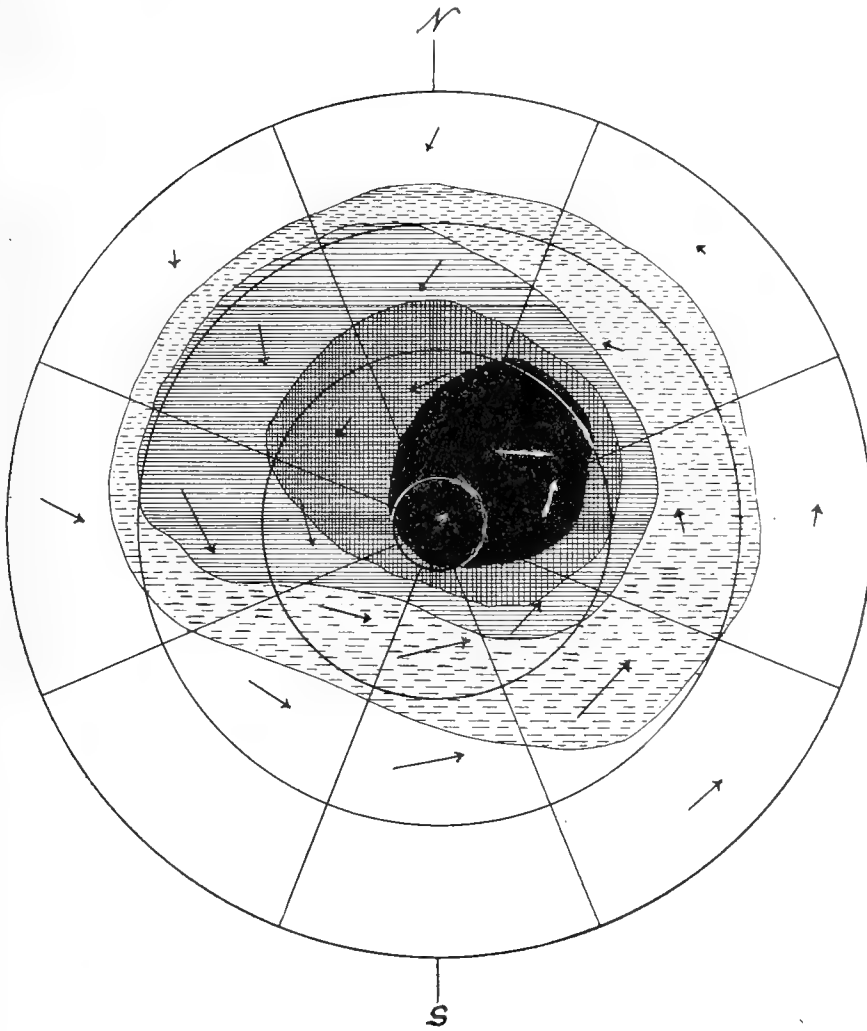


Fig. 6. Showing the distribution of precipitation and wind directions in a composite cyclone, based on the 8 A.M. observations taken at Detroit and Buffalo during the years 1900—1903.

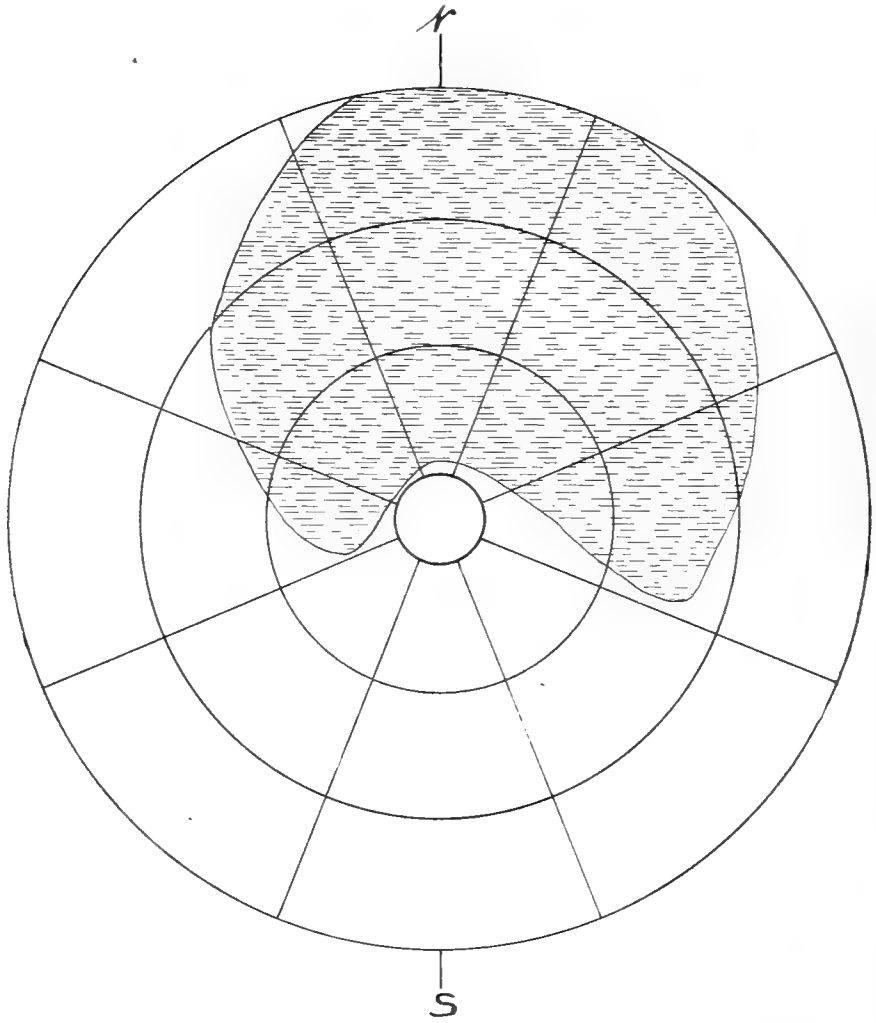


Fig. 7. Showing the distribution of cloudiness in a composite cyclone, based on the 8 A. M. observations taken at Amarillo, Dodge City, Wichita and Oklahoma during the years 1894—1898.

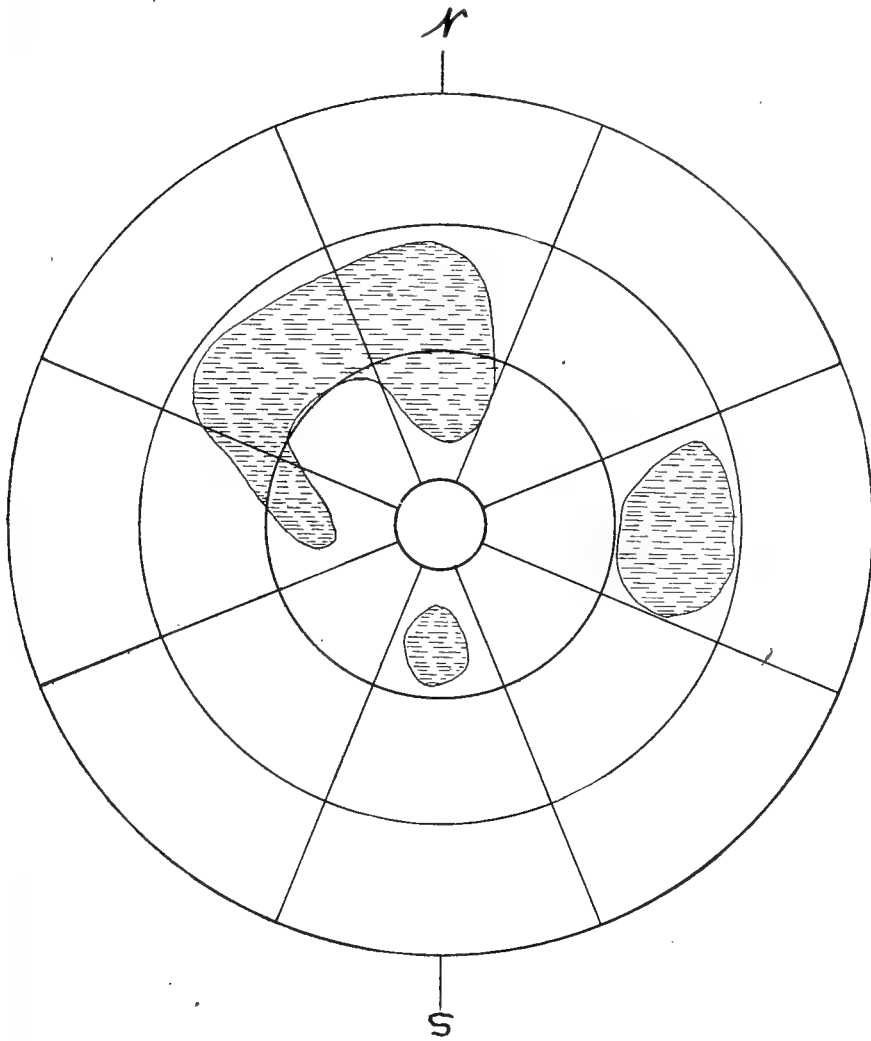


Fig. 8. Showing the distribution of cloudiness in a composite cyclone, based on the 8 A. M. observations taken at Helena, Miles City, Leander and Boise City in 1899.

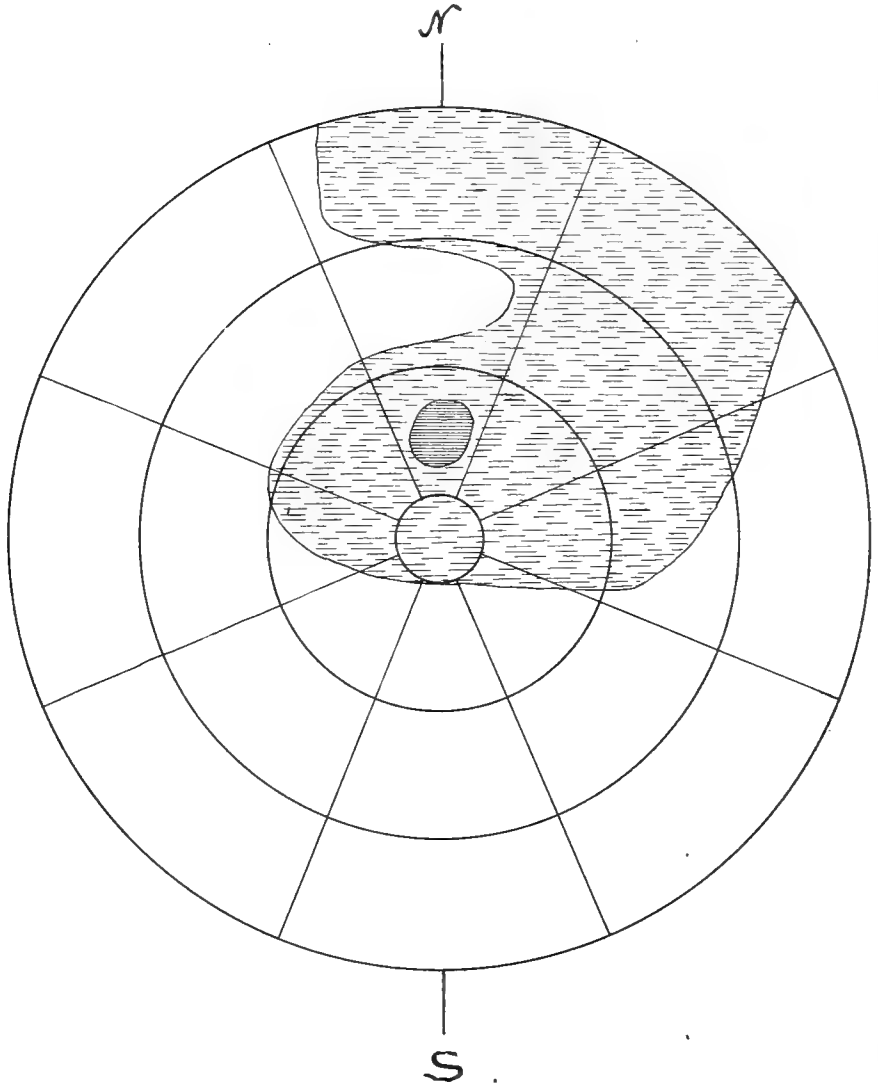


Fig. 9. Showing the distribution of cloudiness in a composite cyclone, based on the 8 A. M. observations taken at all the stations in the Upper Missouri Valley during 1899.

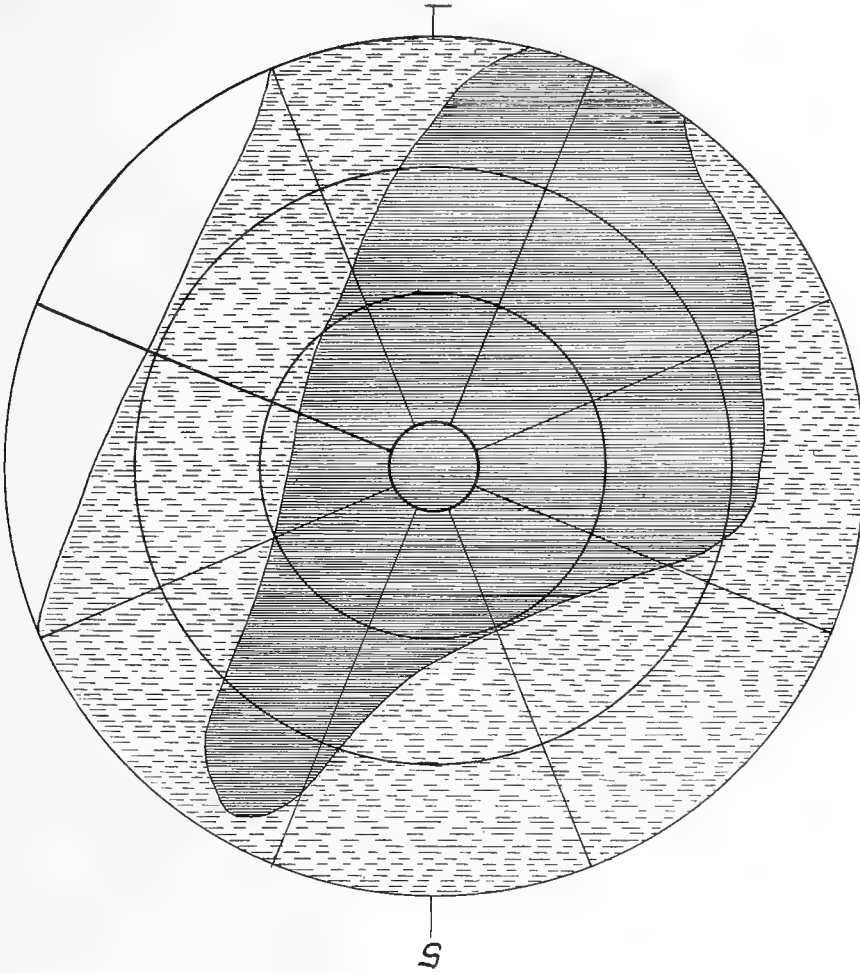


Fig. 10. Showing the distribution of cloudiness in a composite cyclone, based on the 8 A. M. observations taken at Detroit and Buffalo during the years 1900—1903.

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NUMBER FIVE

A PRELIMINARY LIST OF
FOSSIL MASTODON AND MAMMOTH REMAINS
IN ILLINOIS AND IOWA

BY

NETTA C. ANDERSON

ON THE
PROBOSCIDEAN FOSSILS OF THE PLEISTOCENE DEPOSITS
IN ILLINOIS AND IOWA

BY

JOHAN AUGUST UDDEN

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A PRELIMINARY LIST OF
FOSSIL MASTODON AND MAMMOTH REMAINS
IN ILLINOIS AND IOWA

BY

NETTA C. ANDERSON

ON THE
PROBOSCIDEAN FOSSILS OF THE PLEISTOCENE DEPOSITS
IN ILLINOIS AND IOWA

BY

JOHAN AUGUST UDDEN

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OF THE
MUSEUM OF HISTORY
AND ETHNOLOGY

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Remains

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INTRODUCTORY.

In submitting the subjoined Preliminary List of Fossil Elephant and Mastodon Remains in Illinois and Iowa, which is believed to be the first of its kind in these states, the compiler does not intend to imply that the list is nearly complete; she is impelled to publish the result of her research, thus far, in the hope that such a list may be of assistance in securing further data along this line. The difficulty in securing reliable information can be easily appreciated, for comparatively seldom does the working Geologist see such remains *in situ*, and the museums, their ultimate repositories, appear to keep scant record of the circumstances connected with such finds, their geographical and geological position, date of their discovery, etc.

In presenting this list the compiler would therefore make her humble plea for more complete and more carefully kept data from which the specialist must proceed in determining more nearly the true horizon of these huge Proboscidiens. She also wishes to express her gratitude to the State Geologists and Assistants, to Librarians, Curators of different museums, and to numerous private individuals, all of whom have so cheerfully assisted her, and in particular to Dr. J. A. Udden, of Augustana College, does she feel indebted for invaluable assistance and encouragement.

Rock Island, Illinois, May, 1905

ILLINOIS

CALHOUN COUNTY.

From the clay (drift clay) in the side of a ravine in Calhoun county, Illinois, we recovered the jaw of an elephant beside which Jumbo would seem small. One of the teeth from this jaw weighs nearly eighteen pounds.

(*McAdams, Transactions, St. Louis Academy of Science, Vol. IV, No. 3, p. lxxix.*)

CHRISTIAN COUNTY.

Sangamon River.—A tooth of a mammoth was found by David Miller in a sand drift near the South Fork of the Sangamon river, and was presented to the State Cabinet. This specimen is of a chalky white color and does not appear to have been impregnated with any mineral substance since it was imbedded in the earth.

(*Illinois Geological Survey, Vol. I, p. 38.*)

COOK COUNTY.

Evanston.—The tooth of a mammoth was taken from a gravel pit near Evanston. It was placed in the Museum of Northwestern University.

(*Reported by Prof. U. S. Grant, Northwestern University.*)

Glencoe.—A fragment of a mastodon tooth four and three-fourths inches long was dug up by Mr. James Robertson while ditching in glacial drift at Glencoe. The fragment, which is from the proximal end, is now in the possession of Mr. Walter O'Neill of Lake Forest.

(*Reported by Prof. James G. Needham, Lake Forest College.*)

DU PAGE COUNTY.

About 1875 some mastodon remains were found in a bog about eight miles southwest from Naperville. They were donated to the Museum of Jennings Seminary, Aurora.

(Reported by L. M. Umbach, Northwestern College.)

Wheaton.—About 1890 the remains of a mammoth were found while ditching on the Jewell farm near Wheaton. The remains consisted of about a dozen ribs, as many vertebrae, one femur, and other parts of the legs.

(Reported by Pres. Charles A. Blanchard, Wheaton College.)

EDGAR COUNTY.

The bottoms of the prairie sloughs along the western edge of Edgar county generally contain more or less light brown marly clay containing fresh water shells. From one of these slough bottoms a nearly perfect skeleton of a mastodon was obtained some years since, which, after having been exhibited through all this part of the United States, is said to have been sold to a Philadelphia museum. Fragments of this animal are not rare hereabouts.

(Illinois Geological Survey, Vol. IV, p. 216.)

FULTON COUNTY.

The Museum of Knox College contains the tooth of an elephant which was found in Fulton county. This specimen, which is much decayed, was found near the surface of the ground.

(Reported by Albert Hurd, Curator of Museum, Knox College.)

GALLATIN COUNTY.

Equality.—“Half Moon”—Many mammoth and mastodon bones and enamel plates of teeth, the less enduring parts of the latter mouldered into dust, have been found here. Half Moon is

a salt lick beneath which is a yellowish clay mixed with gravel and sand, belonging to the age of drift. The salt work was originally a swamp, for the bones lie on this drift.

(Illinois Geological Survey, Vol. I, p. 38.)

A fine tooth of a mastodon was found in Gallatin county and presented to the State Cabinet, but under what conditions it was found is not at present known.

(Illinois Geological Survey, Vol. I, p. 38.)

Shawneetown.—Teeth of a mastodon were found close to the water's edge in front of Shawneetown. They were imbedded in a shallow deposit of bluish clay resting upon yellow clay and gravel. Corresponds in geological time with bone beds at Half Moon.

(Illinois Geological Survey, Vol. VI, p. 214.)

GRUNDY COUNTY.

Morris.—In 1868 mastodon remains were found at Turner's Strippings, three miles east of Morris, under eighteen inches of black mucky soil and about four feet of yellowish loam and resting on about one foot of hard blue clay, which covered the coal. The bones were badly decayed, and most of them were broken up and thrown away by the miners. Of the remaining, Mr. J. Evan, of Morris, obtained and presented to the State Cabinet, a part of a thigh-bone, a fragment of a lower jaw, three teeth, and a few of the smaller bones. The locality is a part of the old river bottom, and in the lack of personal observation, I am uncertain whether to believe that the presence of the bones indicates that the animal was mired and died there or to suppose that the carcass was deposited there by the river.

(Illinois Geological Survey, Vol. IV, p. 193.)

Minooka.—“In 1902 Mr. John Bamford, in enlarging a bog-spring, encountered a mass of Bison, Deer, and Elk bones at about five feet below the surface. Passing through nearly two

feet of these, he came upon mastodon bones in abundance. Skulls of at least six different individuals had been found in a well ten feet in diameter when I visited the place in 1902. These animals had evidently resorted to this drinking place and had mired in the bog. Old settlers related several instances of cattle becoming mired at this place in the same way."

(Reported by E. S. Riggs, Assistant Curator of Paleontology, Field Columbian Museum, Chicago.)

HANCOCK COUNTY.

Warsaw.—"About five or six years ago one of my nephews found a large fragment (about one-half or more) of a mastodon tooth, sticking out of the bank of a creek, about five miles below Warsaw."

(Reported by Charles K. Worthen, Warsaw, Ill.)

HENRY COUNTY.

Penny's Slough.—The tooth of a mammoth in a good state of preservation was found in Penny's Slough and presented to the Davenport, Iowa, Academy of Science.

(Information obtained from label on specimen.)

Cambridge.—The Museum of the Chicago Academy of Science contains part of a tusk of a mastodon, recovered at Cambridge from a well, sixteen feet below the surface; condition poor.

(Reported by Frank C. Baker, Curator, Chicago Academy of Science.)

JO DAVIESS COUNTY.

Blue Mounds.—Mastodon remains have been taken from a great number of crevices over the whole area of the lead region, showing the species to have lived in immense numbers and through a long period of time. From a crevice near Blue Mounds,

bones of a mastodon were taken. *Elephas* also inhabited this region, though apparently less abundant than the mastodon. Few teeth found near the surface at

Galena are all the remains of this animal I met in this region.

(*Illinois Geological Survey, Vol. I, p. 162.*)

JOHNSON COUNTY.

Bloomfield.—The remains of a jaw and three teeth of a mastodon were found in the yellow clay about three feet below the surface near Bloomfield.

(*Proceedings, American Association for the Advancement of Science, Vol. X (1856), p. 163.*)

KANE COUNTY.

Aurora.—In 1870 tusks and several teeth of a mastodon were obtained from the superficial deposits of this county near Aurora when the excavation for the track of the Chicago, Burlington and Quincy railroad were made. These remains are in the Museum of Clark Seminary at that place.

(*Illinois Geological Survey, Vol. IV, p. 113.*)

Aurora.—In 1853, while extending the Burlington railroad south of Aurora, workmen found teeth and a tusk of a mastodon in a swamp on the edge of Fox river, where the Burlington repair shops at Aurora are located. The remains were presented to Jennings Seminary by an official of the road, Benjamin Hackney.

(*Reported by Mrs. Susan H. Quereau, Aurora.*)

Batavia.—In cutting a ditch to drain a marshy lake of some two hundred acres, some leg-bones and vertebrae of mastodon (along with Bison and other bones) were found in a sticky clay about five feet below the surface.

(*Reported, after personal investigation, by E. S. Riggs, Assistant Curator of Paleontology, Field Columbian Museum, Chicago.*)

KNOX COUNTY.

Galesburg.—Knox College Museum contains:

a) The tusk of an elephant which was found near Galesburg. The specimen is quite imperfect and was taken from recent deposits near the surface.

b) An elephant tooth, much decayed, which was found while ditching on a farm near Galesburg.

Spoon river.—c) A mastodon tooth in good state of preservation, the enamel nearly perfect, which was found in the bed of Spoon river in Knox county.

(The above three instances reported by Albert Hurd, Curator of Museum, Knox College.)

MACON COUNTY.

The museum of the Chicago Academy of Science contains two rami of the lower jaw and several molars of a mastodon, all in good state of preservation, which were found in Macon county.

(Reported by Frank C. Baker, Curator, Chicago Academy of Science.)

MADISON COUNTY.

Alton.—A portion of the jawbone of a mastodon with two teeth remaining was found in the lower part of the loess, just above the city of Alton. This specimen was found about thirty feet below the surface and near the bottom of the loess, where it was only separated from the limestone by two or three feet of local drift. The bones were of chalky whiteness and in very fine state of preservation.

(Illinois Geological Survey, Vol. I, p. 315)

MARION COUNTY.

Sandoval.—At Sandoval, about twenty-four miles north of Beaucoup, mastodon remains were found twelve feet below the surface, in similar position to the one at Beaucoup.

(Proceedings, American Association for the Advancement of Science, 1856, pp. 148—169.)

OGLE COUNTY.

Byron.—Some years ago a large bone, supposed to be from the foreleg of a mastodon, was found two or three miles above Byron. The bank of Rock river had caved down for some distance back from the stream; some five feet below the surface of the highland coming up to the river and about fifteen feet above ordinary water level, the bone was found sticking in the bank. The bank seems to be a sort of modified drift made up of somewhat marly, dark-colored, alluvial clay intermixed with river sand and considerable gravel. The formation is hardly alluvium, but seems to be a kind of river drift. The fossil is light, porous, and whitish in color, in rather poor state of preservation. We obtained it through the courtesy of Mr. Mix and sent it to the State Geological Cabinet.

(*Illinois Geological Survey, Vol. V, p. 110.*)

Harper.—A number of years ago Mr. Gross found the tooth of a mastodon on his farm in Forreston township, one mile south of Harper. A small stream cuts through the farm, and one spring, after a freshet, the tooth was found in a large bed of gravel which had been washed to one place along the shore of the stream. The freshet washed a hole about nine feet deep out of the bed of the stream just above this gravel bed, and the finder, thinking that the tooth might have been washed out of this place, made a diligent search for other remains, but failed to find anything. The tooth measures eight inches in length and four and a half inches in width at the widest point, and is in an excellent state of preservation, having smooth polished surfaces. Another tooth was found in the same place a short time before by a Mr. Ainsworth.

(*Reported by Miss Abba Fager, Forreston.*)

Rochelle.—“In July, 1886, I saw a collection of mammoth fossils at F. G. Rossman’s, a farmer living near Rochelle, which he obtained in a bog in the northwest part of section thirty-three, Lynnville township. The fossils found were; one tusk, two

teeth, one piece of jawbone in which one tooth fitted, four pieces of ribs, and about a panfull of small bits of bones. The tusk weighed seventy-three pounds, but was not complete, each end being broken off. The length of the specimen was about five feet, and it measured twenty inches in circumference at the large end and about eighteen inches at the small end. The teeth each weighed twelve and one-half pounds and had a grinding surface nine inches long by four inches broad. The best rib specimen was forty inches long and five and three-fourths inches in circumference at the dorsal end. Another rib, thirty-four inches long, was not complete. The only further notes I have concerning these specimens is that the grinding surface is three or four inches shorter than the longest diameter of the tooth."

(Reported by Frank Leverett, Ann Arbor, Mich.)

Stillman's run.—Remains of the mastodon were found closely connected with the drift gravels. In 1858 a tooth was found in a little tributary of Stillman's run. The locality is low—somewhat marshy. The stream had cut a channel through the black alluvium of the low prairie. The tooth was washed out and lodged against a clump of willows when found. It is a ponderous grinder, weighs seven and a half pounds, is covered with a shining black enamel, and is a fossil in a high state of preservation.

(Illinois Geological Survey, Vol. V, p. 110.)

PEORIA COUNTY.

Peoria.—The remains of a mammoth, consisting of two molar teeth with a portion of the jaw, were found by Captain Smith in the gravel bed No. 2 of the following section in the Peoria bluff:

No. 1. Brown prairie clay and soil.

No. 2. Coarse gravel and sand with boulders.

No. 3. Clay and sand forming seven or eight distinct beds, some containing coarse gravel and boulders.

The specimen was presented to the State Cabinet.

(Illinois Geological Survey, Vol. V, p. 237.)

PIATT COUNTY.

Atwood.—The Museum of Northwestern University contains the tooth of a mammoth found near Atwood in 1879. The tooth was dug up about six feet below the surface.

(Reported by Prof. U. S. Grant, Northwestern University.)

RANDOLPH COUNTY.

Chester.—Mammoth and mastodon remains have been found in Alton and Chester. The fossils (bones) were found in loess. These belong to the collection of the Honorable Wm. McAdams, Alton.

(Illinois Geological Survey, Vol. VIII, p. 8)

ROCK ISLAND COUNTY.

Milan.—A piece of a tusk was found in the excavation made for brick clay by the Rockford Construction Company (1893?) on the north side of Rock river and on the east side of the Milan road south of Rock Island. It was taken from the red oxidized layer which forms the top of the boulder clay in the base of the bluff here and which was covered by a few feet of loess. The piece of tusk was about two feet long, but crumbled and broke into three pieces on exposure to the air. It was perceptibly curved, and measured about six inches in diameter at the proximal end, and about four inches at the distal end. The specimen is in the museum of Augustana College, Rock Island.

Rock Island.—In laying the overflow pipe from basins of the Rock Island water works on the bluff south of the city, a cut was made in the loess to a depth of about twenty-two feet near the edge of the bluff. In the lower part of this cut there was part of a tooth of an elephant and also a piece of a bone of the leg. The specimens were donated to the museum of Augustana College. The loess, at the point in the bluff where the bones were found, is about thirty-five feet thick, and the lower part of it is seen to be somewhat peaty in some of the cuts in the streets to the west.

Rock Island.—In the excavations which were made on the slope of the bluffs between Nineteenth and Twentieth streets in Rock Island in 1897, Dr. J. A. Udden found a carpal bone of an elephant. It was cuboid in form and measured some three or four inches in diameter. It was found on the surface of the ground in an excavation which was near the contact of the loess and the boulder clay.

Rural township.—A well preserved tooth of a mastodon was found in 1900 in a creek in the west half of section nineteen, township sixteen north, range one west (Rural township). The find was made by Mr. A. Dhuyvetter, after a heavy rain which caused high water in the creek. There are reports of other large bones having been found in the same creek. The drift in this township in places rests on pre-glacial gravels, consisting largely of chert. The tooth was secured for the collection at Augustana College.

(The above four instances were reported by Dr. J. A. Udden.)

SANGAMON COUNTY.

Illioplis and Niantic.—In 1870, between Illioplis and Niantic, near the east line of the county, the jaws of a mastodon, with teeth intact, both tusks, and several of the large bones were found beneath a black mucky surface soil, four feet in depth. These bones, together with some buffalo, elk, and deer, were imbedded in quicksand, which probably once formed the bottom of a pool of water to which these animals had resorted. The fossils now belong to the State Cabinet.

(*Illinois Geological Survey, Vol. VIII, p. 23.*)

The Niantic mastodon was found on the farm of W. F. Corell, in a wet, spongy piece of ground located in a swale or depression of the surface that had evidently once been a pond and had been filled up by the wash from the surrounding highland until it formed a morass or quagmire in dry weather. The bones were about four feet below the surface and partly imbedded in light gray quick-

sand filled with fresh-water shells. Above this quicksand was found four feet of black peaty soil, so soft that a fence-rail could easily be pushed down through it. The quicksand had evidently once formed the bottom of a freshwater pond, fed probably by springs, and was the resort of the animals whose bones were found here.

The first bone met with was one of the tusks, and, supposing it to be a small tree, it was cut in two with an axe before its true character was suspected. The other tusk was taken out whole and measured nine feet in length around the curve and about two feet in circumference where it was inserted in the skull. The lower jaw with the teeth in place and the teeth of the upper jaw and some of the smaller bones were also found in good state of preservation. The depth of the quicksand was not fully ascertained, but it was probed to the depth of two feet or more without reaching solid bottom.

(*Illinois Geological Survey, Vol. V, p. 308.*)

The tooth of a mammoth was found some years ago, in the bluffs of the Sangamon and near the surface and probably came from beds not older than the loess.

(*Illinois Geological Survey, Vol. V, p. 308.*)

VERMILION COUNTY.

Fairmount.—Forty-six years ago the remains of a mastodon were found in loess, two miles southeast of Fairmount. The black soil here is from one to two feet thick, and is underlaid by a light brown, tenacious clay filled with calcareous shells of *Limnea*, *Physa*, etc. Bones of a mastodon were found lying partly upon, partly imbedded in this marly clay, the tip of one of the tusks being within thirteen inches of the surface. The slough had been mostly drained of late years, the air had permeated the bed and pretty thoroughly decayed the bones, which were doubtless in good state of preservation so long as constantly covered with water. The parts were promiscuously mingled, showing that the

animal had not long been left to decay undisturbed. Marks of gnawing upon a few of the bones give reason to suppose that the water in which the carcass lay was so shallow as to give access to carnivorous animals. Fragments are in possession of the Chicago Academy of Science.

(*Illinois Geological Survey, Vol. IV, p. 242.*)

Danville.—Near the town of Danville, in the bluff forming the tableland of the country, the following section was observed:

Soil—five feet.

Gravel, with bones of an elephant—eight feet.

Clay—two feet.

Fine washed sand reposing on rocks of coal measures—two feet.

(*Proceedings, American Association for the Advancement of Science, Vol. X (1856), p. 163.*)

Hoopeston.—The tusks which were used in the restoration of a skeleton of *Mastodon americanus* in the American Museum of Natural History were found near Hoopeston in 1879.

(*Report of State Paleontologist, New York, 1902, p. 926.*)

East Lynn.—“The only mastodon bones ever found in this vicinity were found while the workmen were digging a ditch on the farm of a man named Guingrich at East Lynn, about twenty-four years ago (1881). I have forgotten almost all the circumstances.”

(*Reported by Charles W. Warner, Hoopeston.*)

WASHINGTON COUNTY.

Beaucoup.—According to Dr. Stevens, in an excavation along the line of the Illinois Central railroad near Beaucoup, at the depth of about eighteen feet were found the remains of a mastodon in the prairie drift, below the yellow clay in the older or reddish clay.

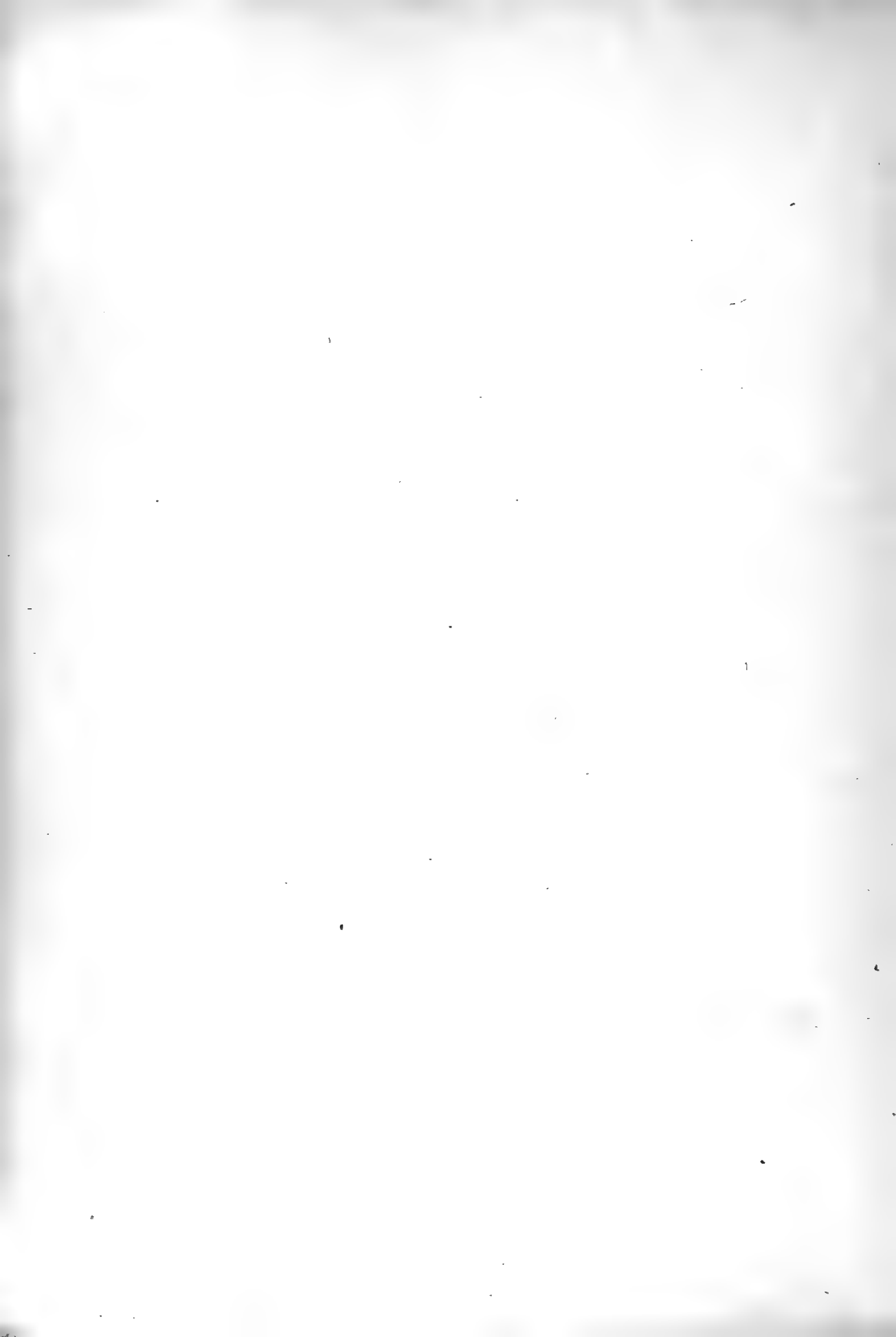
(*Proceedings of the American Association for the Advancement of Science (1856), pp. 148—160.*)

WINNEBAGO COUNTY.

New Milford.—In 1851 a large tooth of a mastodon was found, in a fine state of preservation, in the Kishwaukee. It was drawn up in a seine from near the mouth of the river.

(*Prof. S. P. Lathrop, in the American Journal of Science (2), XII, p. 439.*)

I O W A



ALLAMAKEE COUNTY.

Postville.—During the summer of 1904, Mr. Thomas French found four teeth, the lower jaw, and a portion of the vertebral column of a mammoth sticking out of the bank of Yellow River, where it cuts through his farm, four miles north of Postville. The bank had caved away, exposing the bones, which lay on a gravel bed. The teeth each measured about four and a half by eleven inches and weighed thirteen and a half pounds. The remains are all in an excellent state of preservation.

(Reported by Mr. Thomas French)

BENTON COUNTY.

Shellsburg.—In 1903, Mr. J. Grubb, of Shellsburg, found a mastodon tooth in the alluvium of Bear creek. A portion of a rib was previously found near the same place.

(Reported by Assistant State Geologist T. E. Savage.)

Mr. J. A. Burns, who found the rib, reports further regarding this find: "The tooth and rib were found on my farm in Benton township. The tooth was about the size of an ordinary five or six pound flatiron and was in a splendid state of preservation. It is now in the possession of Mr. Grubb's son, near Kingsley, Iowa. The rib measured about three feet in length. I gave it to a Cornell, Iowa, student."

CEDAR COUNTY.

Several finely preserved mammoth teeth were found on the farm of A. T. Whitnell, on the southeast quarter of the southeast quarter of section six, Springfield township. These were found in a

washout in a small creek. Above the washout a bed of white alluvial clay is overlain by gravels. In which of these the teeth occurred is impossible to say. The teeth are in the museum of Cornell College.

(*Iowa Geological Survey, Vol. XIII, p. 377.*)

Clarence.—Two small molars of a mammoth, in nearly perfect state of preservation, were found in or on the Kansan drift in a shallow creek six miles south of Clarence, and were presented to the Museum of Cornell College. The grinding surface of the teeth is slightly worn.

(*Reported by Prof. Norton, Cornell College.*)

CLINTON COUNTY.

Clinton.—The Davenport Academy of Science contains a mammoth tooth which was found near Clinton and donated to the Museum by Mr. Thomas J. Frasier.

(*Information from label on specimen.*)

Clinton.—The Chicago Academy of Science contains:

a) The whole tusk of a mammoth, in poor state of preservation, which was found near Clinton in Iowa.

b) One molar of a mammoth, in good condition, also found near Clinton and presented to the Museum by J. J. W. Foster.

(*Both instances reported by Frank C. Baker, Curator, Chicago Academy of Science.*)

DAVIS COUNTY.

Floris.—“In 1862 I found in the Des Moines river, near Floris, two mastodon teeth, one weighing fourteen and the other four pounds.”

(*Reported by Justus M. T. Myers, Fort Madison.*)

FAYETTE COUNTY.

Clermont.—Mr. C. E. Allen, of West Union, has a mastodon tooth, which was found in the gravel pit near Clermont.

(*Reported by Assistant State Geologist T. E. Savage.*)

HENRY COUNTY.

Mt. Pleasant.—About ten years ago several teeth and bones of a mastodon were exhumed in sinking a well on the poor-farm at Mt. Pleasant. The remains were found in the Kansan drift or immediately below this drift. I am not certain which. They are in the Museum of the Iowa Wesleyan University at Mt. Pleasant.

(Reported by Assistant State Geologist T. E. Savage.)

Salem.—“I learned of the discovery of the remains of a mastodon and what was said to be the tooth of an elephant (but more probably mastodon), when at Salem in November, 1884, and visited the locality where they were found, but was unable to find the man who had possession of the bones and tooth. The locality is in the valley of Big Cedar creek in section eight, Salem township. The creek had at that time washed a channel into the border of an old bog, in which the fossils were imbedded.”

(Reported by Frank Leverett, Ann Arbor, Mich.)

“Some years ago two teeth of a mastodon were brought me by a couple of men to sell for them. They said they were dug up near the bank of Skunk river, in Henry county.”

(Reported by Dr. J. M. Shaffer, Keokuk, Iowa.)

JACKSON COUNTY.

Maquoketa.—The atlas and two vertebrae of an extinct proboscidian were found near Maquoketa and presented to the Museum of Cornell College.

(Reported by Prof. Norton, Cornell College.)

JEFFERSON COUNTY.

Walnut creek.—In the bed of the creek, where it follows a rocky cliff in the west half of the southwest quarter of section twenty-eight, in Walnut township, Mr. Josia Bates some years ago found the lower jaw of an *E. americanus*. Both molars were

well preserved, and the entire specimen weighed fifty pounds. To what part of the drift it belongs is not evident.

(*Iowa Geological Survey (Udden), Vol. XII, p. 428.*)

LEE COUNTY.

Denmark.—"I saw a large leg bone of a mastodon a few years ago at Denmark, which had been found in Lost Creek Valley in section three or four, Washington township. I think the bone belonged to Mr. Justus M. T. Myers, of Fort Madison."

(*Reported by Frank Leverett, Ann Arbor, Mich.*)

Concerning this find, Mr. Myers himself reports as follows:

"In 1898 I found in Lost Creek, Lee county, one leg bone, six inches in diameter and nearly three feet long, one of the short ribs, eighteen inches of tusk, and two small pieces of bone of mastodon, all close together. Since then have looked the creek over for miles, but have found nothing more. Associated with these remains were one human leg bone and one flint arrow-head."

Montrose.—"In 1896 I found one molar of *Elephas primigenius* in a creek below Montrose, and the same year I also found in

Sugar Creek—The molar of another extinct elephant, which I cannot determine."

(*Reported by Justus M. T. Myers, Fort Madison.*)

"Some years ago there was brought to me—to dispose of—a fine fossil, the larger part of the pelvis—right side—of the mastodon. The acetabulum and attached portions were perfect. Its weight was nearly two hundred pounds (?). This specimen was found on Skunk river, in Lee county."

(*Reported by Dr. J. M. Shaffer, Keokuk, Iowa.*)

LINN COUNTY.

Bertram.—Part of a tusk of a mastodon was found in a gravel pit at Bertram and presented by S. C. Comstock to the Chicago Academy of Science.

(*Reported by Frank C. Baker, Curator, Chicago Academy of Science.*)

Springville.—The small molar of a mastodon and a large crown of a mastodon molar were found in or on the Iowan drift near Springville, and presented to the Museum of Cornell College.
(Reported by Prof. Norton, Cornell College.)

LOUISA COUNTY.

Indian creek.—An elephant tooth was found in digging a shallow well in a small tributary to Indian creek, section twenty-eight, township seventy-five north, range three west.
(Iowa Geological Survey (Udden), Vol. XI, p. 110.)

Otter creek.—A tooth, the lower jaw, part of the pelvis, several ribs, and a large piece of the tusk of an elephant were dug from the bed of Otter creek near the center of the northwest quarter of section twenty-five, township seventy-three north, range four west. These and the above mentioned specimens were found in what Udden thinks was Sangamon soil.
(Iowa Geological Survey (Udden), Vol. XI, p. 110.)

MARSHALL COUNTY

Albion.—A large molar of a mammoth, in a perfect state of preservation, was found in the Iowa river near Albion, and presented to the Museum of Cornell College. The grinding surface of the tooth is well worn.

(Reported by Prof. Norton, Cornell College.)

MILLS COUNTY.

Glenwood.—“I read a paper on the Glenwood mammoth at the Iowa Academy and had some correspondence concerning it. It seems to have been a young one, as indicated by its size, the imperfect ossification of its bones, and the presence of a simple tooth in front of the molars of the upper jaw. I took measurements and a sketch of the position of the bones, but I cannot at present lay my hand on the paper. The bones were quite poorly

preserved. Some of them are in the museum at Tabor. The peculiar simple tooth, which I took out myself, had about the form as sketched. I do not have it at hand. The remains comprise a dilapidated skull with tusks and teeth, several leg bones, but I think only the ends of some of the latter, perhaps the head of a humerus, are all that are at Tabor. The remains were five to eight feet below the surface of the east slope of the cut north of the railroad between Glenwood and Pacific Junction, not far from Keg creek and north of the railroad. They were in the upper part of the boulder clay below the loess. The deposits near them appeared to be water laid, and were quite gravelly."

(*Private communication from Prof. J. E. Todd.*)

Pacific Junction.—Some bones of an elephant or a mastodon were unearthed near the base of the loess, while grading for the Chicago, Burlington and Quincy railroad at the southernmost point of the bluffs between Keg creek and the Missouri bottoms east of Pacific Junction.

(*Iowa Geological Survey, Vol. XIII, p. 170.*)

Malvern.—Bones of a mammoth were exhumed from the lower part of the loess in grading for the Chicago, Burlington and Quincy railroad. The excavation was made in 1879 at the crossing of First avenue and Railway street. There were three teeth, part of a tusk, and two long bones.

(*Iowa Geological Survey (Udden), Vol. XIII, p. 170.*)

"A mammoth was unearthed when the Wabash railroad went through Malvern, in a cut made just northeast of the crossing of the Wabash and Burlington roads. Several teeth, tusk, vertebrae, and ribs were taken out, and several of them are in the Museum at Tabor. The tusk was eight or nine inches through and several feet long. The vertebrae were dorsal and had the long spinous processes on them. The teeth showed the typical *americanus* form."

(*Extract from a letter by Prof. Todd.*)

These notes probably refer to the same specimens as are reported by Udden.

MUSCATINE COUNTY.

Wilton—In 1874, bones of a mastodon or mammoth were found in the south bank of Mud creek, about half a mile south of Wilton, at a point where the stream, coming from the north, bends abruptly to the west. Measured from the water, the bank at the time rose nearly thirty feet high. The several bones lay at about the same level in the bank. The skeleton had evidently arrived entire at the place, but it was dismembered and scattered before it became finally imbedded. The deposits, containing the skeleton, were modified drift, consisting of alternating strata of very fine sand and clay. The fineness of this material, the regular stratification and absence of organic matter indicated that at the time of the imbedding of the skeleton, the locality was covered with comparatively deep, clear, and still water, "having nothing of the character of a marsh, but rather resembling the bottom of some wide lake or some large, slowly moving river." The topography of the surrounding country and the nature of the drift itself favored the idea that a lake at one time covered the territory of the West Liberty plain and reached up to Wilton, and that sediments from some inflowing river had aided in filling the lake. "Occasionally larger bodies, carried by some more powerful agency, found their way out to the deeper parts and became covered up by the accumulating sediment." The evidence was conclusive that the sediments containing the skeleton were laid down *after the ice had disappeared from the region*. In the excavated skeleton the cranium and the cervical vertebra were missing, but of the vertebrae there were exhumed nine dorsal, two sacral, and one caudal; also thirteen ribs, one segment of the sternum, parts of both innominate bones, one femur, the right tibia, a number of the tarsal, metatarsal, and phalangeal bones, one patella, the right scapula, the lower end of the humerus, and some carpal and metacarpal bones. The right scapula was in a particularly perfect condition.

Measurements were taken as follows:

Scapula—	Inches.
Length, from margin of glenoid cavity to superior angle.....	39
Width, from posterior angle to opposite border.....	28
Glenoid cavity, diameter.....	9½, 5½
Circumference of head.....	32½
Weight.....	51½ pounds.
Longest rib, on outer curve.....	52
Widest rib, across.....	4
Vertebra (first dorsal)—	
Width and depth of centrum.....	5½
Across lateral process.....	11½
Length of dorsal process.....	10
Height of neural arch.....	2½
Width of neural arch.....	2½
Right tibia—	
Length.....	35
Circumference at top.....	22¼
Circumference at middle.....	10¾
Humerus, circumference at lower end.....	37

(*Iowa Geological Survey, Vol. IX, pp. 352—353.*)

Mad creek.—About one mile from where it empties into the Mississippi river, Mad creek has cut away the point of a hill, the top of which is loess. This cut forms an almost perpendicular bank, probably forty feet high. About ten feet from the top is a bed of gravel, perhaps one foot thick. In this gravel bed, Mr. Joe Freeman found a considerable fragment of an elephant tooth.

(*F. M. Witter, Proceedings of the Iowa Academy of Science, Vol. I, part 2, p. 67.*)

Muscatine.—From the loess in the city of Muscatine, Professor Witter has taken teeth, bones, and antlers of a species of caribou or deer, and a tusk and teeth of a mammoth or mastodon.

(*Iowa Geological Survey, Vol. IX, p. 360.*)

PAGE COUNTY.

Blanchard.—Large bones which, from the description given, must have belonged to the mastodon or mammoth, were found fifty-four feet below the surface while digging a well at Blanchard,

in the Tarkio Valley. Evidences point to an ancient, filled and only partly re-excavated water course.

(*Iowa Geological Survey, Vol. XI, p. 413*)

Clarinda.—In the valley of the Nodaway, near Clarinda, some teeth of the mastodon have been found.

(*Iowa Geological Survey (White), Vol. I, p. 353.*)

PLYMOUTH COUNTY.

Akron.—Very recently, in the vicinity of Akron, Professor Todd has found elephant bones. These were in the drift.

(*Iowa Geological Survey, Vol. X, p. 117.*)

Professor Todd reports, concerning this find, as follows: "The teeth, tusk, and bone fragments found near Akron were in the upper part of the till, under loess. They were found in a well about two miles east of Akron, and were in the possession of the finders the last I knew. The teeth were those of a mastodon, much worn. The length of the crown of one tooth I measured was nine inches, and the breadth about three. The diameter of the tusk was about three inches."

POLK COUNTY.

Avon.—A few years ago, workmen excavating in the gravel pit at Avon unearthed numerous bones, among which were a large tusk and other bones of some very large animal, either mastodon or mammoth. Unfortunately, no attempt to save the bones was made, so they became broken and lost. The drift in which these bones were found is post-Kansan—pre-Wisconsin (?) in age.

(*Reported by John L. Tilton, Simpson College.*)

Polk City.—A perfectly preserved molar tooth of *Elephas primigenius* was found in 1898 by a Chicago and Northwestern railroad employee at Polk City. The tooth occurred in the gravels which occur at that place, and are evidently late Wisconsin in age.

“These finds are interesting in that it makes it reasonably certain that these huge proboscidians roamed over these counties during the late Wisconsin or even during post-glacial times.”

(*Iowa Geological Survey, Vol. IX, pp. 210—211.*)

Raccoon river.—The femur of a mammoth in good state of preservation was taken from a sandbar of Raccoon river in Polk county. Belongs to the Museum of Drake University.

(*Reported by Prof. L. S. Ross, Drake University.*)

POTTAWATTAMIE COUNTY.

The bones of an elephant are reported to have been found on section thirty-four, apparently in the loess.

(*Iowa Geological Survey (Udden), Vol. XI, p. 260.*)

POWESHIEK COUNTY.

Grinnell.—“About the year 1884, in excavating for a cellar at the corner of Main street and Fourth avenue, a tusk of a mammoth, together with a number of molar teeth and some fragments of other bones, were uncovered. These remains are now in the museum of Iowa College. Excavations in this same vicinity at an earlier date had exposed fragments of undoubtedly the same animal. This last fall, in the excavation for another cellar, other fragments were discovered, all, however, in a state beyond preservation, and mere small pieces. All the pieces found evidently belonged to a single individual. The geological formation in which they occur is the loess. As I remember, the tusk was at a depth of about six feet below the surface. The tusk is about seven feet long and is in a fair state of preservation. The molar teeth are also well preserved. The other pieces are so small that I do not feel able to guess at their original location in the skeleton.

(*Reported by Prof. W. H. Norris, Iowa College.*)

SCOTT COUNTY.

Big Rock.—The Museum of the Davenport Academy of Science contains a tooth of an *E. primigenius*, found near Big Rock and donated by A. W. Manchester.

(Information from label on specimen.)

Blue Grass.—A portion of a skeleton of a mammoth was discovered near Dr. Carpenter's residence (June 27, 1858), imbedded in yellow clay and lying about ten feet below the surface of the ground. This is not, however, its first discovery. In 1844, in the same locality, the tusks were found, and, it is said, were eleven feet in length. Some of the molar teeth were taken at the same time and in almost perfect state of preservation, the enamel being clearly discernible, as in the case of the one lately discovered.

“The tusks of the animal formerly unearthed were fully the size mentioned, but they soon crumbled to pieces on exposure to the atmosphere. The largest of the molar teeth was about fourteen inches in length. It was exhumed in three pieces, and may now be seen in an almost perfect state of preservation in our cabinet, where also may be seen some of the bones, showing very perfectly their osseous formation and the kind of clay in which they were imbedded.”

(Editor Davenport Daily Gazette, June 30, 1858)

Davenport.—A tusk, several molars, and some bones of the mammoth were exhumed in the west part of the city. They were found at the junction of the yellow and bluish clays, three feet above the peat bed, indicating that the skeleton was deposited after the blue stratum of the loess, the body having floated there or the creature having waded in to his destruction. The specimen is in the Davenport Academy of Science.

(Proceedings of the Davenport Academy of Science, Vol. I, p. 98.)

Dr. C. A. White comments on this locality as follows: “Such of these deposits (alluvium), as partake more of the character of marsh accumulations are found in somewhat similar positions,

but all seem to have taken place at an earlier period in the process of deepening the river valley. For example, one of these deposits occurs almost on the very brow of the bluffs that border the valley of the Mississippi near Davenport. This example is one of unusual interest, in consequence of the existence there of an extensive bed of ancient peat, which is covered to the depth of several feet beneath the prairie soil, and the discovery, in the clay above the peat, of the remains of a mammoth. The exposure was made by the excavation for the Chicago, Rock Island, and Pacific Railroad company, previous to which there was no appearance at the surface to indicate anything more than the ordinary drift deposit."

(*Iowa Geological Survey (White), Vol. I, p. 119.*)

SHELBY COUNTY.

Defiance.—About 1890 H. B. Sooy came into possession of a huge tusk of a mammoth or mastodon, which measured six feet long and seven inches in diameter at the base and three and a half inches at the tip. He kept it about four months, when it began to crumble, and continued to do so, until all but about two feet of the tip was destroyed. The tusk was found at the bottom of a well on the bank of a small stream about three miles from Defiance. Parties made search for the skeleton by boring close to the old well, and came upon something resembling bone. They then attempted to dig down to the skeleton, but as it lay below the bed of the creek, water came into the hole so fast that the search was abandoned, and no attempt has been made since to investigate further.

(*Reported by H. B. Sooy.*)

STORY COUNTY.

In 1894, a mammoth was found on the farm of Dr. H. M. Templeton. It was discovered while digging a well which was being sunk in one of the numerous depressions in this part of the

country. This depression formerly contained a few feet of water, and it still receives surface drainage in times of heavy rainfall. The soil was composed of the washings from the surrounding land and the remains of marsh vegetation characteristic of similar surface conditions on the Wisconsin drift. When the digging had proceeded to a depth of about four or five feet, a deposit of bone fragments was discovered. This included the bodies of four or five dorsal vertebrae, portion of one rib, a short section from the lower end of the tibia, and the lower extremity of the left femur, besides a number of fragments difficult to assign to their exact location in the skeleton. The masses would about fill a half-bushel basket. There were none of the long bones complete and none of the pieces would give a very correct notion of the entire length of any of these portions of the skeleton. The parts giving the best idea of proportion are the vertebrae, the head of a rib, in quite good state of preservation, and the lower extremity of the femur. The vertebrae show both anterior and posterior articular surfaces, in a perfect state of preservation. The transverse and vertical measurements of these surfaces are nearly exactly the same, four and one half inches. The antero-posterior diameter, of the vertebral body, is exceedingly short, considering the immensity of the other measurements. The length is but two and one-half inches. This must have given the creature a back grotesquely short in comparison with its gigantic size. The articular facets on the inner surface of the head of the rib measure three and one half inches. The excavations at the anterior and posterior extremities of the vertebral bodies almost blend into one another. The part giving the most correct notion of the enormous size of the animal is the remains of the thigh bone. The fragment represents a section from the lower end of the bone just long enough to show the femoral trochlea and the two condyls. These are almost perfect, with the exception that a small fragment has been broken away from the external posterior part of the external condyl. The internal condyl is in a perfect state of preservation. The extreme length of the articular surface ex-

tending from the lower border to the external condyl to the upper margin of the trochlear surface on which the patella glides is sixteen inches. This mass is from eight to ten times the size of the corresponding part of an average horse. All the parts are quite firm and in such state of preservation that they have not in the least been affected by exposure since their removal from the ground. The conditions were such as to lead to the conclusion that the bones could never have been buried to a greater depth than that at which they were discovered. The superincumbent covering must have been increasing in thickness rather than diminishing, on account of the process of gradual filling now going on in these shallow prairie basins. A number of trial excavations were made in different parts of the depression without unearthing any additional portions of the skeleton.

(*Iowa Geological Survey, Vol IX, pp. 210-211.*)

WARREN COUNTY.

Indianola.—“In June, 1903, workmen engaged in laying a cement foundation for a culvert on the Chicago, Burlington and Quincy railroad, two and a half miles east of Indianola, found large bones at a depth of six feet below the bottom of the draw or ravine. The two fragments brought me are parts of the centra of vertebrae, each about four inches across and two and a half inches thick. There is also a fragment two inches long that seems to be part of a rib. They were found in the Kansan drift. I do not know whether these remains are of the mastodon or mammoth.”

(*Reported by John L. Tilton, Simpson College.*)

WASHINGTON COUNTY.

Having observed some newspaper notices of large bones and teeth found in Washington county, Iowa, by Mr. Jerry Hoppin, we went down there on the eighteenth of July (1881), to see what discoveries had been made. We found Mr. Hoppin's farm on sec-

tion fourteen, township twenty-two, range three, and made a careful examination of the objects and the locality where they were discovered. The remains consisted of the following teeth and bones of *Elephas primigenius*, viz.; the two upper molars—beautiful specimens, very well preserved and nearly black. The grinding surface on each is eleven by four and three-fourths inches, and the greatest depth of the tooth nine and one half inches. To each of these teeth is attached a portion of the jaw-bone, showing also a part of the socket of the tusk.

A fragment of a tusk, thirty inches in length and twenty-one inches in circumference. It is very much decomposed and falls to pieces rapidly. A considerable quantity of finely broken fragments was also found.

The atlas, absolutely perfect. The extreme width of this bone is seventeen and one half inches; its anterior-posterior diameter, nine inches: articulating surface, ten by four and one half inches.

Three other well preserved vertebrae, one cervical, one lumbar, one uncertain, having an articulating surface of six and one half inches in diameter.

The left scapula, from which a portion is broken off. Its extreme length is thirty-four inches: greatest width of part preserved, twenty inches; articulating surface, nine and one half by six inches.

One segment of sternum, very perfect. Its dimensions are: length, eleven inches; depth, six and one half inches; and width, four and one half inches.

Head of femur, of hemispherical form, seven and one half inches in diameter.

A portion of humerus, thirty-six inches long, both extremities wanting, and the whole much decayed and very fragile.

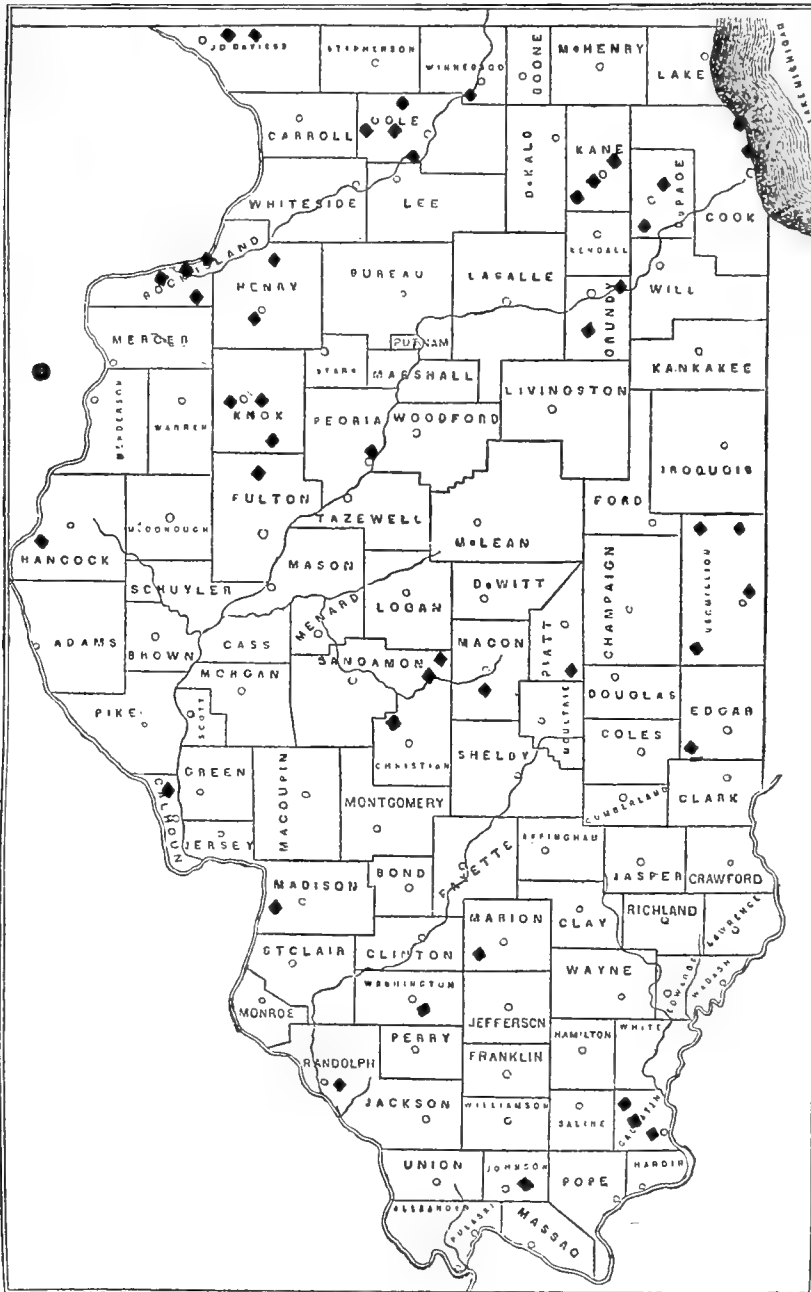
One fibula, quite perfect, twenty-seven and a half inches long.

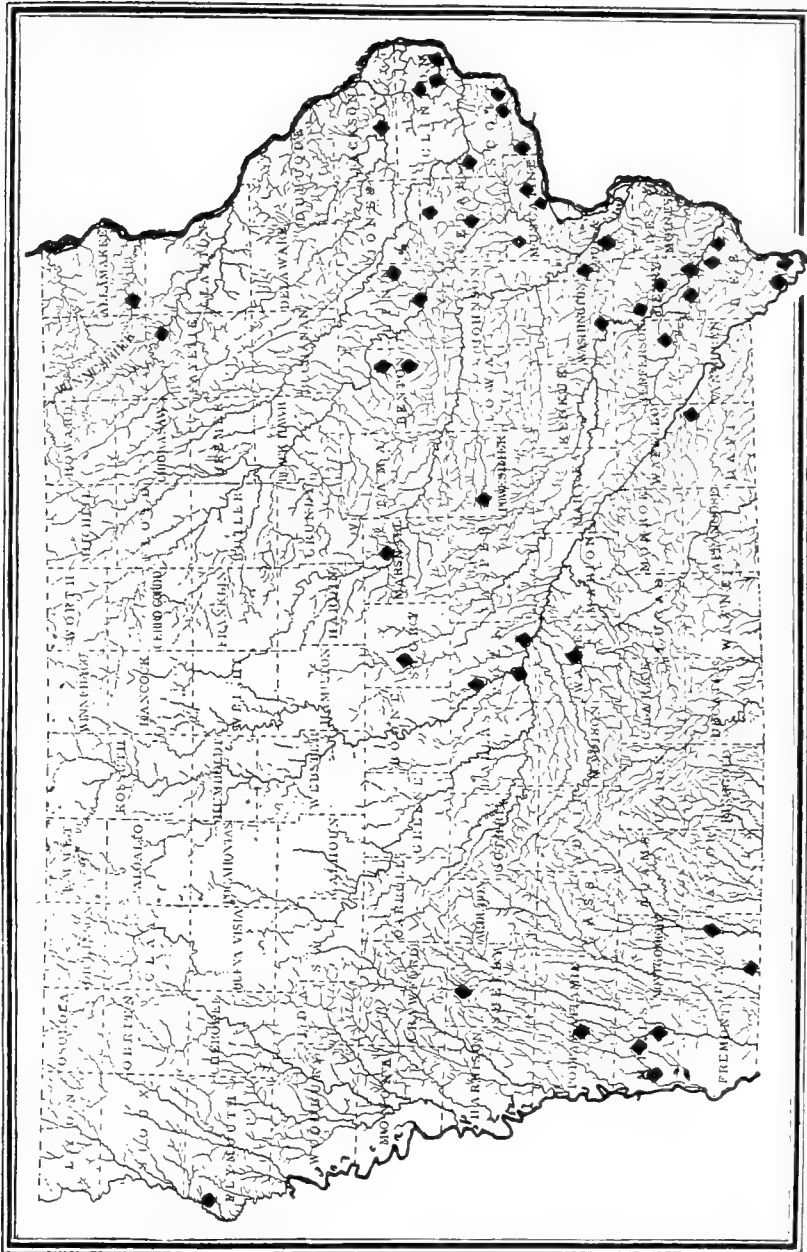
Several fragments of ribs, one piece three feet in length, and some of the pieces indicating the full length of a rib to be over five feet. In addition, there were a good many small and indeter-

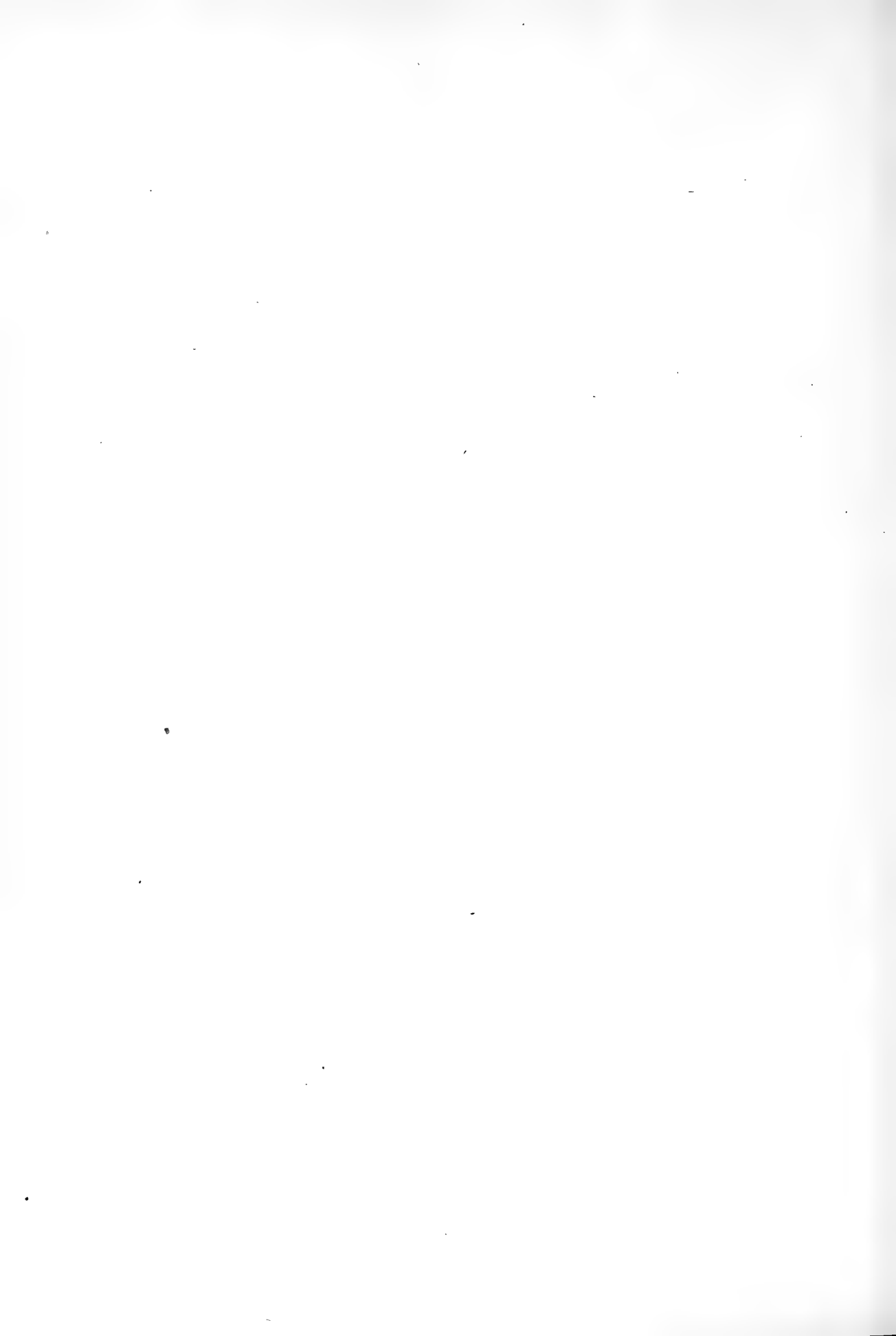
able fragments, though it is possible that, upon a more extended examination of the whole, the true place of them might be ascertained.

These relics were discovered in a small stream, running through the bottomland on the farm. The scapula was first found by Mr. Hoppin's boys while bathing. They at first took it for a piece of wood, but, upon discovering its true character, they made search for more, and found several of the other bones within a few feet of the same place. Mr. Hoppin then continued the search by digging into the adjacent bank; and there found the teeth and several of the other bones. All the bones were found within an area of fifteen feet each way, in the black mud (sedimentary deposit, chiefly of vegetable mold with some clay), and about six feet below the surface of the level ground.

(*J. Gass, Proceedings, Davenport Academy of Science, Vol. III, pp. 177—178.*)







On the Proboscidean Fossils

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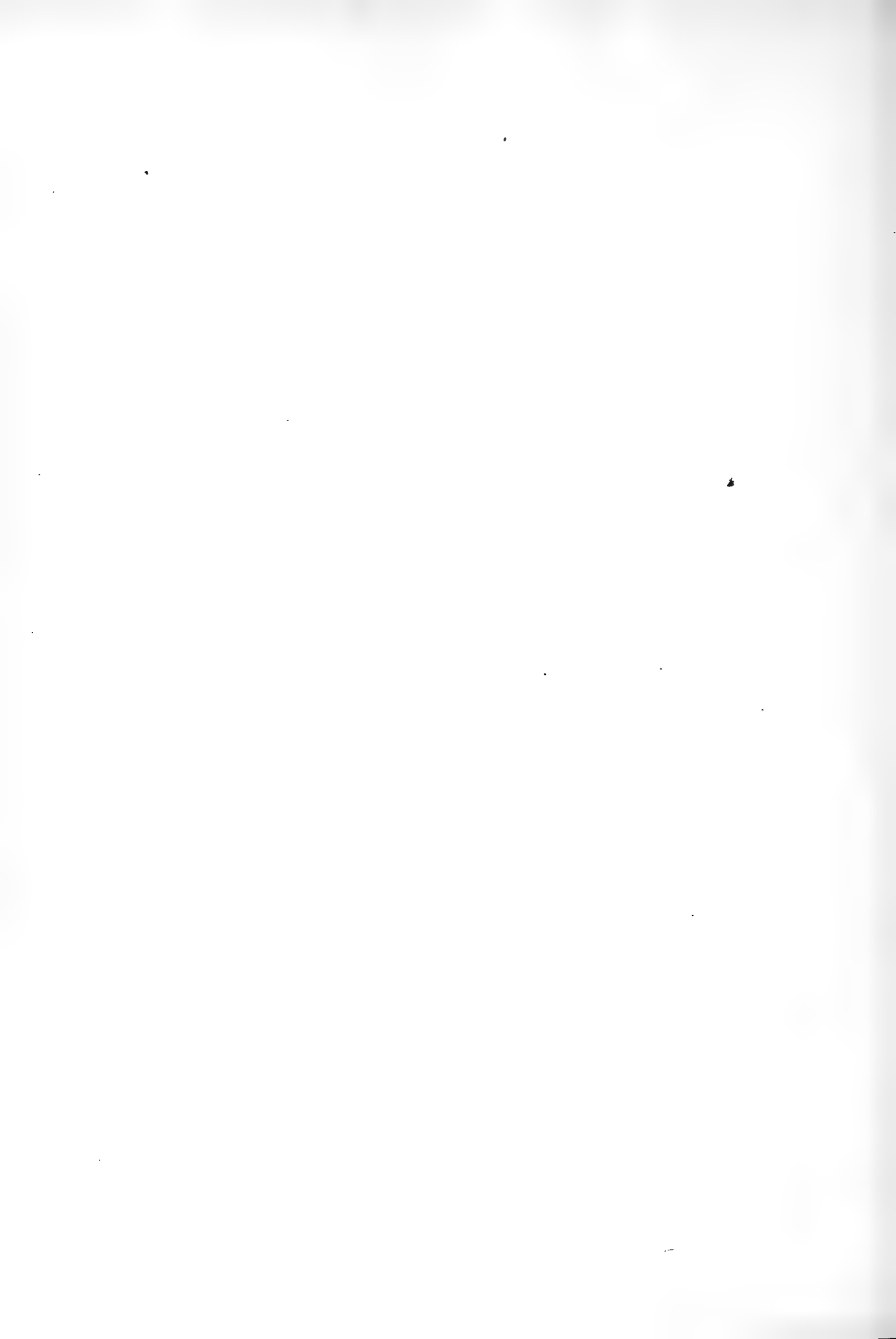
Pleistocene Deposits

IN

ILLINOIS AND IOWA

BY

JOHAN AUGUST UDDEN



The data collected in the foregoing paper by Netta C. Anderson on the fossil Mastodon and Mammoth remains in Illinois and Iowa, give valuable and various information, which seems profitable to briefly summarize and discuss. It brings together a number of observations made by different parties at different places and at different times, extending back sixty years or more. Some special points suggest themselves for review: 1) the conditions of interment of these animals, 2) their specific determination, 3) their relation to different drifts and 4) their association with other fossils.

Mode of Interment.

The eighty odd recorded finds set forth, quite clearly, the conditions attendant on the interment of these animals and the manner of the preservation of their remains. The broad statement is warranted that the greater number of the animals, whose remains have been discovered, perished in low and boggy localities. In two instances it is clear that they had come in search for water and salt, for near Minooka, in Illinois, parts of the skeletons of six individuals were recovered from the ground near a bog spring, and in Gallatin county, in the same state, numerous bones were found near the "Half Moon" salt lick.

In the case of sixty recorded fossils, their location is given with sufficient detail to enable us to make inferences as to their mode of interment. We find that remains of thirteen individuals were discovered in stream beds or in undoubted alluvial deposits. Of these, ten consisted of detached teeth, one was a single bone, one was a jaw, and one consisted of a tooth and a bone. Five finds were found in terrace and glacial gravels, and four of these

consisted of single teeth. Evidently, these single teeth which are found in stream beds and in drift gravels, are not *in situ*, but have been dislodged by streams and glacial currents from the beds which originally contained them, and they have been separated from the other parts of the skeleton to which they belong.

In eighteen instances, remains were found in boggy places, or near springs, and in every case save one these consisted of several parts of a skeleton, usually teeth and some bones. Many of these also came from alluvial deposits, but it is evident that they were found in the places where the animals perished.

But most of the fossils have come from the loess or from near the surface of the boulder clay under the loess. There are twenty-four such finds, and only one is mentioned as consisting of a single tooth. The rest are referred to as "numerous bones", "several bones", "parts of skeletons", or as "remains". In cases of this kind, the fossils are likewise *in situ*. In other cases it is not possible to make out from the data given whether the finds should be classified as from alluvium or as from bogs, for it seems quite likely that some of the bogs may have been on alluvial lands. Barring such, the number of finds representing different modes of interment may be tabulated as follows:

SPECIMENS FOUND IN	Number consisting of two or more parts of a skeleton	Number consisting of single teeth or bones
Streams or in alluvium.....	2	17
Glacial gravels.....	1	4
Bogs or near springs.....	17	1
Loess, or on glacial clays.....	23	1

Specific Determination of the Fossils.

Among the individuals represented in the list, *Mastadon*, *Elephas primigenius* and *Elephas americanus* have been expressly

identified. Specific determination of *Mastodon* is in no case expressed, but it is presumably *M. americanus*. The list mentions in all thirty-nine individuals of this genus. In ten cases identification was made from other parts of the animals than from their teeth, and it may, perhaps, be somewhat uncertain. Twenty-one of these finds are reported as mammoths and five as *Elephas primigenius*, making twenty-six specimens of this species. Nineteen of these determinations were made from teeth, often occurring with other bones, one appears to have been made from a tusk, and four were probably made in absence of either teeth or tusks. *Elephas americanus* is reported from two places in Iowa. Ten of the specimens are spoken of merely as elephants, and these are presumably *Elephas primigenius*. Except in two cases, the determinations of these nine specimens were also made from teeth. In one instance, only a tusk was present, and in another, both teeth and tusks seem to have been wanting. In all, the list includes thirty-five elephants and thirty-four mastodons. Thirteen specimens are reported merely as "proboscideans", as "mammoth or mastodon", or as "elephant or mastodon". In eleven of these cases, the remains did not include any teeth, and in nine there were neither teeth nor tusks. Thus it appears that specific determinations have not been made except in the presence of either teeth or tusks. These furnish the most obvious and reliable characteristics for that purpose. From the above facts, we may conclude that the determinations are sufficiently accurate to warrant the general conclusion from the figures given that the remains of the elephant and of the mastodon are about equally frequent in these two states. It will be noticed that nearly all of the fossils are from the drift-covered region. Professor J. D. Whitney* states that in the lead region (the driftless area) mastodon remains are much more frequent than those of the elephant.

* Geological Survey of Illinois, Vol. I, p. 162.

Table of Specific Determinations.

	Teeth and tusks both present	Teeth pres- ent, tusks absent	Teeth absent, Tusks present	Teeth and tusks both absent
"Mammoth".....	2	13	1	5
"Elephas primigenius".....		5		
"Elephas americanus".....	1	1(?)		
"Mastodon".....	2	24	3	5
"Elephant".....		7	1	1
"Proboscidean", "elephant or mastodon", "mam- moth or mastodon".....		2	2	9

Relation to Different Parts of the Drift.

The relation of these fossils to the different drifts in the Mississippi valley is by no means clear in every case. Many of the observations were made long before different drifts had been recognized, and some were even made by geologists who did not regard land ice as necessarily an agent in the deposition of the glacial till. A thorough study of the geological position of these fossils would require visits to many of the localities in the field. Though this is impracticable, the data in the list warrant some general observations in this line.

In fifteen cases, the notes furnished by the observers quoted either give insufficient or no data from which we may judge of the relations of the fossil to the drift. These are mostly in cases of discoveries of single teeth or tusks. In fourteen instances it is only known that the remains, likewise mostly teeth, came from some creek or from some river. One tooth is reported as having been caught in a seine. Others are spoken of as exposed in banks of streams, and where these consist of single bones or teeth, one must regard them as in transit and not necessarily as fossils

originally belonging to the alluvium from which they came. Finally, several teeth have been found in gravels, whose age is unknown, and in which they are evidently inbedded secondarily. It appears that about one half the number of all the fossils recorded cannot be assigned to any particular relation to the drift on the evidence of the original record.

Mastodon remains are reported in one case as coming from the "Kansan drift or immediately below this drift". This find was made in a well on the poor-farm at Mount Pleasant, in Iowa. Coming from such an excavation, circumstances seem to have been favorable for exact determination of the horizon. There were several teeth and bones, and this makes it reasonably certain that the bones were *in situ*. In all likelihood the animal lived, perished, and was buried on the land in eastern Iowa before the advance of the ice which brought the Kansan drift. Fossils in a till can hardly be regarded as *in situ*. They would be ground to pieces by the ice.

Parts of skeletons of the mastodon have been found in somewhat similar positions on the upper surface of the Kansan drift, in the so-called "ferretto zone". This is the old and weathered land surface which developed after the Kansan drift had been deposited. This drift is now covered by loess, but in some localities it has been almost entirely removed. Under thirty feet of loess, which rested on two or three feet of drift, a mastodon jaw with two teeth was found near Alton, in Illinois. In Washington county, in the same state, other mastodon remains are recorded as having come from the same horizon, one from near Sandoval, and another from near Beaucoup. Some teeth, a tusk, and some bones of a mastodon were recently found "in the upper part of the till, under the loess", near Akron, in Plymouth county, in Iowa. This till is also believed to belong to the Kansan.

The "ferretto zone" is to be seen under the loess only beyond the borders of the drift sheets which are later than the Illinoian. Fossils from this zone must be younger than the Kansan drift

itself, as they have become imbedded in its eroded and weathered surface. As long as this till was being subjected to progressive destruction, no remains of land animals could very well be preserved. They would be destroyed with it, except in special situations, where the general condition of erosion may have locally come to a standstill, or may have been reversed. These fossils must hence be regarded as rather belonging to the stage when loess began to accumulate on the Kansan till. This stage is not definitely fixed among the series of events of the glacial period. By some it is believed to be contemporaneous with the deposition of the Iowan drift, but others think that much of the loess is older than this. So that the only thing we can know with certainty of these fossils is that they are post-Kansan and pre-loessian. They may be only slightly younger than the Kansan drift, or only somewhat older than some much later loess.

There is another similar zone over the area of the Illinoian drift. It marks in the same way the time when the loess began to accumulate on the Illinoian till. The conditions attendant upon the beginning of loess accumulation on this till were somewhat different from those resulting in the burial of the ferretto zone on the Kansan. The Illinoian drift surface seems to have been less well drained. It is less affected by oxidation, and boggy conditions were apparently more frequent when the loess began to accumulate. Only two proboscidian fossils are mentioned in the list as clearly imbedded in the Illinoian drift. One was found in some waterlaid material at a point one half mile south of Wilton, in Muscatine county, in Iowa. This consisted of a considerable part of a skeleton. The other was a tusk, occurring just under the base of the loess, in the bluff near the bridge across Rock river, south of Rock Island, in Illinois. The only reasonably certain conclusion we can draw as to the age of these fossils is that they are post-Illinoian and pre-loessial. In neither case were these fossils generically identified.

Of just as indefinite age are such fossils as have been recovered

from the loess. There are at least eight of these. Six or seven came from the base of the loess, and nearly all of these were from the area covered by the Illinoian drift. One, or perhaps two, came from Fremont county, in Iowa, and hence were from the area of the Kansan drift. All of these might perhaps as well be classified with the fossils in the ferretto zone and with those in the loess-covered upper surface of the Illinoian drift, for they were evidently buried at the beginning of the accumulation of the loess in which they lie. If the modern view that the loess is a land deposit is correct, it appears quite probable that its basal part is not everywhere of the same age. The loess may have begun to form on the Kansan drift even before the Illinoian ice invaded this region. On the other hand, the relation of the loess to the Iowan drift is such as to make it unlikely that the bulk of the former deposit is of a later date than this drift itself. Therefore we are justified in believing that the fossils which come from the base of the loess are post-Kansan and pre-Iowan, when found beyond the limits of the Illinoian drift, and when they come from the area of this till, they must be post-Illinoian and pre-Iowan.

From Grinnell, in Iowa, a mastodon is reported as coming from the loess. Grinnell lies on the area of the Iowan drift, and while this drift usually is without any loess covering, such a covering is reported as being present in the adjoining (Tama) county. This loess is, of course, of post-Iowan age, and so must this fossil be, which was excavated from a depth of six feet from the surface. Two mastodon teeth are also reported from a creek on the Iowan drift in Forreston township, in Ogle county, in Illinois, and the greater part of a skeleton of the mammoth was recovered from a boggy place in Lynnville township, in the same county. This latter point is almost on the boundary between the Wisconsin and the Iowan drift, and, it may be, on the surface of the latter. In either case, the interment of this fossil was probably much later than the deposition of the Iowan drift, as it came from near the surface. The same must be said of some other finds which have been made at

shallow depths on the area of the Iowan drift. They are post-Iowan.

Twelve fossils are reported from the area of the Wisconsin drift. Two of these were teeth, presumably not *in situ*, as they were taken from gravel. One, a part of a mastodon skeleton, was taken from a tenacious clay on the early Wisconsin drift (Champaign till sheet of Leverett) near Fairmount, in Vermilion county, in Illinois. The others have come from low and swampy places on the but slightly modified surface of this late till. They seem to belong in the soil on the drift or in local accumulations of wash or perhaps incipient loess deposits on low divides where the drift is practically yet untouched by erosion. These are clearly post-Wisconsin in age.

In some dozen cases, considerable parts of skeletons, or at least a few bones, with or without some teeth, but enough to indicate that the remains were practically in place, have been found in alluvial sediments. Some of these are evidently much older than the others. Bones are thus mentioned by Professor Calvin as having been found in a well at a depth of fifty feet in the Tarkio valley, on the Kansan drift, near Blanchard, in Iowa. Other finds were made in alluvium on driftless territory, as in Gallatin county, in Illinois, and in Allamakee county, in Iowa. All these may be older than the fossils which come from alluvium or later drifts. One mastodon came from the alluvium along Illinois river, three miles east of Morris. Most of the alluvium in this valley must be as late as Lake Chicago, which drained in this direction. It appears certain that both the elephant and the mastodon are represented among the alluvial fossils, on the Wisconsin drift. They are both of post-Wisconsin age, and, judging from their occasional shallow interment in alluvium, in loess, and in modified surface drift, they are sub-recent.

In tabulated form, the relation of the proboscidian remains to the members of the drift are as below:

AGE	Teeth or tusks only	Bones, mostly with teeth or tusks
Specimens of unknown age.		
Mammoth.....	9	
<i>Elephas primigenius</i>	2	
Elephant.....	7	
Mastodon.....	13	2
Undetermined.....		1
Specimens of the pre-Kansan (?) or Kansan (?) age.		
Mastodon.....		1
Specimens from the ferretto zone, post-Kansan and pre-loessian.		
Mastodon.....		4
Specimens from the surface of the Illinoian drift, post-Illinoian and pre-loessian.		
Undetermined.....	1	1
Specimens from the base of the loess, post-Kansan and pre-Iowan.		
Elephant.....		2
Mammoth.....		2
Mastodon.....	1	
Undetermined.....		1
Specimens from the loess.		
<i>Elephas americanus</i>		1
Mammoth.....		2
Undetermined.....		1
From the area of the Iowan drift, post-Iowan.		
Mammoth.....		1
Mastodon.....	1	
From the area of the Wisconsin drift, post-Wisconsin.		
<i>Elephas primigenius</i>	1	
Elephant.....		1
Mammoth.....	1	2
Mastodon.....	2	4
Undetermined.....		1
From alluvium, mostly sub-recent, but some, perhaps, older.		
<i>Elephas primigenius</i>		1
Mammoth.....		2
Mastodon.....		10
Undetermined.....		4

Associated Fossils.

From what is known concerning the age of the latest glacial drift, and from the fact that many of the remains have been found in alluvium which is later than this drift, there seems to be good reason to believe that elephants and mastodons have inhabited these states within the time of the last five thousand years, or perhaps still later. The association of their remains with those of other animals not yet extinct in this part of the world likewise indicates that they have but recently been exterminated. These associated fossils are of various kinds. In Rock Island, the loess which contained elephant bones also contained fragments of coniferous wood, and at Davenport, in Iowa, the peaty loess, from which tusks and other bones were taken, has a seam of diatomaceous earth, in which no less than thirty-three now living species of diatoms have been identified.* Only a short distance from this locality, the same horizon carries the usual land snails, such as *Helicina*, *Succinea*, *Pyramidula*, *Bifidaria*, *Limnæa*, and others which are characteristic of the loess. In Sangamon county, in Illinois, the mastodon-bearing alluvium contained such common pond snails as *Planorbis*, *Cyclas*, and *Physa*, and at Fairmont, in Vermilion county, where mastodon remains were found in what appears to be a waterlaid clay, this contained *Limnæa*, *Physa*, *Planorbis*, and *Sphærium*, all typical pond mollusks of to-day.

The mammals which are mentioned as found in immediate association with the mastodon, are the American buffalo, or the bison, which is reported from three localities, the wolf, the peccary, the deer, and the elk, each of which is reported only once. In the country around Chester and Alton, in Illinois, where Professor Wm. McAdams made extensive observations on the fossils of the loess many years ago, he is reported as having found in this deposit *Mastodon*, *Megalonyx*, *Bosprimigenius*, *Castoroides*, *ohioensis*, and many small rodents. The latter occur in the so-called

* See Iowa Geological Survey, Vol. IX, p. 356.

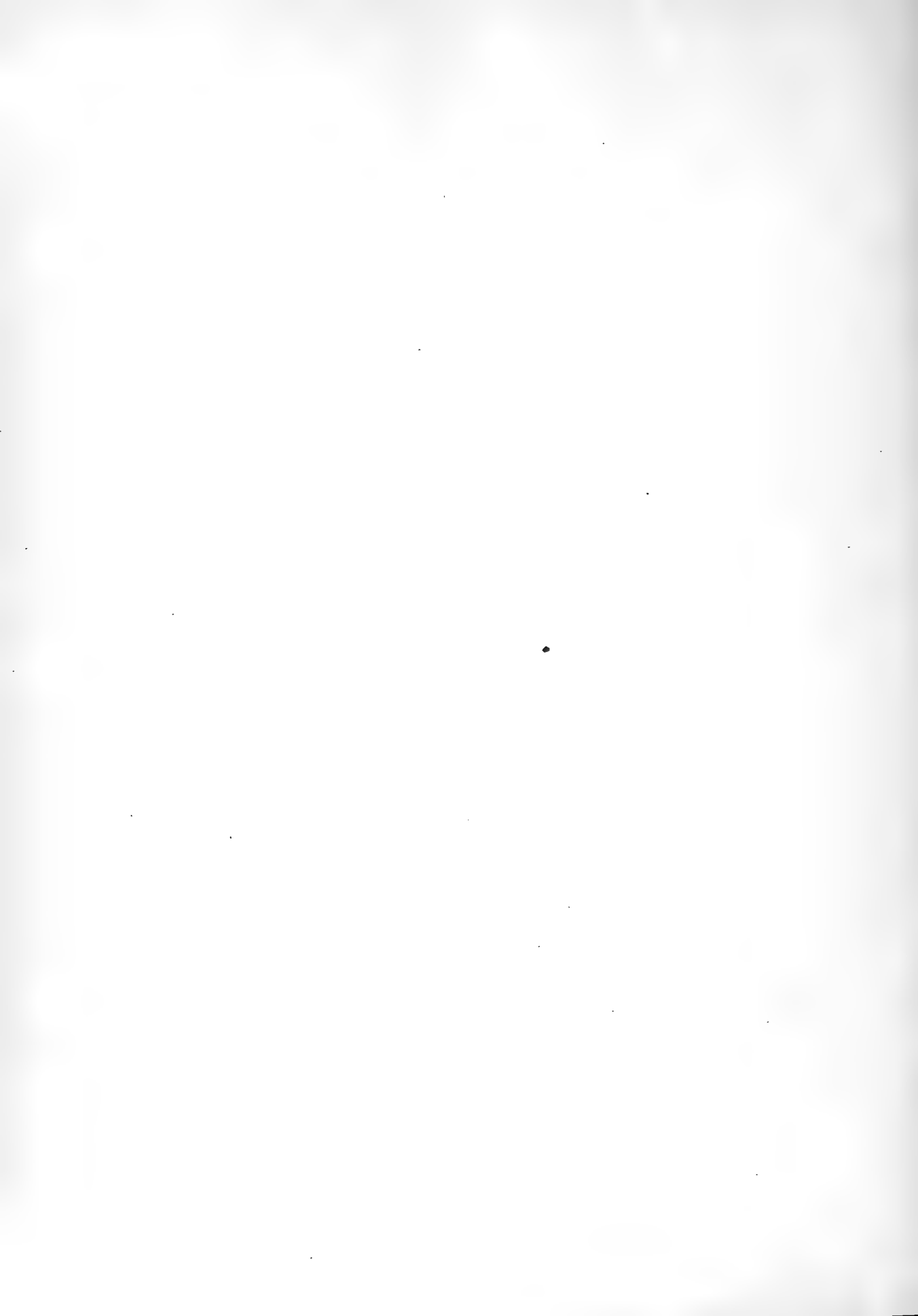
loess-kindchen.* But it is not known in this case that these mammals came from the same localities as the mastodon, and the present writer believes it can be shown that all the loess in that region is not of the same age. Hence it is perhaps a question whether the co-existence of these fossils with the mastodon is really proven by Professor McAdams's observations. That they all really did inhabit this country contemporaneously, is none the less most probable.

Man and the Elephants.

On the question of the co-existence of the elephant or the mastodon with man, these data give no direct testimony except in one instance, which is mentioned by M. T. Myers, of Fort Madison. He reports having found "one human leg bone and one flint arrow-head" associated with the remains of a mammoth recovered from the alluvium of Lost creek, in Lee county, in Iowa. It is not known precisely how close this association was, and in view of the importance of the question, this find would seem to merit a more detailed study and a more full statement of facts. The association is reported from a region where so-called "elephant pipes" have been claimed to occur in mounds constructed by earlier inhabitants of this country.* If these pipes are genuine, they prove beyond a doubt that the race who built the mounds were the contemporaries of the elephant, for the pipes are fashioned with the form of this animal. At all events, the evident recency of some of the proboscidian remains makes us expectant of some fortunate discovery giving conclusive proof that man lived on this continent while these huge mammals were yet here.

* Geological Survey of Illinois, Vol. VIII, p. 8.

* Proceedings of Davenport Academy of Natural Sciences, Vol. III, p. 132, and Vol. II, p. 349.



LINNÉ MEMORIAL NUMBER

AUGUSTANA ◦ LIBRARY ◦ PUBLICATIONS

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OF THE FLORA OF NORTH AMERICA
BY PER AXEL RYDBERG, PH. D.

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TEXAS LAND COMPANY, LTD., IN THE UPPER
RIO GRANDE EMBAYMENT IN TEXAS
BY JOHAN AUGUST UDDEN

PUBLISHED

BY THE AUTHORITY OF THE BOARD OF DIRECTORS OF
AUGUSTANA COLLEGE AND THEOLOGICAL SEMINARY
ROCK ISLAND, ILLINOIS

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The two hundredth anniversary of the birth of Linné was made the occasion for a celebration in the chapel at Augustana College and Theological Seminary, April 13th, 1907. An address on *The Place of Linné in the Scientific World* was then delivered by Dr. Charles E. Bessey of the University of Nebraska, and another address on *Linné and the Love for Nature* was given by Mr. E. K. Putnam of the Davenport Academy of Sciences. Brief addresses were made by Dr. Josua Lindahl of the Cincinnati Museum of Natural History, by Dr. P. A. Rydberg of the New York Botanical Garden, and by Dr. J. A. Udden of Augustana College.

Dr. P. A. Rydberg was invited by the committee on arrangements to prepare a paper to be published in commemoration of the occasion. He chose for his subject, *Scandinavians who have Contributed to the Knowledge of the Flora of North America*.

GUSTAV ANDREEN

Scandinavians
who have Contributed to the
Knowledge of the Flora of North America
By Per Axel Rydberg, Ph. D., Curator
New York Botanical Garden



A Memoir
Prepared for the Celebration, at
Augustana College and Theological Seminary, of the 200th
Anniversary of the Birth of Linné

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SCANDINAVIANS

Who Have Contributed to the Knowledge of the Flora of North America. *

When we this year celebrate the two hundredth anniversary of the birth of Linnæus, the first questions that suggest themselves to us are: "What did the immortal Swede achieve for botany and zoology, the two sciences he loved so well?", and "Has the work of Linnæus any direct bearing upon the botany and zoology of America?"

The first of these questions has been answered so many times, and will be answered over and over again this spring at hundreds of places where the anniversary will be celebrated. I say hundreds, for there will scarcely be any college or university of any repute, where natural history is taught, throughout the whole world, which will not have a commemorative celebration of some kind; and what would be more natural for a speaker of the day or an *in memoriam* writer to dwell upon than the life work of the man in whose memory the celebration is held. To exploit the achievements of Linnæus will therefore be left in the hands of many abler men than the present writer is.

The second question the writer has been asked to answer in a short address at the celebration to be held here in New York on the 23rd of May. Undoubtedly, it will be answered at more than one place in this country this spring.

When the writer some time ago was asked by Professor J. A. Udden to prepare a "fest-skrift" for the Linné anniversary at Augustana College, Rock Island, Illinois, he hesitated very much whether to accept this honoring invitation or not. He did not know if it would be possible for him in the short time, and with all the busy hours of a curator at an institution such as the New York Botanical Garden, to prepare a memoir creditable to such an oc-

* Reprinted from the Augustana College Library Publications Number VI.

casation. At last he dared to undertake the work, and hopes that the institution for which it has been prepared and the author's contemporaries in general will receive it as it is, and have forbearance with its shortcomings.

After accepting the invitation, the writer had to choose a subject. As he did not dare to undertake the answering of the first question of the day, because it would have been too hard a task and he would have had too many competitors, and as it was only reluctantly he had agreed to make a short address, in which he would try to answer the second, he hardly knew what to write about. His national pride helped him in choosing the subject, and he will try to answer the question: "Have the Scandinavians contributed anything to the knowledge of the flora of North America?"

Swedes, Norwegians, Danes, Icelanders, and the descendants of Swedes who settled in Finland a few hundred years ago, are in reality but one nation, although ruled by four different crowned heads. Many of these Scandinavians have chosen, like the present writer, to settle on this side of the Atlantic and to swear allegiance to the stars and stripes. They have not thereby lost their nationality, nor its virtues. As Scandinavians have also been counted a few men of Scandinavian parentage (of the first generation), if this was known to the writer.

With North America the writer understands not only the United States and Canada, but the whole continent north of the Isthmus of Panama and adjacent islands, hence comprising also Mexico, Central America, and the West Indies. This view is the one generally adopted by American botanists, since the acquisition of Porto Rico and the overtaking of the Panama Canal work by the United States. From that time the heaviest work on the flora of these countries has shifted from Europe to America.

When trying to write a sketch of the Scandinavians more or less connected with the history of botany of North America, the writer naturally has to deal with this history and with the history of botany in general. It may not be amiss to state that the history of botany is here taken in a rather narrow sense, including only that of systematic botany, plant geography and related branches, not of plant physiology, nor general morphology, etc.

The best history of botany (or we may say, of botanists) in the library of the New York Botanical Garden is Emil Winckler's

Geschichte der Botanik. Unfortunately, this history brings us only up to 1850. Winckler divides the history into the following periods:

The ancient writers.
 Medicus—Bauhin, 1478—1601.
 Bauhin—Tournefort, 1601—1694.
 Tournefort—Linnæus, 1694—1735.
 Linnæus—Jussieu, 1735—1789.
 Jussieu—R. Brown, 1789—1817.
 R. Brown—....., 1817—1850.

Pritzel divides it into the following periods:

Ancient writers.
 Tournefort—Linnæus, 1694—1736.
 Linnæus—R. Brown, 1736—1810.
 R. Brown—DeCandolle, 1810—1824.
 De Candolle—....., 1824—.....

These two writers agree in regarding Tournefort, Linnæus, and Robert Brown epoch-making botanists. There is no question that the two first were. As to Robert Brown, there is no doubt that he was one of the greatest systematic botanists the world has produced, and scarcely anyone has known as many plants as he; but as far as the botany of North America is concerned, the writer cannot see that a new epoch began either 1810 or 1817. There are many more reasons for assigning the beginning of new epochs with Jussieu and De Candolle, or rather with the appearance of the works in which they proposed their new systems of classification.

As far as the North American botany is concerned, new epochs apparently began about 1840 and 1890. The beginning of the first of these was too near the time when Winckler and Pritzel wrote, and was naturally overlooked by them.

The writer has adopted in general the periods by Winckler, but with some modification in the later ones.

1. MEDICAN PERIOD, 1478—1601.

This period extends from the time of Medicus to the appearance of Kaspar Bauhin's *Pinax*. During this time nothing of any value was written on American botany except the work of Hernandez, who traveled in Mexico in 1570—6. Only a portion thereof was published 1615, 1648, 1651, and 1791. So even the publication of Hernandez's work does not belong to this period.

Nothing was contributed to the knowledge of the American flora by Scandinavians.

2. BAUHINIAN PERIOD, 1601—1694.

This period extends from Bauhin's *Pinax* to Tournefort's *Institutiones*. The former of these was a remarkable book for its time. It aimed to catalogue and describe all known plants. The names of the plants and the descriptions were of the usual form of the time. Of course, the work is written in Latin. The names consist of a noun together with a descriptive phrase of one or more adjectives or adjective modifiers. The descriptions are crude, but often as good as were used by the immortal Linnæus himself, 150 years later.

During this period the flora of the West Indies and Mexico was explored and described by Sloane, a noted Irish physician and naturalist, and the Jesuit Barnabas Cobo; but nothing was done by Scandinavians.

3. TOURNEFORTIAN PERIOD, 1694—1735.

Tournefort's *Institutiones* was the epoch-making book. In this appear for the first time botanical genera in their modern sense. Tournefort had in many cases even a clearer idea of generic limitations than Linnæus himself. The majority of the genera in the *Genera Plantarum* of the latter were adopted from this work of Tournefort. Tournefort's descriptions are about as good as those of Linnæus, and have the advantage of being accompanied by illustrations. What Tournefort's *Institutiones* lacked was the systematic arrangement.

During this period the flora of North America was investigated by Plumier, who made four journeys to this continent. W. Houstoun, who collected in the West Indies and Mexico, John Lawson, in Carolina, and M. Catesby, in Virginia, Florida, and the Bahamas.

The first Scandinavian who, as far as the writer knows, contributed to the knowledge of the flora of North America, was Hans Egede, who spent fifteen years as missionary in Greenland. Greenland is not always counted to America, but there is no reason why it should not be. It is much nearer America than Europe. Even botanically it belongs to the former. It is true that it contains many plants common to northern Europe but not found elsewhere in North America, but still it is more American than European. The larger number of plants growing in Greenland are circumpolar ones, i. e. found in America as well as in Europe and Asia. If these are excepted, the flora is decidedly more American than European, especially in the northern part. This is not the case at all with the neighboring Iceland. The latter could be counted geographically to America, but not so botanically. Its flora consists almost exclusively of plants common to it, northern Scotland, northern Scandinavia, Spitzbergen, etc., with a few common to it and Greenland but with no American plants, if the circumpolar ones are excepted.

Hans Egede was born at Trondenæs, Norway, the 31st of January, 1686. He served some years as a minister in his native land. He went to Greenland as a missionary in 1721, and stayed there till 1836. He died at Stubbekjöbing on the Island of Falster, Denmark, the 5th of November, 1758. He made a collection of plants, which are still preserved at Copenhagen. After his return from Greenland, he published a very interesting account of the country, its people, fauna and flora, under the title:

Det Gamla Grönlands Nye Perlustration eller Natural-Historia, 1741. (Translated also into French.)

It is claimed that what most tempted Egede to go to Greenland was the idea that he might find there some descendants of the old Norwegian and Icelandic settlers from the time of Leif Ericson. He did not find any Norsemen, although he visited all the places where the old colonies were supposed to have been. The temporal as well as the spiritual welfare of the heathen Greenlander weighed heavily upon his heart. In order to alleviate their wretched condition, he induced a Norwegian company to establish trading posts at several places. After the company had lost one of its best vessels, and as the trading never had been a very paying business, the company decided to withdraw its men and discontinue the trade. This happened in 1726. Egede and his family and a few volunteers remained. Egede sent such a strong plea to the king of Denmark, that in the second year a vessel was sent to Greenland, the Danish government reopened some of the posts, and has carried on from that date a regular communication and continuous commerce with the island.

Paul Egede, son of Hans Egede, was born in 1708, became a missionary to Greenland in 1734, received the title of theological professor in 1761, and that of bishop in 1779. He died in 1789. He has left the following publications:

Herbarium vivum samlet i Grönland ved Colonierne Christianshaab og Godthaab, 1739.

Efterretninger om Grönland, uddragne af en Journal holden fra 1721 til 1788.

4. LINNEAN PERIOD. 1735—1789.

A new epoch began with the appearance of Linnæus's *Genera Plantarum*. In this Linnæus's new system of classification was used. Before this time there had been no definite system, or there had been used only such crude systems as we sometimes find to-day in some popular books, where, for instance, the plants are

classified according to the color of the flowers. Linnæus based his system on the number and different arrangement of the stamens and pistils. This was an artificial system, and Linnæus knew it to be so. He once expressly stated that he expected it to be superseded by a more natural one, where the relationship of the plants would be better shown. The Linnean sexual system was and is a very convenient one, and has been used more or less up to our times, where the aim has been to give a key, by the means of which one could quickly determine the names of the plants. That Linnæus saw the natural relationship of plants is shown by the fact that he later gave names to several of our modern families of plants, and that he arranged his artificial system so that several of his classes or orders are practically equivalent to modern families, as for instance the 14th, 19th and 20th classes, and his orders of the 15th and 17th classes.

Another invention of his was the uniform binomial names of the species. This was introduced in his "Species Plantarum" of 1753. Before Linnæus, the botanists, especially since the time of Tournefort, recognized genera in the same sense as we now do, and designated them by Latin nouns. In order to designate the species, they added to these nouns descriptive phrases consisting of one or usually several adjectives*, or their equivalents. Linnæus reduced the specific name to one adjective. We find occasionally binomial names in works before Linnæus, but he was the first to use consistently only such names.

By these two systems it was from this time easy to tabulate and arrange the known facts about plants, and it was comparatively easy to find the description of a certain plant; for each genus had a certain place in the system and had only one name, and the species had only one additional name to distinguish it from other species of the same genus, in a similar way as John Smith and Andrew Smith of the same family have different personal names.

During this period many native American botanists explored the country, as John Clayton, John Mitchel, and Thomas Walter the southern states, C. Colden, Jane Colden, William and John Bartram the northern. Many Europeans made extensive travels in this continent, as Patrick Browne, N. J. von Jacquin and Swartz in the West Indies, and Miguel Venegas and A. Menzies on the Pacific coast.

The following Scandinavians made contributions to the knowledge of the North American flora during this period:

A. United States and Canada.

Pehr Kalm was born at Nerpis, Finland, in 1715, and died as professor at the University of Åbo, the 16th of November, 1779.

In the seventeen hundred and nineties, Baron Sten Carl Bjelke, then the vice president of the court of appeals (hofrätten) of Finland, proposed to the Royal Swedish Academy of Sciences at

* An illustration of the difference in the nomenclature of Linnæus and that of his predecessors is found below on page 12 in the citation from Kalm, in which the latter first gives the old way of naming the plant, named after him, and the Linnean way, viz., *Kalmia latifolia*.

Stockholm to send a botanist to Siberia and Iceland, which are on the same latitude as a part of Sweden, to collect seeds of plants as would "improve the Swedish husbandry, gardening, manufactures, arts, and sciences." Dr. Linnaeus suggested that North America would be a better country than either. About the same time a Captain Triewald gave in Stockholm an exhibition and lecture on his observations on silk-culture. As Linnaeus had described a species of mulberry* from North America and native of a climate similar to that of Sweden, this gave additional strength to the choice of North America. When Count Tessin, who could nearly always have his own way, and who was in favor of the project, became president of the Royal Academy, it was decided to send Professor Kalm. An appeal was sent to the three universities of Sweden, at Upsala, Lund, and Åbo, to contribute what they could for the advancement of science. Åbo was the first one to answer, and sent a small sum, Lund had nothing to spare, but Upsala contributed liberally, considering the times and the country. Now-a-days, \$450 seem to us rather a small sum. With the contributions from other sources, the fund amounted to about twice that sum. Professor Kalm, however, spent not only this and his own salary, but about \$650 of his own money, and the journey left him with very limited means for the rest of his life.

After passports had been secured from the courts of London, Paris, Madrid, and the Hague, Kalm sailed from Gothenburg the 11th of December, 1747, accompanied by Lars Jungström, a gardener by profession. Overtaken by a severe storm, the vessel had to put in at Grimstad, Norway, where the travelers had to stay till the 8th of February, 1748. They arrived at London the 17th of the same month, stayed in England till August 15, and arrived at Philadelphia the 26th of September.

In Philadelphia Kalm stayed about a month, and made there the acquaintance of John Bartram, the most prominent American naturalist at that time. Then he set out on a journey to New York, passing through New Frankfort, New Bristol, Pa., Burlington, N. J., then the residence of the governor, Trenton, "Prince-town", New Brunswick, and Elizabeth, returning to Philadelphia Nov. 5.

In November he visited Racoon, N. J., where a number of

* This was *Morus rubra* L., which can be grown in southern Sweden, but, unfortunately, this species is not well adapted to silk-culture.

Swedes lived. Kalm afterward published three volumes on his travels. In these he describes very minutely everything he saw, the people, their industries and customs, the conditions and nature of the country through which he traveled. Of the animals and plants he met with, he gave only short descriptions, as he intended to publish these more extensively in a scientific work in Latin. In the diary of his stay in Racoon, he describes what the Swedes called the spoon-tree, because the Indians were said to make spoons from its wood. Kalm adds: "The English call this tree Laurel, because its leaves resemble those of the *Laurocerasus*. Dr. Linnæus, conformable to the peculiar friendship and goodness with which he has always honored me, has been pleased to call this tree, *Kalmia foliis ovatis, corymbis terminalibus* or *Kalmia latifolia*."

With the exception of a few days spent on a revisit to Philadelphia and a short visit to Penn's Neck, Kalm staid at Racoon the whole time till May 21, 1749. From June 3 to June 10 he was in New York. From there he sailed in a yacht to Albany. From there he traveled through Saratoga, Fort Nicholson, Fort Anne, Fort St. Frederic, Fort St. John, and Prairie de la Magdelene to Montreal, at which place he arrived on the 24th of July. He arrived at Quebec the 5th of August, visited several neighboring places, and returned to Montreal the 15th of September.

The three volumes of his "En resa till Norra Amerika" describes his travels up to this period. Evidently he intended to publish the account of the remainder of his stay in North America, but it was never done, probably on account of lack of funds. In the preface is given a synopsis of his travels. From this we find that he returned to Philadelphia the same fall. In 1750 he visited western Pennsylvania and the shores of New Jersey. After this he undertook his second long journey, through New York, the Blue Mountains, to Albany, then along the Mohawk River, visited the Iroquois Indian nations, the Mohawks, Oneidas, Tuskaroras, Onandagas, and Kayugas, saw the shores of Lake Ontario and Niagara Falls, and returned to Philadelphia in October. In a letter to Bartram he has given a vivid and most interesting description of his impressions at Niagara.

In 1751 he returned home by the way of England, and arrived at Gothenburg on the 16th of May. He resumed his duties as professor at the University of Åbo. In his private little garden

he raised many of the seeds he had gathered, and many more were cultivated in the Botanical Garden at Upsala. As stated before, he published:

En resa till Norra Amerika (A Journey to North America), in 3 volumes, 1853-'61. [This has been translated into German and English, and is one of the best accounts of this country at that period.]

Norra Amerikanska färge-örter, published in 1763.

He intended to publish a larger descriptive work on the plants and animals he met with on his journey, but this was never done, very likely because he had spent all his funds. All, or at least most of his plants were published by Linnæus in his "*Species Plantarum*."

Carolus Linnæus or CARL VON LINNÉ was born at Råshult, Småland, Sweden, the 13th of May (old style), 1707, and died at Upsala the 10th of January, 1778. There is no need of going into details of his life-history, for it will be given extensively over and over again this year. Only a few words may be given to show his work on American botany. I shall give it more extensively elsewhere.

He became acquainted with the North American plants from the finely illustrated works of Plumier, Plukenet, Catesby, Sloane, and Gronovius; also those of Petiver, Morrison, and Cornuti. Through Gronovius he had a chance to see Clayton's collection. Sloane's and Catesby's plants he saw on his visit to England. He described himself the plants collected by Kalm. A few American plants were already under cultivation. These were all incorporated in the first edition of "*Species Plantarum*." He afterwards received plants from Barthram and from Colden and his daughter Jane. He corresponded with John Ellis, a resident in the West Indies, and Dr. Gardner, who botanized in Carolina and Florida. Later he purchased a set of West Indian plants collected by Patrick Browne, and received a part of Jacquin's collections through exchange. These were described in the 10th edition of his "*Systema Naturæ*" and in the 2nd edition of "*Species Plantarum*." In all, he described about 2,000 North American plants.

The works which in part bear on North American botany are:

Species Plantarum, 1753; Edition 2, 1762-'63.

Systema Naturæ, Ed. 10, 1758-'59.

Daniel Carl Solander was born the 12th of February, 1733, at Piteå, Sweden. In 1759 he moved to England, and became libra-

rian of the British Museum in 1765. Solander died in London the 13th of May, 1782. Together with Banks, he was a botanist on Captain F. Cook's first voyage around the world in 1768—71. As a result of this journey the following scientific work was published by the trustees of the British Museum in 1900—'05: Illustrations of the Botany of Captain Cook's first voyage around the world. Solander also helped Aiton in publishing:

Hortus Kewensis, 1789.

In this Solander has contributed the descriptions of many new plants from America as well as elsewhere. Six of the new genera published in Swartz's West Indian flora are really from Solander's hand, as Swartz found the descriptions as well as the names in Solander's manuscript in the Banksian herbarium.

B. Greenland and Arctic America.

Many of the men in charge of the Danish trading posts in Greenland, established at the instigation of Hans Egede, and many of the sea captains engaged in the trade on Greenland or whaling near its coasts, brought home botanical specimens. One of the earlier and the most important of these was,

Carl Peter Holböll, who was born at Copenhagen the 31st of December, 1795. In 1821 he was appointed lieutenant in the marine, and some years later captain and governor of one of the colonies in Greenland. After his return to Denmark, he sailed in 1856 to revisit Greenland, and neither he nor his vessel was ever heard from. He was interested in both zoology and botany, and published an article on the birds of Greenland. His collection of plants is at the botanical museum at Copenhagen. At least one plant, *Arabis Holboellii* of the mustard family, is named after him.

The plants from the older of these collections, as well as those made by Egede and his son, were mostly described in the splendid work that bears the name *Flora Danica*. It is a large folio in sixteen volumes, and was intended to figure every plant growing in the kingdom of Denmark and its possessions. It includes, therefore, Norway, Faroe Islands, Iceland, Greenland, Schleswig-Holstein, and Oldenburg, which all at some time have belonged to Denmark. It was begun in 1764 by Öder, and was concluded in 1871.

Georg Christian Öder was born at Anspach, Germany, the 3rd of February, 1728. He took the degree of doctor of medicine in 1749, later moved to Denmark, where he was appointed professor at the University of Copenhagen in 1754, became "Stiftsamtman" at Drontheim, Norway, in 1773, moved to Oldenburg in 1773, where died the 28th of January, 1791.

His most prominent botanical work was the above mentioned *Flora Danica*, of which he published the first three volumes. These contain a large number of Greenland plants.

Christen Frítés Rottböll was born at Hörby, Zealand, Denmark, the 3rd of April 1727, became doctor of medicine in 1755, professor in 1756, and director of the botanical garden in Copenhagen in 1776. He died in Copenhagen the 15th of June, 1797.

The only article from his hand that bears directly on American botany is,

Afhandling om en Deel rare Planter, som i Island og Grönland ere fundne, etc. 1770.

Anders Johan Retzius was born at Christianstad, Sweden, the 3rd of October, 1742, became doctor of philosophy in 1766, and was professor at the University of Lund 1777—1812. He died at Stockholm the 6th of October, 1821. Linnæus, Læstadius, Wahlenberg, and Retzius are those of the older botanists who did the most to make the flora of Lapland known. They therefore laid the foundation to the knowledge of the Arctic vegetation in general. Among other botanical works he published the following, which also included Greenland:

Flora Scandinaviæ Prodromus, 1779 [together with two supplements].

C. West Indies and Central America.

Carolus Linnæus (See above).

Carl Gustaf Sandmark, a pupil of Linnæus, wrote a dissertation which was based on a collection secured by Linnæus from P. Browne. In reality this did not contain anything new, as the species had already been described in "Systema Natura" by Linnæus. The only value Sandmark's dissertation has is that it gives more extensive descriptions.

Flora Jamaicensis, 1759.

Gabriel Elmgren, also a disciple of Linnæus, wrote a dissertation based on the same collection of P. Browne. What is said

of Sandmark's dissertation, applies also to this. Elmgren's work, however, contains many species not found in Linnæus' "Systema." Three of these are accompanied by descriptions and belong by right to Elmgren, although they as a rule have been credited to Linnæus.

Plantarum Jamaicensium pugillus, 1759.

Daniel Carl Solander (See above).

Carl von Linné, f., the son of the immortal Linnæus, was born at Falun, Sweden, the 20th of January, 1741, became professor of medicine in 1763, and died at Upsala the 1st of November, 1783.

As far as the writer knows, he published only a few Central American plants collected by Mutis.

Supplementum Plantarum Systematis vegetabilium, 1781.

Olof Swartz was born at Norrköping, Sweden, the 21st of September, 1760. His father, whose name was also Olof Swartz, was a factory owner and a man of some means. This fact made the son independent and able to spend money both in travels and in publishing his works. Olof Swartz was a pupil of Carl von Linné, the younger. As a student he showed such ability that his teacher said of him: "*Botanices studiosus optimæ spei.*" In 1780 and 1783 he took the two preliminary examinations then required for the degree of doctor of medicine. During the summers of this period he undertook several botanical expeditions to different provinces of Sweden and made several new discoveries.

Swartz had for some time contemplated making a journey into the tropics, and in 1783 he was ready to go. He went on board the 5th of August, and sailed in a merchant vessel to Boston, where he landed the 3rd of October. He did not intend to stay there, but took the first opportunity offered him to go to Jamaica. He left Boston on the 26th of November and landed in Montego Bay on the 5th of January, 1784. He set to work with an untiring zeal to make as thorough a survey of the natural history of the island as possible. Not long after his arrival he was invited to remain as government botanist, but he declined. In 1785 he spent a few months in Cuba and San Domingo, and returned to Jamaica. According to Wikström, he also visited Porto Rico, but this is denied by Urban.

In 1786 Swartz went to England to compare his collections

with the Linnæan and Banksian herbaria there. During his stay he was offered another position, viz., to go to India as physician of the East India Company; but he declined, having decided to serve his own native country. His collections were very rich, and his *Flora Indiæ Occidentalis*, the ultimate result of his travels and labor, is the foundation of our knowledge of the flora of the West Indies. It contains the descriptions of 892 species of plants. Of these 723 were new to science.

After his return to Sweden, Swartz continued his botanical explorations in different parts of Sweden. In 1802 he was called to become the successor of Prof. Lepechin as director of the Royal Academy of Sciences at St. Petersburg, but again he declined. He was appointed director of the Royal Academy at Stockholm in 1807, made a knight of the Order of Vasa in 1808, and professor of the Royal Carolinian Medico-Chirurgic Institute at Stockholm in 1814. He died the 19th. of September, 1818.

Swartz's knowledge of American plants, however, was not limited to his own collections. While in England, he studied the collections found in the herbaria of Sloane, Plukenet, Petiver, and Banks. He corresponded freely with such men as Schreber, Willdenow, Schræder, Persoon, Mohr, Hooker, and Fischer, the prominent botanists of his time. He received from Rev. Muhlenberg in Pennsylvania a fine collection of American plants collected in 1710 and 1711. From these he described six new species of mosses.

In 1817 Rev. Forström, then residing on the island St. Bartholomew, sent him a large collection of Antillian plants. These furnished the material for his "Flora Bartholomensis et Guadeloupensis", containing 34 new species.

He was an acknowledged authority on ferns, mosses, and lichens. He was the father of fern-knowledge; his *Synopsis Filicum* made a revolution in that science. He was one of the first to adopt and apply the system of genera and species of mosses by Hedwig; the father of bryology, and he knew almost as much about lichens as his friend Acharius. In his books on these three classes of plants are found numerous descriptions of North American plants.

The following publications from Schwartz's pen refer wholly or partly to North American plants:

- Tolf nya slag af Urticæ-släktet från Vestindien, 1787.
 Beskrifning på nio nässlor (*Urtica*), hvilka nyligen på Jamaica blifvit upptäckta och beskrifna af O. Swartz, 1787.
 Nova Genera et Species Plantarum, etc., 1788.
Cinchona augustifolia, en okänd växt från Västindien, 1788.
Solandra, ett nytt släkte från Västindien, 1788.
Quassia excelsa, en ny växt från Västindien, 1788.
Stylanthus, ett nytt örtsläkte, 1788.
 Observationes botanicæ quibus plantæ Indiæ occidentalis, 1791.
 Icones plantarum incognitarum quas in India occidentale delexit atque delineavit. 1794.
 Flora Indiæ occidentalis aucta atque illustrata, etc., 1797—1806.
 Synopsis Filicum, 1806.
 Lichenes Americani, 1811.
 Flora Bartholomensis et Guadaloupensis, 1825 & 1827.

5. JUSSIEUAN PERIOD, 1789—1819.

This period begins with the publication of the *Genera Plantarum secundum ordines naturales disposita* by Antoine L. de Jussieu. In this appears for the first time a system of classification based on the natural relationship of the plants. This system was in reality founded by his uncle, Bernard de Jussieu, but never published. The system was much more natural than the sexual system of Linnaeus, but was also much more complicated. As it had many inconsistencies, and as there was no uniformity in the names of the families, it did not receive the adherents that it deserved, and there are few books in which we find it used during this period. Even if the Jussieuan system of classification did not leave deeper marks on the period which bears its name, it is evident that a new era began at this time, a very active one, especially in systematic botany, with such systematists as Willdenow, Arton, Salisbury, Persoon, Sprengel, and Robert Brown, the latter, however, belonging just as much to the next period.

Before this time nothing had been published that exclusively treated on North America except Walter's "Flora Caroliniana", which appeared the year before Jussieu's "Genera". During this period were published all the older floras of this country, viz., those of Michaux, Pursh, Barton, and Bigelow, and Nuttall's "Genera". Elliott's work was published a few years after the beginning of the next. H. Muhlenberg and C. C. Robin belonged to this time. Lewis and Clark made their famous expedition across the continent, A. Poiteau, John Lunan, and G. Richard de Tussac explored the West Indies, David Cranz, a Moravian missionary, collected in Greenland, and another one of the same creed, Kolmeister, in Labrador.

The following Scandinavians partook in the work; none of them, however, contributed anything important to the knowledge of the flora of the continent. Their work was mostly limited to the West Indies.

A. West Indies.

John Ryan was a planter on St. Croix. When and where he was born and when he died, I have not been able to ascertain, but

he was a contemporary of Vahl's. He made several journeys to different parts of the West Indian islands and to Surinam and Brazil. He corresponded with and sent numerous specimens to Vahl.

Julius Philip Benjamin von Rohr, an officer of the garrison of the Danish West Indies, served from 1757 as civil engineer, and from 1765 as superintendent of constructions at the government buildings and forts. In 1787-'91 he made a series of journeys in the interests of cotton culture, and died as lieutenant colonel in 1793, on a journey from North America to Guinea. He was an ardent collector, and described 8 new genera of plants from St. Croix, Montserrat, Guadeloupe, and Martinique. His collections were afterwards elaborated by Vahl. At least one publication is from his hand:

Plante-Slægter med tilføiede Anmærkninger af Hr Professor Vahl, 1792.

Hans West was born in 1758 at Mesinge, on Hindsholm, Fyen, Denmark. In 1788-1800 he was the president of the school at Christianssted on St. Croix. In 1802 he was appointed minister to Holland, and died at Cassel, returning from a journey to France 1811. He made in the Danish West Indies and Porto Rico extensive collections, which were sent to Vahl. He published the following, a work of 363 pages:

Bidrag til Beskrivelse over Ste. Croix, med en kort Udsigt over St. Thomas, St. Jean, Tortola, Spanishtown og Crabeneiland, 1793. [Several new species are there published].

Martin Vahl was born at Bergen, Norway, the 10th of October, 1749. He became lector at the Botanical Garden at Copenhagen in 1779; director of the Botanical Garden in 1800; professor at the university in 1801, and died the 24th of December, 1804. He studied under Linnæus in 1769-'75, and edited *Flora Danica*, Vols. 6 and 7, in 1787-1803. He was specially interested in the flora of the West Indies. The plants he described were collected by von Rohr at St. Croix, Montserrat, Guadeloupe, and Martinique; by Dr. Ryan at Montserrat, St. Croix, and St. John; by Hans West on the Danish West Indies; by Mertfeldt on Guadeloupe, and Dr. Pflug on St. Croix.

The following, referring to American plants, are from him:

Flora Danica, Vols. 6 and 7, 1787-1803.

Eclogæ Americanæ, 1796-1807.

En deel Kryptogamiske Planter fra St. Croix, 1802.

Om Slægten *Cucurbita* og dens Arter. 1797.

Icones illustration, plantarum Americanarum in Eclogis descriptarum insertis. 1798-'99.

Anmærkninger til Oberst-lieutenant von Rohrs Beskrivelse over nogle Planter. 1793.

Beskrivning over *Stellaria Grønlandica* og *Dryas integrifolia*. 1797.

Samuel Fahlberg, a Swedish physician, came to St. Bartholomew in 1785, soon after that island had become a Swedish possession. He published:

Utdrag af samlinger till naturalhistorien öfver ön St. Barthelemi i Västindien. 1786.

Bengt Anders Euphrasen, a botanical student, undertook in 1788 a journey to the West Indies under the auspices of the Royal Swedish Academy of Sciences, and visited St. Bartholomew, St. Eustatius, and St. Kitts. After his return he published:

Beskrifning öfver svenska västindiska ön St. Barthelemi samt öarne St. Eustache och St. Christopher. 1795.

Paul Erdman Isert was born in 1757, and in 1783 went out as head physician of the Danish Colonies in Guinea, which he left in 1787 and sailed in a slave-ship to the West Indies. He visited St. Croix, St. Thomas, St. John, St. Eustatius, Guadeloupe, and Martinique. He returned to Copenhagen, where he died in 1789. He published:

Reise nach Guinea und den Caraibischen Inseln im Columbien. 1788.

Reb. Forström. Nothing more is known to the writer than that he was a Swedish clergyman residing on the island of St. Bartholomew, and sent a large collection to Swartz in 1817.

Olof Swartz (See preceding period.)

6. CANDOLLEAN PERIOD, 1819—1840.

This period began, in the writer's opinion, rather with the appearance of the second edition of Augustin Pyramus de Candolle's *Theorie elementaire de la Botanique* in 1819, than with that of the first volume of his "Prodrômus", in 1824; for the epoch-making publication was the publication of his system of classification. It is true that his system had already been published in 1813 in the first edition of the "Theorie;" but it received considerable modifications in the second edition, where it is practically as we know it to-day.

De Candolle's system was based to a great extent on that of Jussieu; but not only had the related genera been brought together into families, but the related families into orders, and arranged in a series. Except in a few cases, he had formed the name of each family from the name of a representative genus belonging to it by suffixing the ending *-aceæ*, as, for instance, *Rosaceæ* from *Rosa*. His

system was adopted almost immediately by the leading botanists of the world, and the Natural System has from that time prevailed over the artificial Sexual System of Linnæus.

Before this time nearly all botanical publications relative to the flora of North America had been made by foreigners. From this time on, at least as far as the United States and Canada are concerned, the bulk of the published works is from the hands of native Americans. During this period lived here the following botanists: Nuttall, A. Eaton, Schweinitz, Barton, Rafinesque-Schmaltz, Torrey, Beck, Riddell, Engelmann, Darlington, Elliott, and Gray. Douglas and Drummond made their trips across the continent. E. Meyer explored Labrador; de la Pylaie Canada; Scoresby, Ross, Parry, and Richardson the Arctic regions; Maycock, Ehrenberg, and Macfadyen the West Indies; Llave, Lexarza, Schiede, Deppe, Moricand, Hartweg, and Ehrenberg Mexico.

None of the Scandinavian botanists visited the northern part of the continent proper, and none wrote specially on the flora of the United States or Canada; but two of the most prominent Swedish botanists published works in which numerous North American plants are described. These were:

Carl Adolf Agardh was born at Båstad, Sweden, the 23rd of January, 1785, received his Ph. D. in 1805, became docent at Lund in 1807 and professor in 1812, was appointed bishop of Karlstad, where he died the 28th of January, 1859. He was an ardent student of sea-weeds, and can be called the father of algology. His work was continued by his son, Jacob Georg. The elder Agardh has, as far as the writer knows, published nothing that bears exclusively on American botany; but in his principal works he describes many American plants. These works are:

Species algarum, 1820.

Systema algarum, 1824.

Eltas Magnus Fries was born at Femsjö, Småland, Sweden, the 15th of August, 1792, received his Ph. D. degree in 1814, became docent at Upsala in 1814, and professor and director of the Botanical Garden in 1851-'63. He died at Upsala the 8th of February, 1878. The place Agardh held in algology, Fries can be said with fully as good a right to have held in mycology. It is especially the higher fungi, and above all the *Hymenomycetes*, which have been treated with a master's hand by him. In his large works we find many American species described, and still more that are common to the Old and the New World.

Systema mycologicum, sistens fungorum ordines, genera et species, 1821-'29. With a supplement, 1830-'32.

B. Greenland and Arctic America.

With the nineteenth century began an active period in the investigation of polar regions. It was especially Arctic America that was an object for explorations. During this time Sabine, Ross, Parry, and Franklin undertook their famous expeditions. The following Danes added not a little to the knowledge of the flora of Greenland and the neighboring islands. The first one belongs rather to the preceding period, but is included here, as his work is closely connected with the work done later.

Captain Morten Wormskjöld was born at Copenhagen the 16th of January, 1783. He made a journey to Greenland in 1812-'14, and another around the world in 1815-'19, resided in Kamtschatka 1816-'18, and died in Gaunö, Denmark, in 1845. He brought home a fine collection of plants. At least one American plant is named after him, *Veronica Wormskjöldii*, which grows in Greenland and Arctic America as well as in the Rocky Mountains.

Count Raben made a journey to Greenland in 1823 and brought home a collection, which was determined by Hornemann.

Wilhelm August Graah was born the 24th of October, 1793, and died in 1863. He made several journeys to Greenland, the first in 1823. On his third journey, 1828-'31, he wintered at Nanolatic, Nubarbik, and Julianehaab. He was director of the Greenland Company in 1832-'50, and appointed captain in 1840.

Undersögelse Reise til Ostkysten af Grönland, 1832.

Expedition to Search for the Lost Colonies on the East Coast of Greenland.

Jens Lorenz Mustue Vahl, son of M. Vahl, was born the 27th of November, 1796, was for a long time librarian of the Botanical Garden at Copenhagen, and died the 12th of November, 1854. Vahl traveled in Sweden, Germany, Austria, France, and Spitzbergen. He made one journey to Iceland and another to Greenland in 1828-'36. From his hand is the following publication:

Voyage en Island et au Grönland, 1841.

He also contributed to *Flora Danica* and to "Naturhistoriske Bidrag til en Beskrivelse af Grönland" by Rink.

Hans Christian Lyngbye was born at Blendstrup, Denmark, the 29th of June, 1782. He was a minister of the gospel, and died at Söeborg the 18th of May, 1837. He was especially

interested in water plants; contributed to *Flora Danica*, and is the author of

Tentamen Hydrophytologia Danicæ [which also included Greenland], 1819.

Jens Wilken Hornemann was born at Marstal, Aerö, Denmark, the 6th of March, 1770, received the honorary degree of Ph. D. in 1836, was professor of the university of Copenhagen 1808—'39, and died in Copenhagen in 1841. He was one of Denmark's most prominent systematic botanists, and added much to the knowledge of the flora of Scandinavia. He determined the collections made by Count Raben, Captain Graah, and others. Besides, he published the following works which contain descriptions of North American plants:

Dansk Oekonomisk Plantelære, 1837.

Hortus botanicus Hafniensis, 1813—'15.

Bemærkninger om Vegetationen i Grönland samt nogle der af Wormskjöld og Gieseke fundne sjældne Planter, 1815.

Om Grönlands flora, 1832.

Flora Danica, Vols. 8—13, 1810—'40.

C. West Indies.

Peder Eggert Benzon was born at Vesterskov on Lolland, Denmark, the 27th of October, 1788. He took his pharmaceutical examination in 1814, and arrived at St. Croix in 1817, where he practiced as apothecary. In 1822 he was elected superintendent of the natural history collections made by the order of the government. In 1848 he returned to Copenhagen, where he died the 24th of July, the same year. He made large collections which were sent to Copenhagen, and carried on an extensive correspondence, especially with Hornemann.

Om den vestindiske Salop, dens Dyrkning, Tilberedelse og almindelige Egen-skaber, 1823.

Peter Rabn was born in Dröbak, Norway. In 1816 he took his surgical examination and became ship-surgeon on a Danish man-of-war. As such he visited, as early as 1820, the Danish West Indies and Porto Rico. In 1830 he became surgeon of the garrison on St. Thomas, and died in 1839. He collected plants in the Danish West Indies, Crab Island (Vieques), and Curacao. Although a man of poor health, he made large collections and corresponded with Prof. A. P. Candolle at Geneva and Prof. Horneman at Copenhagen.

Hans Baltzar Hornbeck was born the 9th of January, 1800, at Copenhagen. In 1829 he took his surgical examination, and went out the same year as ship-surgeon on the government vessel "Diana", to the West Indies. Two years later he took his examination as doctor of medicine and moved to St. John as practicing physician. He returned to Denmark in 1844, and died in 1870. He was an ardent collector, and corresponded much with Prof. Schouw in Copenhagen.

Johan Emanuel Wikström was born at Venersborg, Sweden, the 1st of November, 1789, became doctor of medicine in 1817, and was director of the Botanical Museum at Stockholm in 1818-'56. He died the 4th of May, 1856. For many years he published "Öfversigt af Svenska Vetenskapsakademiens handlingar." There are numerous publications from his hand, but only the following, as far as the writer knows, refer to American botany. They were principally based on the collections made by Dr. Fahlberg, Euphrasen, Richard, l'Herminier, Bertero, and Forström.

Öfversigt af ön Sanct Barthelemis flora (6 new species), 1826.

Öfversigt af ön Guadeloupes flora (21 new species), 1828.

Enumeration of Plants of St. Eustache and Saba.

Den amerikanska Agaves eller den så kallade hundraåriga aloens naturalhistoria.

6. HOOKERIAN PERIOD, 1840—1889.

The appearance of Hooker's *Flora Boreali-Americana*, 1829-'40, and about the same time of Torrey and Gray's *Flora of North America*, 1838-'43, marks the beginning or rather the end of a period, at least as far as North American botany is concerned. These two books represent the work done during the Candollean period of two decennia of most active work. The new period was also an active one, for during this were undertaken the botanical explorations connected with the Mexican boundary survey, the Pacific Railroad surveys and Hayden's geological surveys. Nuttall, Torrey, and Engelman were still at work during the earlier part. C. C. Parry, Hall and Harbour, Bigelow, Watson, Thurber, Wolf, Porter, Coulter, Palmer, Brandegee, Lemmon, Bolander, Kellogg, Greene, etc., were exploring the West; Palmer and Pringle began their work in Mexico, and the Marcou, father and son, theirs in Canada. The systematic part, at least on the flowering plants, passed over almost exclusively to one institution, viz. Harvard, where Gray was the leading spirit.

Bentham and Hooker's *Genera Plantarum*, in which was inaugurated modifications and improvements on the Candollean system of classification, appeared about the middle of this period, 1862-'83. It would hardly be advisable to assign as the beginning of a new period the time when this appeared; for the "Bentham-Hookerian system" differs in no essential respect from that of De Candolle

and had little effect on botany at large. The "Genera", however, have been of inestimable value, for no work contains such good and complete descriptions of the genera of the world as this.

The following work was done by Scandinavians during this period:

A. United States and Canada.

Thure Ludvig Theodor Kamlien was born at Herrlunda, Västergötland, Sweden, the 9th of November, 1819, graduated at Skara Gymnasium, and was for some time a pupil of Elias Fries at Upsala. He emigrated to America in 1843 and settled near Lake Koshkonong, Wis. For twenty years he made collections for the museums at Upsala, Stockholm, Leyden, the British Museum, and the Smithsonian. He was a zoologist as well as a botanist, and a great lover of nature. In 1867 he became instructor in botany and zoology at Albion College, and in 1883 conservator of the Milwaukee Public Museum. He died the 5th of August, 1888. He published very little. The only botanical publication, as far as the writer knows, is the following:

On the Rapid Disappearance of Wisconsin Wild Flowers, 1876.

Jacob Georg Agardh, son of C. A. AGARDH, was born at Lund, Sweden, the 8th of December, 1813, received his Ph. D. degree in 1832, became docent at Lund in 1834, extra-ordinary professor in 1847, and professor in 1854, retired in 1879, and died the 17th of January, 1901. He was one of the most prominent phycologists in the world, and specialized in the marine algæ, especially the red sea-weeds. He has written little that bears directly on American botany, but his principal work, "Species, genera et ordines Algarum", comprises the whole world, and therefore contains many American plants. The first one given below contains more North American species than exotic ones. The following are from his hand:

Synopsis generis Lupini, 1835.

Nya alger från Mexico, 1847.

Species, genera et ordines algarum, 1848-'63.

Bidrag till kännedom af Grönlands Laminarier och Fucaceer, 1872.

Till algernas systematik, 1872-'90.

Grönlands Floridier och Ulvaceer.

Nils Johan Anderson was born at Gärderum, Småland, Sweden, the 20th of February, 1821, received his Ph. D. degree in 1845, was lector at the Gymnasium of Stockholm in 1851-'53, and director of the Botanical Museum in 1856-'79. He died

March 27, 1880. In 1851—'53 he was the botanist of the journey around the world of the Swedish man-of-war *Eugenie*, on which tour the Galapago Islands were especially studied. Anderson was the most prominent salicologist of his time, and numerous willows from America as well as elsewhere have been described and named by him. The works from his hand that bear on North American botany are the following:

Salices boreali-americanæ, A Synopsis of the American Willows, 1858.

Monographia Salicum hucusque cognitarum, 1867.

Salicaceæ in De Candolle's *Prodromus*, 1868.

Veit Brecher Wittrock was born at Holm, Dalsland, Sweden, the 5th of May, 1839, received the degree of Ph. D. in 1866, was appointed docent at Upsala the same year, and professor in 1878. The following year he became director of the Botanical Garden at Stockholm. He is a prominent algologist and a specialist on green algæ. The following publications refer more or less to American plants:

Algologiska studier, 1867.

On the Development and the Systematic Arrangement of the *Pithophoraceæ*, a new order of Algæ [all Tropical, some West Indian], 1877.

Prodromus Oedogoniorum, 1874.

Sextus Otto Lindberg was born at Stockholm the 29th of March, 1835, received his Ph. D. in 1865, and became professor and director of the Botanical Garden at Helsingfors, Finland, in 1865. He died there the 20th of February, 1889. He was one of the most prominent bryologists of the world, and is the author of a new system of arrangement of the genera and species of mosses. Works that bear directly on the North American flora are the following:

Revisio critica iconum in opere Flora Danica muscos illustrantium, 1871.

Europas och Nord-Amerikas hvitmossor, 1882.

B. Greenland and Arctic America.

In 1870 began a series of expeditions to Greenland and other parts of Arctic America; but before this time several collections had been sent to Copenhagen by men who had made longer or shorter stays in Greenland. The most important of these were made by

Captain Norman,

Dr. L. Schiödte, who was a physician at Ivigtut in 1867, and by

Henrik Johannes Rink, who was born in Copenhagen the 26th of August, 1819, received his degree of Ph. D. in 1844, made a journey around the world in 1845—'47, one to northern Greenland in 1848—'51, and another to southern Greenland in 1852—'68. Dr. Rink was governor of the colonies at Julienhaab and Godthaab in 1853, became general inspector of South Greenland in 1858—'68, and one of the three directors of the government explorations of Greenland in 1871—'82. He died at Christiania in 1893. He published contributions as follows:

Grönland, geographisk og statistisk beskrevet, 1852—'57. [Natural history contributions to this were made by J. Reinhart, J. C. Schiödte, O. A. L. Mörch, C. Luetken, and J. Lange (See below.)]

Greenland, 1877. [The botanical account in this was by R. Brown (Campst.) and J. Lange.]

Salomon Thomas Nicolai Drejer was born at Evedrup, Viborg, Denmark, the 15th of February, 1813, became docent at the university in 1839, and died at Copenhagen the 21st of April, 1842. He was an acknowledged authority on sedges, especially the genus *Carex*. He described numerous new species of this genus, of which not a few are found in America. The most important work from his hand is

Revisio critica Caricum borealium in terris sub imperio Danico jacentibus inventarum, 1841.

In 1870 and 1871 two Swedish expeditions were made to Greenland under Prof. Nordenskiöld. The botanist of the first expedition was S. Berggren; of the second, T. E. Fries.

Sven Berggren was born at Hör, Skåne, Sweden, the 12th of August, 1837, received his Ph. D. degree in 1865, became docent in 1866, extra ordinary professor at Upsala in 1881, and professor at Lund in 1898. He made a journey to Spitzbergen in 1868, to Greenland in 1870, and to New Zealand in 1874—'75. The following contributions are from his hand:

Alger från Grönlands inlandsis, 1871.

Förteckning öfver kärlväxter och mossor från Grönlands-expeditionen 1870, 1871.

Bidrag till kännedom om fanerogam-floran vid Disko-bugten och Auleitsivik-fjorden på Grönlands västkust, 1872.

Undersökning af mossfloran vid Disko-bukten etc., 1875.

Theodor Magnus Fries, son of Elias Fries, was born at Femsjö, Småland, Sweden, the 28th of October, 1832, received his Ph. D. degree in 1857, became docent the same year, was professor at

the university and director of the botanical garden in 1877—'99. He accompanied Nordenskiöld to Spitzbergen in 1868 and to Greenland in 1871. Some of his works which bear directly on North American botany are the following:

Lichenes Arctoi Europæ Grœnlandiæque hæctenus cogniti, 1861.

Grönland, dess natur och invånare, 1872.

On the lichens collected during the English polarexpeditions 1875—'76, 1879.

The botanical collections of these expeditions have been worked up by several other Swedish botanists. The principal of these are:

Jacob Georg Agardh. See page 25.

Frans Reinhold Kjellman. See page 32.

Carl Fredrik Otto Nordstedt was born at Jönköping, Sweden, the 20th of January, 1838, became conservator of the Botanical Museum at Lund in 1880, received the honorary degree of Ph. D. in 1881 and the title of professor in 1903. He has been for many years the editor of the "Botaniska Notiser". He has made extensive collections, and is an acknowledged authority on fresh-water algæ. He has published:

Desmidieer samlade af Sven Berggren under Nordenskjöldska expeditionen till Grönland, 1870, 1885.

Ueber einige Characeen aus Porto Rico, 1888.

In 1876 began a series of expeditions to Greenland, undertaken to a great extent by the Danish government. The results of these expeditions have been printed in that excellent work which is known under the title

Meddelelser om Grönland.

The principal collectors on these expeditions were:

Andreas Nikolaus Kornerup, born at Copenhagen the 7th of February, 1857, became docent at the Agricultural College in 1880, and died the 3rd of September, 1881. He was the botanist of Steenstrup's expedition in 1876 and of Captain Jensen's in 1878—'79. His rich botanical collections were determined by Lange. He also contributed to *Meddelelser om Grönland*. The most important of these articles are:

Bemærkninger om Grönlands almindelige natur.

Om det organiske Liv paa den østlige Nunatak.

Knud Johan Vogelius Steenstrup was born the 7th of September, 1842, at Møv, Aalborg, took his pharmaceutical examination in 1863, became assistant in the Mineralogical Museum in 1866,

and has been since 1871 the geologist of the Danish explorations of Greenland. He received the honorary degree of Ph. D. in 1894. He made two expeditions to Greenland, one in 1876 to Julianehaab, and another in 1878-'80 to North Greenland. On the first Docent Kornerup was the botanist; during the second Steenstrup made the botanical collections himself.

Gustav Frederik Holm was born in Copenhagen in 1849 and became captain in the marine in 1885. He partook in the expedition under Steenstrup in 1876. He led an expedition to South Greenland in 1880-'81, and another to East Greenland in 1883-'85. He published,

Den Danske Konbaadsexpeditionen til Grönland, 1883-'85.

*C. Petersen**, Ph. Cand., was the botanist of the expedition to South Greenland in 1880 under CAPTAIN G. F. HOLM.

Jens Arnold Diderich Jensen was born at Flensborg the 24th of July, 1849, became captain in the marine in 1886, bureau-chief of the marine department in 1887, and retired in 1892. He made several journeys to Greenland: In 1877 to South Greenland, in 1878 to Godthaab and Fredrikshaab, in 1879, 1884 and 1885 to Holstenborg, Suckertoppen, and Godthaab. On the second of these journeys he was accompanied by Kornerup, and on the last by Dr. Sören Hansen, who acted as botanists. On the others he collected some plants himself.

N. Sylow, Ph. Cand., was the botanist of the expedition to North Greenland in 1879-'80 under LIEUT. R. HAMMER, and of that to South Greenland in 1883 under CAPTAIN HOLM.

P. Eberlin and *N. Knutson*, Ph. Cand., were the botanists of the expedition of 1883-'85, under CAPTAIN HOLM.

Carl Hartvig Ryder was born the the 12th of September, 1858, at Copenhagen, became lieutenant in the marine in 1879, and captain in 1897. He partook in Poulsen's expedition to Godthaab and Suckertoppen in 1885, made one to Upernavik in 1886, and another to the east coast of Greenland in 1891-'92, during which he himself made extensive botanical collections.

Johannes Eugenius Buelow Warming (See West Indies, page 48), and

* I have not been able to give any biographical sketch either of him or of several of the following collectors, as those volumes of *Meddelelser om Grönland* in which the account of their work published, are not found in the libraries of the City of New York.

Theodor Holm (See under United States, page 40) were the botanists on the Fylla expedition of 1884 under CAPTAIN NORMAN. They visited the Disco-Godthaab district.

On the Fylla expedition of 1886, under CAPTAIN BRÆM, the botanists were J. L. A. K. ROSENVINGE (see below) and THEODOR HOLM (see United States). They visited the districts of Upernavik, Prøven, Godhavn, Holstenborg, Suckertoppen, Godthaab, and Fredrikshaab.

Nikolaj Eg Kruse Hartz, M. A., was born at Randers, Denmark, the 23rd of August, 1867, and is an assistant in the Danish Geological Survey. He has had charge of several expeditions to Greenland, one to the Holstenborg, Fredrikshaab, and Tasermint districts in 1889, to Vaigattet and Holstenborg in 1890, and one to East Greenland in 1899—1902. From these he returned with many botanical specimens. During the last of these expeditions he was accompanied by KRUSE as botanist.

Botanisk Rejse beretning fra Vest Grønland, 1894.

Östgrönlands Vegetationförhold, 1895.

Fanerogamer og Karkryptogamer fra Nordöst Grønland, 1895.

Johan Martin Christian Lange was born at Ödstedgaard, Fredericia, Denmark, the 18th of March, 1818, became docent in 1846, was director of the Botanical Garden in 1856—'76, and received the honorary degree of Ph. D. in 1877. He died in Copenhagen the 3rd of April, 1898. He continued after Hornemann the publication of

Flora Danica, of which he edited Vols. 15—17.

He became much interested in the flora of Greenland, determining most of the collections made there. He left several publications, of which the following may be mentioned:

Oversigt over Grönlands Planter, 1857.

Naturhistoriske Bidrag til en Beskrivelse af Grönland, 1857.

Synopsis of Greenland's flora, 1877.

Bemærkninger om de af Cand. Kornerup i 1878 samlede Planter paa Vestkysten av Grönland, 1879.

Studier til Grönlands Flora, 1881.

Del Planter fra Nordgrönland, insamlede af Dr. Hansen, 1889.

Conspectus Floræ Grönlandicæ in "Meddelelser om Grönland", Vol. 3.

This is by far the most important work that has appeared, treating of the flora of Greenland. The first part appeared in 1880.

The contents of this publication is as follows:

Part I. Phanerogamer og Karsporeplanter:

[Introduction]—Lange.

Bemærkninger om Grönlands almindelige Natur.—Kornerup.

[Systematic part.]—Lange.

Tillæg om grønlandske Plantenavne.—Rink.

Part II. Tillæg til Phanerogamerne og Karsporeplanterne.—Lange.

Grönlands Mosser.—Lange & C. Jensen.

Part III. Lichenes.—Deichmann-Branth & Grönlund.

Fungi.—E. Rostrup.

Marine Algæ.—Rosenvinge.

Andet Tillæg til Phanerogamer og Karsporeplanter.—Rosenvinge,

Carl Christian Howitz Grönluna was born at Vordingborg, Denmark, July 14, 1825, served as teacher at Haderlev College and as microscopist at Ny Carberg, Copenhagen, where he died August 10, 1901. He made a journey to Iceland in 1868 and another in 1876. He has published, besides his *Islands Flora* and the contributions to *Conspectus Floræ Grænlantiæ*, also

Lichenes samlede i Grönland af Prof. Fr. Johnstrup i sommaren 1874, 1877—'78.

Fredrik Georg Emil Rostrup, born at Steensgaard, Lolland, Denmark, Jan. 28, 1831, became teacher at the Normal School at Skaarup, 1858, honorary Ph. D. in 1894, and professor in 1902. He contributed the part on fungi in the "Conspectus".

Tillæg til Grönlands Svampe, 1888.

Janus Lauritz Andreas Kolderup Rosenvinge was born at Copenhagen the 7th of November, 1858, became Ph. D. in 1888, docent at the University in 1895 and at the Polytechnic Institute in 1900. Besides his work on the *Conspectus Floræ Grænlantiæ* mentioned above, we find, among other contributions:

Det sydligste Grönlands Vegetation, 1896.

Grönlands Halvalger, 1893.

Vegetation de la partie plus meridionale du Grönland, 1901.

Sur la vegetation d'algues marines sur les côtes du Grönland.

Nye Bidrag til Vest-Grönlands Flora, 1898.

Deuxieme memoir sur les algues marines du Grönland, 1900.

Om Algevegetationen ved Grönlands Kyster, 1900.

Jacob Severin Deichmann-Branth was born at Nykjöbing the 7th of December, 1831, was a minister by profession, and traveled in Germany and Italy. He, together with Grönlund, contributed the part on lichens in the *Conspectus Floræ Grænlantiæ*.

Tillæg til Grönlands Lichen-Flora, 1892.

Ludwig Kumlien, the son of Thure Kumlien (see under United States, page 25), was born in Wisconsin, and died in 1902. Evidently he had inherited from his father the love of natural history. He was, however, more of a zoologist than a botanist, and was especially interested in birds. He was a field agent of the Smithsonian for a number of years and collected in Wisconsin and the New England States. He was the naturalist of the Howgate Polar Expedition in 1877—'78 to Cumberland Sound. The plants he collected were mostly from Niantic Harbor, Annanactook, Kikkerton Island, and from the Island of Disco, Greenland. He published the report of the expedition, in which the plants were determined by Gray.

Contribution to the natural history of Arctic America, made in connection with the Howgate Polar Expedition, 1879.

Frans Reinhold Kjellman was born on Torsö, Västergötland, Sweden, the 4th of November, 1846, became Ph. D. and docent at the University of Upsala in 1872, and professor in 1883. He accompanied Nordenskjöld as botanist to Spitzbergen in 1872—'73, to Nova Zemlia and Siberia in 1875, and around the world in 1878—'80, during which journey they passed through the Behring Sea and visited Fort Clarence and the St. Laurence Island. He died at Upsala the 22nd of April, 1907. He was a prominent phycologist, and has paid attention especially to the algæ of the Arctic regions. Only a few of his works refer, however, to North American botany.

Fanerogam-floran på St. Lawrence-ön, 1883.

Om Behring-hafvets algflora, 1889.

Om Floride släktet *Galaxaura* [Species from Florida, West Indies, Mexico, etc.]

Algæ of the Arctic Sea, 1883.

Ernst Bernhard Almquist was born at Skogs-Tibbe, Upland, Sweden, the 10th of August, 1852, received his M. D. in 1882, and became professor at the Carolinian Institute at Stockholm in 1891. He was the physician and lichenologist of the Nordenskjöld expedition around Asia in 1878—'80.

Per Teodor Cleve was born at Stockholm the 10th of February, 1840, received his Ph. D. in 1863, became docent the same year, and professor at Upsala in 1873. He is a prominent chemist and geologist, but also a botanist, having paid special atten-

tion to the diatoms, desmids and other fresh water algæ. He partook in a geological journey in 1868—'69 to North America and the West Indies.

Diatoms from the West Indian Archipelago, 1878.

Diatoms collected during the expedition of the Vega.

Färskvattens diatomaceer från Grönland och Argentinska Republiken, 1881.

On the diatoms collected during the Arctic expedition of Sir George Nares, 1883.

Diatoms from Baffins Bay and Davis Strait, 1896.

Synopsis of the Naviculoid Diatoms, 1894.

Johan August Berlin was born at Malsta, Upland, Sweden, the 7th of August, 1851, received his degree of Ph. D. in 1888. He was the botanist of the Nordenskjöld expedition to Greenland in 1883.

Kärlväxter, insamlade under den svenska expeditionen till Grönland 1883, 1884.

Alfred Gabriel Nathhorst was born at Väderbrunn, Södermanland, Sweden, the 7th of November, 1850, took the degree of Ph. D. in 1874, and became docent the same year. He became professor and director of the Paleophytological Museum, Stockholm, in 1884. He has made journeys to Spitzbergen in 1870, 1882 and 1898, to Greenland (with Nordenskjöld) in 1883, and to East Greenland in 1899. He is a prominent paleontologist and phytogeographer.

Botaniska anteckningar från nordvästra Grönland, 1884.

Förssatta anmärkningar om den grönländska vegetationens historia, 1891.

Två somrar i Norra Ishafvet.

Johan Georg Robert Boldt was born at Kuopio, Finland, the 3rd of January, 1861, took his Ph. D. examinations in 1891, and has been instructor of geography and history at Björneborg since 1899. He is a specialist on algæ, especially the desmids.

Desmider från Grönland, 1888.

C. West Indies.

Albert Heinrich Rüse was born the 11th of September, 1810, on Aerö, Denmark. He became apothecary on the island of St. Thomas, where he remained until 1870. He died the 18th of October, 1882. He made important collections, which are preserved at Copenhagen.

Henrik Johannes Krebs was born at Svendborg, Denmark, June 8, 1821. He took his pharmaceutical examination in 1840, and went to St. Thomas in 1843. He made several journeys to North, Central, and South America, to the Bermudas, Bahamas, Cuba, St. Domingo, Porto Rico, St. John, and St. Croix. In 1853 he became Swedish-Norwegian consul, and from 1860 he was first a member and then the speaker in the local legislature of the Danish West-Indies. In 1870 he returned to Copenhagen. He made considerable collections and published the following:

Et Bidrag til St. Thomas' Flora, 1847.

Catalogue of plants found on the island of St. Thomas, 1852.

Axel Theodor Goes was born at Rök, Östergötland, Sweden, the 3d of July 1835, served as government physician on St. Bartholomew 1865—70 and died at Stockholm Aug. 20, 1897. He made collections of West Indian plants.

Vegetationen på St. Bathelemy, skildrad i ett bref 1867. [Published by Th. M. Fries.]

Carl Conrad Berg was born in Copenhagen 1845. He was a machine worker by trade, came to St. Thomas in 1864. In 1867 he had charge of the dredging of the harbor at that place and in 1897 he became "Dock-master" for an English company. He came in contact with Baron Eggers and learned the scientific names from him. He has made an extensive collection of tropical woods, especially those of St. Thomas and St. John.

Frederik Michael Liebman (See Mexico, page 36).

Anders Sandö Örsted (See Mexico and Central America).

Baron Henrik Franz Alexander Eggers was born at the city of Schleswig, the 4th of December, 1844. He partok in the war of 1864. After the end of this war, he entered the service of Austria, followed Emperor Maximilian to Mexico, 1865—67, and was taken prisoner. After his release, he traveled for some time in Mexico. He went to St. Thomas in 1870 and entered the Danish service as a lieutenant, was advanced to captain and pensioned in 1885. He has lived in Copenhagen since 1887.

He visited San Domingo in 1880, Porto Rico in 1881 and 1883; Tortola, St. Kitts, San Domingo, Hayti, Turks Islands in 1887; Hayti, Jamaica, Bahamas in 1888; Cuba in 1889; Tabago, Trinidad, Grenada, St. Vincent and Barbados in 1889—90, Tab-

ago, Jamaica, Panama and Curaçao in 1891—93, and made extensive collections. The following publications are from his hand:

- Erindringer fra Mexico, 1869.
 St. Croix's Flora, 1876.
Rhizophora Mangle L., 1877.
Reynosa Griseb. En hidtil ufuldstandig kjendt Slægt af Rhamnaceernes Familie, 1877.
 Naturen paa de Dansk-Vestindiske Öer. 1878.
 The Flora of St. Croix and the Virgin Islands, 1879.
 Et Besög paa Öen Dominica, 1880.
 Die Poyale des östlichen Porto Rico, 1882.
 Porto Rico, 1883.
 Reise in das Innere von Sto. Domingo, 1888.
 Flora of the Bahamas, 1892.
 Supplement til St. Croix's og Jomfruöernes Flora, 1889.
 Botanical Exploration to Cuba, 1890.
 Die Insel Tobago, 1893.

Veit Brecher Wittrock (See United States and Canada, page 26).

Carl Emil Hansen Ostenfeld (See Greenland and Arctic America, page 45).

Carl Fredrik Otto Nordstedt (See Greenland, page 28).

William Nylander was born at Uleåborg, Finland, Jan. 3, 1822, received the degree Ph. Cand. in 1843 and that of M. D. in 1847. He lived in France from 1851 to 1857, when he was appointed professor at the University of Helsingfors, Finland. He returned to France in 1863 and died in Paris the 29th of March, 1899. He was perhaps the most prominent lichenologist of the world and was the author of numerous publications. Those relating to North America are the following:

- Synopsis methodica Lichenum omnium hucusque cognitorum, 1858—'59.
 Collectio lichenum ex insula Cuba, 1866.
 Enumeration des Lichenes récoltés par M. T. Husnot aux Antilles francaises, 1868.
 Circa Pyrenocarpeos in Cuba collectos a C. Wright, 1876.
 Lichenes nonnulli insulæ St. Thomas Antillarum, 1880.
 Enumeratio lichenum Freti Behringii, 1888.
 Mexicanas plantas nuper a collectoribus expeditionis scientificæ [together with E. Fournier and E. Bescherell].
 Lichenes exotici a W. Nylander descripti 1892.

Nils Gustaf Lagerheim was born at Stockholm the 18th of October, 1860. In 1889 he became conservator at the museum at

Lisbon; from 1889 to 1892 he was at Quito, 1892—5 at Tromsö, Norway, and in 1895 became professor at Stockholm. He has specialized in the lower cryptogams, especially the Desmids. The following contributions bear on American Botany.

Bidrag till Amerikas desmidieflora, 1885.

Ueber einige Arten aus Cuba, Jamaica und Puerto Rico. [Desmids found in material collected by Sintens, Swartz, and Wright], 1887.

Sur un nouveau parasite dangereux de la Vigne, *Uredo Viale* in Jamaica, 1889.

Mykologische Studien, 1899.

D. Mexico and Central America.

Frederik Michael Liebman was born at Helsingör, Denmark, the 10th of October, 1813, made journeys in Germany 1835, and in Norway 1836, and became docent at the University of Copenhagen in 1837.

In 1840 he started for Mexico in company with Rathsack, a gardener, and arrived at Vera Cruz in February, 1841. Here he met the Russian botanist Karwinsky, and they traveled together for some months. He visited several places north of Vera Cruz, as for instance Antiqua, Colima, Misantla and as far north as Papantla. Then he turned south and after having visited several places he stayed for a considerable time at Hacienda Mirador on the eastern slope of Mount Orizaba. This mountain he climbed in company with the German botanist Ghiesbrecht. Then he visited Tehuacan and returned to Mirador. Rathsack returned to Denmark in 1842 with numerous boxes of herbarium specimens, samples of woods, fruits, seeds and living plants. Liebman himself undertook a journey southward, visiting the city of Orizaba, Cuicatlan, Oaxaca, etc., climbed the peaks of Zempoaltepec and El Pelado, visited among other places, San Pedro Alto, Huamamelula and even Tehuantepec, and on his return again Oaxaca and Mirador.

On the home journey from Vera Cruz, he stopped two or three weeks in Cuba. He died the 29th of October, 1856, as professor at the University of Copenhagen.

Liebman did not have time before his death to publish much from the results of these collections. Most of this fell on the shoulders of Örsted. Still the following important contributions are from Liebman's hands.

Mexicos Brægner, 1849.

Mexicos og Central-Americas Neldeagtige Planter (*Urticeæ*), 1851.

Mexicos Halvgræs (*Cyperaceæ*), 1850.

Les chênes de l'Amérique tropale (*posthumous*, edited by Örsted), 1869.

Liebman also contributed to *Flora Danica*, of which he edited the 14th and 15th volumes and a supplement.

Anders Sandöe Örsted was born at Rudkjöping, Denmark, the 21 of June, 1816, began teaching in 1837, took his M. A. degree in 1844 and the Ph. D. in 1854, was appointed docent in 1851, received the title of professor in 1860 and became full professor in 1865. He died the 3rd of September, 1872.

He made a botanical journey to the West Indies and Central America in 1845—48. His stay in the West Indies was rather short. Besides the Danish West Indies, he visited also Jamaica, where he stayed six weeks. Örsted was one of the most productive botanists, and the mere list of his publications would occupy half a dozen pages. The following contains the most important publications bearing on American botany.

Ein Reise i Guanasti i Costa Rica, 1849.

Naturens physionomie i Central America, 1849.

Central Americas Rubiaceer, 1852.

Compositæ centroamericanæ [together with Bentham], 1852.

Geographisk-statistisk Oversigt over Central-Americas Compositeer, 1852.

Leguminosæ centroamericanæ, 1853.

Scrophularinæ centroamericanæ, Labiatæ do. and Malpighiaceæ do. [together with Bentham], 1853.

Gentianeæ centroamericanæ [together with Grisebach], 1853.

Mexicos og Central-Americas Acanthaceer, 1854.

Myrtaceæ centroamericanæ [together with D. O. Berg], 1855.

Om det centralamerikanske Balsamtræ og Balsamkysten, 1856.

Plantæ novæ centroamericanæ, 1856.

Centralamerikas Lobeliaceer [together with Planchon], 1857.

Plantæ novæ centroamericanæ, 1857.

Centralamerikas Gesneriaceer, 1858.

Palmæ centroamericanæ, 1858.

Myrsinæ centroamericanæ et mexicanæ, 1861.

L'Amérique centrale, 1863.

Skildring af Naturen paa Jamaica, 1863.

Det centralamerikanske ambratræ, 1870.

Præcursores floræ centroamericanæ (*posthumous*), 1873.

Jacob Georg Agardh (See above).

7. ENGLERIAN PERIOD, 1889—.

In 1889 appeared the first fascicle of Engler and Prantl's *Natuerlichen Pflanzenfamilien*, and three years later Adolph Engler's *Syllabus*. The former [not yet completed] gives an extensive account of all families and genera of plants, not only the flowering plants, as the *Genera Plantarum* of Bentham and Hooker and their predecessors. It was in this that the Englerian system of classification was first used, and it was in the *Syllabus* that it was first given in full. The Englerian system differs mainly from those of Bentham and Hooker and of deCandolle in the fact that Engler begins with the lower plants and advances from lower to higher forms, while the other systems begin with some of the higher families and proceed to the more simple ones. The names of the families are in most cases retained, but their relative position in many instances considerably changed. As the general arrangement of families and genera is much more natural than in other systems, Engler's system is now adopted at the leading institutions of this country. In individual cases the arrangement could be improved, and in some cases it is not as good as in the two preceding systems.

About the time that this system was made public, the two leading botanists of this country passed away, A. Gray in 1888, and S. Watson in 1892. This in itself might have been regarded as the end of a period, for the prominence of especially the former had been so great that the work of almost everyone else had been overshadowed. Now came a period of general comradeship and good-feeling, in which the tendency is: "Let also the smaller lights shine." To mention all the workers during the last eighteen years would be impossible, and it would be without the scope of this paper. During this period not only the Scandinavians on the other side of the Atlantic have taken an active part in American botany; there has grown up also a set of men in this country who have made no small contribution to the knowledge of North American botany, consisting partly of Scandinavians who in younger days immigrated, and partly of the sons of immigrants.

A. United States and Canada.

a. SCANDINAVIANS.

Nils Conrad Kindberg was born at Karlstad the 7th of August, 1832. He took his Ph. D. degree in 1857, and became lecturer at the College of Linköping 1860—1900. He is one of the leading bryologists in the world. He is a productive writer. The publications relative to North American botany given below (and this list is very likely not complete) can not by any means be compared in number with the works on Old World bryology.

Enumeratio muscorum qui in Grœnlandia, Islandia et Færoer occurrunt, 1888.

Bidrag till kännedom om Canada-området mossflora, 1890.

Checklist of European and North American Mosses (*Bryineæ*), 1894.

New or less known species of Pleurocarpous Mosses from North America and Europe, 1895.

New or less known species of Acrocarpous Mosses from North America and Europe, 1896.

European and North American Bryineæ, 1896-'98.

Genera of European and North American Bryineæ, 1897.

Mousses recoltées en Alabama, 1898.

Musci in J. Macoun, Catalogue of Canadian Plants, 1892.

European and North American *Polytrichaceæ*, 1894.

Notes sur un Hypopterygium in Canada, 1899.

Addition to the North American and European Bryology, 1900.

Bemerkungen über Nordamerikanische Laubmoose, 1903.

New North American Bryineæ, 1905.

Johan Nordal Fischer Wille was born at Skjolden Haaböl, Norway, the 28th of October, 1858, received his degree of Ph. D. in 1885, became amanuensis at the Natural History Museum at Stockholm in 1883, professor at Stockholm in 1886, and professor at the University and director of the Botanical Garden of Christiania in 1893. He is a prominent phycologist, and has published considerably, but rather little that refers specially to American botany for instance:

New Forms of Green Algæ, 1899.

Studien über Chlorophyceen, 1901.

Algologiska notiser, 1903.

Johan Ivar Lindroth was born at Sibbo, Nyland, Finland, took his examination for the Ph. D. degree in 1903 and has been since 1902 teacher of Natural History at the Forestry Institute at Evo, Finland. He is specialist on parasitic Fungi. The following publications contain some North American species.

Mycologische Notizen, 1900.

Uredineæ novæ, 1901.

Carl Christensen, Ph. Cand., assistant in the Botanical Museum at Copenhagen, is an ardent fern student. He has served the world by issuing his *Index Filicum*, a work which is to the pteridologist what the Kew Index is to the phanerogamic systematist. It is even in many respects superior to the Kew Index, especially in the matter of citing synonyms. As yet, Mr. Christensen has published but little referring to American Botany. Of these the most important are:

American species of *Leptochilus* section *Bolbitis*, 1904.

Index Filicum, 1905.

b. SCANDINAVIAN-AMERICANS.

August Gustaf Eisen was born at Stockholm, Sweden, the 2nd of August 1849, received his degree of Ph. D. in 1872 and became

docent in Zoology at Upsala the same year, but emigrated to America. He is a prominent zoologist, has made several journeys to Mexico and Central America, and collected botanical as well as zoological specimens. He is a member of the California Academy, whose President he was in 1905.

Explorations to the Cape Region of Baja, California, 1894-'95.

Biological Studies of Figs, etc., 1896.

Herman Theodor Holm was born the 3rd of February, 1854, at Copenhagen. He was the naturalist of the Danish North Pole Expedition of 1881—82 and accompanied Warming to Greenland in 1884 and Rosenvinge in 1886. In 1888, he emigrated to America, and became assistant botanist of the United States Department of Agriculture, 1893—96. He is a specialist in anatomy and morphology of flowering plants. He received his Ph. D. degree in 1902. He has published many papers on plant anatomy. The following are some of those referring more especially to North American botany:

Contribution to the Flora of Greenland, 1896.

Catalogue of Plants Collected by Messrs. Schubert, Stein, and White on the East Coast of Baffin's Land and the West Coast of Greenland, 1900.

Allies of *Stellaria media*, 1901.

Biological Notes on Canadian Species of *Viola*.

On Some Canadian Species of *Gentians*, 1901.

On the genus *Arctophila* Rupr., 1902.

Studies upon Cyperaceæ, I—XXIV, 1896—1905.

John H. Sandberg was born the 24th of July 1848, at Broby, Skåne, Sweden. He received his college education at Lund and also studied pharmacy in Sweden. He came to America in 1868 and located at Minneapolis in 1887. He studied medicine in this country has been practicing at Jenkins and Minneapolis, Minnesota. He is an enthusiastic collector and brought together a large herbarium of Minnesota plants, which some years ago was secured by Gustavus Adolphus College at St. Peter, Minnesota. In 1892 he became a field agent of the division of botany, United States Department of Agriculture, and collected in company with D. T. MacDougal and A. A. Heller, in Northern Idaho and adjacent Washington and Montana, and the following year in company with John B. Leiberger in the same region.

John B. Leiberger, was born the 7th of October, 1853 at Malmö, Skåne, Sweden, where he graduated from the Gymnasium, arrived

in America in 1868, and settled in 1880 near Lake Coeur d'Alene, Idaho. He accompanied Dr. Sandberg on his second botanical expedition to the mountains of Idaho in 1893, acted as field agent for the Botanical Division of the United State Department of Agriculture the summers of 1895 and 1896, and collected in Idaho, Washington, Nevada, and Oregon. In 1897, he became connected with the United States Geological Survey, up to 1903, and in 1905—6 carried on investigations in reference to the timber supply of the Forest Reserves of Montana, Idaho, Oregon, California and Arizona and was Forestry Inspector in the Philippines in 1904—5. The following publications are from his hand.

Contributions to the Flora of Iowa, 1870.

Contributions to the Upham's Flora of Minnesota, 1880.

General Report on a Botanical Survey of the Coeur d'Alene Mountains in Idaho, 1895.

Delphinium viridescens and *Sambucus leiosperma*, 1897.

The Bitterroot Forest Reserve, 1899.

The Priest River Forest Reserve, 1899.

Forest Conditions in the Northern Sierra Nevada, California, 1902.

Forest Conditions in the San Francisco Mountains Forest Reserve, Arizona [with T. F. Rixon and A. Dodwell].

Aven Nelson was born at Keokuk, Iowa, the 24th March, 1859, his parents being Norwegians. He received his degree of M. S. in 1890, A. M. 1892, and Ph. D. 1904. He has been professor of biology at the University of Wyoming since 1887. He is a prominent systematic and economic botanist, has made extensive collections in the Rocky Mountain region, especially in the state of Wyoming, and has built up the largest herbarium found within the Rocky Mountain states. He is one of the most prolific writers on systematic botany, and hundreds of new species have been described by him. The following are the most important of his publications:

First Report on the Flora of Wyoming, 1896.

The Worst Weeds of Wyoming, 1896.

New Plants from Wyoming, I—XV, 1898—1904.

Rocky Mountain Species of *Thermopsis*, 1898.

The Trees of Wyoming and How to Know Them, 1899.

The Western Species of *Argulus*, 1899.

New Species of *Oreocarya* and its Allies, 1899.

Some Species of *Tetraneuris* and its Allies, 1899.

Some Notes on the Flora of Yellowstone National Park, 1899.

Som Native Forage Plants on Alkali Soil, 1899.

- Some Rocky Mountain *Chrysothamni*, 1900.
 Cryptogams of Wyoming, 1900.
 Contributions from the Rocky Mountain Herbarium, I—VII, 1900—'06.
 Broom-grasses of Wyoming, 1901.
 An Analytical Key to Some of the Common Plants of the Rocky Mountain Region, 1902.
 The Genus *Hedysarum* in the Rocky Mountains, 1902.
 Native Vines in Wyoming Homes, 1902.
Psilostrophe, a Neglected Genus of Southwestern Plants, 1903.
 The Wheat-grasses of Wyoming 1903.
 Plantæ Andrewsianæ, 1904.
 New Plants from Nevada, I—II, 1904—'05.
 Plantæ montrosenses, I [together with Kennedy], 1906.

Per Axel Rydberg was born the 6th of July, 1860, in Ohd Parish, Westergötland, Sweden, and studied at the Royal Gymnasium at Skara, where he was graduated in 1881. The following year, he emigrated to America. From 1884—1893 he taught at Luther Academy, Wahoo, Neb. He received his M. A. degree at the University of Nebraska in 1895 and his Ph. D. at Columbia University, New York; in 1898; was professor of natural sciences and mathematics at Upsala College, Kennilworth, N. J., 1895—6 and 1897—9, and is since that time one of the curators of the New York Botanical Garden. In the summers of 1891—93, 1895, and 1896 he was a field agent of the United States Department of Agriculture and collected in western Nebraska, the Black Hills of South Dakota, Montana, Idaho, Wyoming and Colorado. In 1897, 1900, and 1905 he collected for the New York Botanical Garden in Montana, Colorado, California, and Utah. The list of his publications is omitted for obvious reasons.

List of Papers Published by Dr. P. A. Rydberg.*

- On the American Black Cottonwood, 1893.
 Flora of Nebraska. Part 21, Rosales, 1895.
 New species of *Physalis*, 1895.
 Flora of the Sandhills of Nebraska, 1895
 Flora of the Black Hills of South Dakota, 1896.
 The North American species of *Physalis* and related genera, 1896.
 Notes on *Potentilleae.*, I—VI, 1896—7.
 Notes on two western plants, 1897.
Antennaria dioica and its North American allies, 1897.
 Rarities from Montana, 1897.

* *Editor's Note.* This paper would be lacking in a most important particular, if the writings of its author were omitted. The editor, for that reason, takes the liberty to here insert as complete a list as he has been able to secure of the published papers of Dr. P. A. Rydberg to the present date.

Report on the grasses and forage plants of the Rocky Mountain region, (together with C. L. Shear), 1897.

A monograph of the North American Potentilleae, 1898.

The cesptose Willows of Arctic America and the Rocky Mountains, 1899.

Delphinium carolinianum and related species, 1899.

New species of the western United States, 1899.

An annotated catalogue of the Flora of Montana and the Yellowstone National Park, 1900.

What is *Prunus insititia*? 1900.

Composition of the Rocky Mountain Flora, 1900.

Studies of the Rocky Mountain Flora, I—XVII, 1900—7.

The American species of *Linnorchis* and *Piperia*, 1901.

Further notes on the *Potentilleae*, 1901.

Is the Whitefruited Strawberry of Pennsylvania a native species? 1901.

The North American Twinflowers, 1901.

The Oaks of the Continental Divide north of Mexico, 1901.

Our yellow Lady's-Slippers, 1902.

A new station of *Isotria affinis*, 1902.

Some generic segregations, 1903.

Explorations in Utah, 1905.

Penthoraceae (in the North American Flora), 1905.

Parnassiaceae (in the North American Flora), 1905.

Astragalus and segregates as represented in Colorado, 1905.

Saxifragaceae (in the North American Flora, together with J. K. Small), 1905.

Hydrangiaceae (in the North American Flora, together with J. K. Small), 1905.

Flora of Colorado, 1906.

Julius Hjalmar Flodman was born the 23rd of September in Heda Parish of Östergötland, Sweden. While he was a small boy, his father emigrated to America in 1868 and settled in Polk County, Nebraska. Flodman graduated at Augustana College, Rock Island, Ill., in 1890, and received the degree of A. M. in 1900, has been teaching at Luther Academy, Wahoo, Neb., since 1890, except one year, when he attended the University of Nebraska. He accompanied the writer on two of his botanical expeditions, viz. to western Nebraska in 1891, and Montana in 1895, and distributed sets of herbarium specimens collected on the last mentioned expedition.

Alexander Pierce Anderson was born at Red Wing, Minnesota, his parents being Swedish. He received his degree of A. M. in 1895 and of Ph. D. in 1897. He was botanist and bacteriologist at Clemson College, S. C., 1897—9, assistant professor of Botany at

the University of Minnesota, 1899—1900, biologist and entomologist at Clemson, 1900—1. He is the inventor of the famous "Puffed Rice" and other starchy products. He is now the botanist and experimental chemist of a company, which is engaged in developing his discoveries and inventions. The following systematic and economic papers are from his hand:

Diseases of Plants, 1898.

A New *Tilletia* parasitic on *Oryza sativa*, 1899.

Rice Blast and a New Smut on the Rice Plant, 1899.

Tilletia horrida Tak. on Rice Plant in South Carolina, 1902.

Dasyscypha resinaria, causing the canker growth on *Abies balsamea*, 1902.

Philip Dowell was born at Attica, Indiana, the 3rd of December 1864, his father being a Swedish-American clergyman. He received his degree of A. B. in 1885, A. M. in 1895, and Ph. D. in 1900, taught at Augustana College, Rock Island, Ill., in 1889—90; at Hope Academy, Minnesota, in 1890—1; at Upsala College, Brooklyn, 1896—7; was professor of sciences at Muhlenberg College, Allentown, Pa., in 1896—1902; was botanical assistant at the United States National Museum in 1902; and is now instructor in the New York High Schools since that year. He is a zoologist as well as botanist. The following botanical publications are from his hand:

Addition to the Flora of Staten Island, 1905.

Botanical Notes, 1906.

Distribution of Ferns on Staten Island, 1906.

North American Species of *Calceolaria*, 1906.

Observations on the Occurrence of Boott's Fern, 1906.

Elias Nelson was born in Sweden, Sept. 7th, 1876, came as a boy to America, studied at the University of Wyoming, where he took his M. A. degree in 1899. He was a pupil of Prof. A. Nelson. He has been a scientific aid in the U. S. Department of Agriculture in 1900, and assistant in Horticulture and Agrostology at the University of Wyoming in 1901—5, and is now the superintendent of the Experimental Farm at Bend, Oregon, since 1905. He has made extensive collections, especially in Wyoming and neighboring states. He has made a speciality of grasses and forage plants.

Revision of the Western North American Phloxes, 1899.

Some New Western Species, 1899.

Some new species of Wyoming Plants, 1900.

Shrubs of Wyoming, 1902.

Notes on certain species of *Antennaria* 1902.

Some Western Species of *Agropyrum*, 1902.
Native and Introduced Saltbushes, 1904.

Carl Otto Rosendahl was born the 24th of October at Spring Grove, Minnesota. His parents were Norwegians. He graduated at the University of Minnesota in 1901; was instructor in botany at the same institution, 1901—2; and took his Ph. D. at Berlin, Germany, in 1905. He has paid special attention to the flora of Minnesota. He has published the following:

An Addition to the Knowledge of the Flora of Southeastern Minnesota, 1903.
Die Nordamerikanischen *Saxifragineæ*, 1903.
Observation in Plant Distribution in the Renfrew District of Vancouver Island.

Pehr Hjalmar Olson-Seffer was born at Ekenäs, Finland, the 14th September, 1873, became instructor in Swedish at Mariehamn College in 1896 and of botany at Helsingfors College in 1896, made a journey to Australia and migrated to America in 1903. He became instructor in systematic botany at Leland Stanford University in 1903, and received his Ph. D. in 1904. In 1905, he made a journey to Central America and in 1906—7 a journey around the world, in order to study rubber-culture and tropical agriculture. His specialty is Phytogeography and Economic Botany. He was for a short time the director of La Zaculpá Botanical Station and Plantation in Chiapas, Mexico, and was lately appointed Governmental Commissioner of tropical agriculture of Mexico. He is the editor of the department of tropical agriculture in the Mexican Investos.

Mexico — Rubber Experiment Station Prospectus, 1906.

Ivar Tidestrom was born the 13th of September, 1865, in the Province of Nerike, Sweden, and came to America in 1881. From 1890—5, he was a student and assistant of Prof. E. L. Greene, at the University of California, and later at the Catholic University of Washington, D. C., where he received his Ph. B.

Notes on *Botrychium virginicum*, 1905.

Notes on the Gray Polypody, 1905.

Elysiun marianum [Ferns and Fern-allies of Maryland and Virginia].

J. Lunell was born at Kalmar, Sweden, the 30th of March 1851, received his license to practice medicine in Dakota in 1889, and is now a practicing physician at Leeds, North Dakota. He has made extensive botanical collections in Dakota and in Oregon. A few new plants discovered by him have been described by Prof.

A. Nelson. As far as the writer knows, the only botanical paper he has published is

The Genus *Alisma* in North Dakota, 1907.

O. M. Oleson was born near Drontheim Norway, where he also learned gardening. He came to America and settled at Fort Dodge, Iowa, in 1870, and two years later entered a drug store. In 1876—77 he attended the College of Pharmacy at Philadelphia, where he graduated. He has collected considerably in Iowa, and in 1904 in the Yellowstone Park and in 1906 in California. He is the Chairman of the Board of Park Commissioners of Fort Dodge, Iowa.

Flora of Webster Co., Iowa, [together with M. P. Somes] 1905.

B. Greenland and Arctic America.

Johan Alfred Björling was born in Stockholm the 19th of October, 1871. He was the botanist of two arctic expeditions, viz. one to Spitzbergen in 1890; the other to Arctic America, in 1892. While engaged in this expedition, he died on Ellesmereland (west of Greenland).

Frederic Christian Emil Børgesen. (See West Indies).

Christian Krause was born at Lillio, Korsör, Denmark, the 6th of June, 1867, received the degree of M. Sc. in 1895, and became adjunct professor at the College of Randers. He made one journey to West Greenland in 1897, and another to East Greenland in 1899—1902.

List of Phanerogams and Vascular Cryptogams found on the Coast 75°—66° 20' Lat. N. of East Greenland, 1905.

Morten Pedersen Porsild was born at Store Andst, Jylland, Denmark, in 1872, became assistant in the Botanical Museum at Copenhagen in 1895, received the degree of M. Sc. in 1900 and became director of the Arctic Botanical Station at Godhavn, Greenland, in 1905. Before that time he made two journeys to Greenland, viz. in 1893 and 1902. He has published:

Bidrag til en Skildring paa Disco, 1902.

O. Gelert was born at Nybol, Sundeved, Denmark, November 9, 1862. He took his Phar. Cand. examination in 1883, served for some time as druggist, and was later employed in a sugar-refinery.

This place he was forced to leave on account of poor health. He then received a position in the Botanical Museum at Copenhagen. Here he worked especially on the arctic collection together with Ostenfeld. Their aim was to publish an Arctic Flora. The work has been continued by Ostenfeld, and the first fascicle has been published. In 1897, Gelert made a journey to the Canary Islands. He died the 20th of March, 1899, at Copenhagen.

Notes on Arctic Plants, I [Crucifers], 1897.

Per Dusen was born at Wimmerby, Sweden, the 4th of August, 1855. He is a civil engineer by profession and has made the following journeys, mostly in the interest of botany: to Kamerum in 1890—2, Terra del Fuego in 1896—7, East Greenland (with Nathorst) in 1899, and Patagonia 1904—5. He is an amanuensis at the Museum of Rio Janeiro since 1901.

Beitrag zur Laubmoosflora Ostgrönlands und der Insel Jan Mayen, 1901.

Några viktiga växtfynd från nordöstra Grönland, 1901.

Zur Kenntniss der Gefässpflanzen Ostgrönlands, 1901.

Herman Georg Simmons was born at Dalby, Skåne, Sweden, the 16th of August 1866, became Ph. Cand. in 1892, and amanuensis at the Botanical Museum at Lund in 1893. He was the botanist of Sverdrup's expedition to Ellesmereland (west of Greenland) in 1898—1902. The following are his publications:

Preliminary Report on the Work of the Second Norwegian Polar Expedition 1903.

Flora of Ellesmereland, Part I, 190...

Carl Emil Hansen Ostenfeld was born at Randers, Denmark, August 3rd, 1873. He has been inspector of the Botanical Museum at Copenhagen since 1900. He has made as his specialty the study of the flora of arctic regions. The following publications referring to America are from his hand:

Om inslæbte Planter fra Ivigtut (Syd Grönland), 1902.

Flora Arctica, Part I, 1902.

Halophila Aschersonii [native of St. Croix], 1902.

Hugo Gustaf Adolf Dahlstedt was born at St. Lars, Östergötland, Sweden, the 8th of February, 1856, became amanuensis at the Botanical Garden at Stockholm in 1890 and at the Botanical Museum in 1892—4. He is a specialist on several Cichoriaceous genera, especially *Hieracium*. He has furnished some contributions to the knowledge of the North American Flora. He wrote

the manuscript of the genus *Hieracium* for the *Conspectus Florae Groelandicae*.

Studien über süd-und centralamerikanische Peperomien, 1900.

Studier öfver arktiska *Taraxaca*, 1905.

Arktiska och alpina arter inom formgruppen *Taraxacum ceratophorum*, 1906.

C. West Indies.

Johannes Eugenius Buelow Warming was born on Manö, Jylland, Denmark, the 3rd of November, 1841, received the degree Ph. D. in 1871, became docent at the University of Copenhagen in 1874, at Stockholm, 1882—6, and was appointed professor and director of the Botanical Garden at Copenhagen, in 1887.

He undertook in 1863 a journey to Brazil, where he remained for three years. The book published on Lagoa Santos after his return home, placed him at once as one of the leading phytogeographers of the world. In 1884 he and Theodor Holm joined the Fylla Expedition to Greenland, and in 1891 and 1892 he undertook a botanical exploration of the West Indies and South America. He was accompanied by Holger Jørgen Lassen, and Mr. Levissen, a forester, and visited Barbados, Trinidad, Venezuela, Porto Rico, and the Danish West Indies. During these travels of his he gathered extensive material and knowledge, which he used in his phytogeographical and ecological works. He drew also from the work done in the West Indies by Börgesen and Paulsen. The works that treat more or less of the North American Flora are the following:

Biologiske Optegnelser om Grönlændske Planter, 1886—'90.

Halophytstudier, 1897.

On the Vegetation of Tropical America, 1899.

Familjen *Podostemaceae*, 1881—1901.

Om nogle arktiske Væxters Biologi, 1886.

Holger Jørgen Lassen was born at Copenhagen, July 10th, 1868, and received the degree Ph. Cand. in 1887. He partook in the Greenland Expedition of 1890, and accompanied Prof. Warming on his journey to the West Indies and Venezuela in 1891—2. He died, October 3rd, 1897. He has published some smaller articles on tropical America, and besides

Momenter af Västindiens geografi.

Frederik Christian Emil Børgesen was born at Copenhagen, Jan. 1st., 1866, received his Master's degree in 1891, and became librarian of the Botanical Garden in 1900. He has made several journeys in Sweden, Denmark and Norway and has made a specialty of the fresh-water algae, especially the Desmids. He made two visits to the Danish West Indies, one in 1893, the other in 1895—6, together with O. Paulsen. Here he studied especially the marine algae. He has published the following papers:

Ferskvandsalger fra Östgrönland, 1894.

Om Vegetationen paa de dansk vestindiske Öer [with O. Paulsen], 1898.

La Vegetation des Antilles Danoises [together with O. Paulsen], 1900.

Vore vestindiske Öer, 1900.

A Contribution to the Knowledge of the Marine Algae Vegetation on the Coast of the Danish West Indies [also in Danish], 1900.

Ove Vilhelm Paulsen was born at Aarhus, Denmark, March 22nd, 1874. He made several shorter journeys in Denmark and Norway, and went with Børgesen to the West Indies in 1895—6. In 1897, he received his Master's degree and in 1898—9 he partook in the expedition to Pamir under Lieutenant Olufsen. He became assistant at the Botanical Garden in 1900. Together with Børgesen he published:

Om Vegetationen paa de Dansk-Vestindiske Öer, 1898.

Carl Emil Hansen Ostenfeld. (See under Greenland and Arctic America, page 47).

Carl Olav Ernst Hansen was born at Ölstykke, near Copenhagen, the 7th of June, 1865. He was a gardener by trade; came in 1885 to the Botanical Garden at Copenhagen; made a journey to France in 1888, where he was employed for some time at Jardin des Plantes. In 1892 he was offered to go to the West Indies and eventually take charge of an Experimental Station which was contemplated. He visited Barbadoe, Jamaica, Domingo, and St. Lucia, where he studied the botanical gardens and sugar plantations. He made collections of plants, which he sent to Copenhagen.

Mexico and Central America.

August Gustaf Eisen (See United States, page 39).

Pehr Hjalmar Olson-Seffer (See United States, page 45).

Report on
A Geological Survey of the Lands
Belonging to The New York and Texas
Land Company, Ltd., in the Upper
Rio Grande Embayment in Texas
By J. A. Udden.

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INTRODUCTORY.

The rocks which underlie the upper part of the Rio Grande Embayment, belong to the Cretaceous and the Tertiary systems. They consist of limestones, sandstones, clays and marls. In a few very limited localities dark porphyry has been injected between these stratified formations. The rocks have suffered but little disturbance. Generally speaking, we find them in the position they were originally deposited on the bottom of the ancient waters, excepting that they have been elevated toward the northwest and have sunk down toward the southeast. The general tilting in that direction amounts to about forty or fifty feet to the mile.

By the process of general erosion and land waste, these formations have been cut down so that the land now presents a quite even plain, whose surface has a general slope in the same direction as the beds dip. For the whole area this slope averages less than ten feet to the mile.

As a result of this general erosion and tilting we now find the lowermost and oldest strata exposed to the northwest and the uppermost and more recently deposited beds appear farthest south and east.

From Devil's river to the Dos Hermanos country there are exposed some 4,400 feet of strata. In the following report I shall describe these, beginning with the oldest formation, giving in full my observations on their mineral character, the surface distribution, and underground extent. (See map).

THE CRETACEOUS SEDIMENTS.

THE DEVIL'S RIVER LIMESTONE.

This name is here applied to the limestones which are found exposed on Devil's river. They include what is known in central Texas as the Edwards and the Georgetown limestones. The upper hundred feet, or less, correspond to the latter, and the lower four hundred feet are the equivalent of the greater part of the former. They are not separated by any well marked horizon of change, but merge gradually into each other.

This rock consists of mostly thick ledges of a white or gray limestone of quite pure composition. It varies from a moderately coarse grained to an almost compact and structureless texture. The ledges are mostly thick, occasionally measuring as much as ten or even twenty feet. But there are two horizons where the seams of stratification are more closely laid, and these occur at from seventy-five to a hundred and fifty feet, and again at from two hundred and twenty-five to three hundred feet below the top of the formation. This alternation of horizons of more and less enduring rock causes the bluffs on either side of Devil's river to vary in their declivity at different heights. The cliffs of the more enduring divisions are more difficult to scale and often impassable, while the slopes are less abrupt on the exposed edges of the less heavily bedded strata. In the same way we find the valley of the river more open at points where it runs over the softer beds, as above the mouth of San Pedro creek, at Pafford's crossing, below the old Newman's ranch, and again above the old Ames's ranch, while it takes on the true character of a narrow canyon when cutting on the harder ledges, as it does for several miles north of the mouth of San Pedro creek, north of Deadman's canyon and above Newman's ranch. For the same reason the roads leading down to the river from the plateaus through the arroyos from either side are least satisfactory, where these canyons lead over the heaviest limestone ledges. In fact, it is these ledges which make most of the lateral canyons impassable. In surveys 26, 27,

and 28 in block D, on both sides of Cedar creek, the difference in weathering of these several horizons is perhaps most clearly exhibited, viz:

1. The ledges in which the river is now cutting yield but slowly, and the channel is contracted and bordered by narrow, rocky and sloping benches formed by the lowermost indurated ledges. One of these was seen to contain some sand and a faint impregnation of bituminous material.

2. A slight recession of the bluffs above this level marks the presence of somewhat softer beds.

3. Then there is a shoulder in the bluff, which again consists of more heavily bedded strata.

4. These are overlain by other more rapidly disintegrating beds.

5. Uppermost the bluffs are carved into buttes consisting of the highest member in the Edwards limestone, which is quite as resistant to the destructive agencies at work as any of the lower horizons.

6. The limestone which follows above this corresponds to the Georgetown limestone. Everywhere along the river this forms the outer border of the dissected plateau. It weathers in such a manner as to leave in the thin residual soil, usually present on the surface, a number of angular boulders, which render the wagon roads exceedingly uncomfortable for travel.

This entire formation consists of limestone, but there is considerable difference in the texture of different ledges. The broad statement is true that all ledges consist of open sea sediments and that foraminiferal shells constitute a large ingredient in the calcareous material of which they are composed. Some of the lower indurated ledges near Indian creek contain these minute shells in great abundance. In the thinly bedded ledges there is more of comminuted fragments of these shells. The upper indurated ledges show a crystalline texture, typical of much of the Edwards limestone elsewhere. Certain of the ledges are more porous than the rest, and these have become the conduits of underground water, and frequently exhibit in their outcrops deeply etched surfaces. One of these ledges lies only about one hundred feet below the top of the formation. It may be seen in the banks of Evan's creek above the railroad bridge in the southeast quarter of section 19 in block A. Another such ledge remains as a porous and

decayed stratum which may be seen in the banks of Indian creek near its mouth. Above Ames's ranch another porous stratum forms the exit of a large number of springs known as the Cold springs. This stratum lies about 400 feet below the top of the formation, and it is the most important water bearing horizon in the formation.

Mineral Occurrences.

Mineral occurrences in these limestones are nowhere of much consequence and not frequent. Calcite is occasionally found in veins and cavernous pockets. The latter vary in size from a few inches to considerable masses, which are apparently associated with springs and ancient caverns. Several small veins were noted on survey 24, near the springs in the base of the cliff on the east side of Devil's river, about two miles east of the mouth of Satan's creek. It consists of columnar calcite crystals and averages about three inches in thickness. Another occurrence was noted just north of the Twin Water holes, about half a mile west of the centre of survey 33, in block A. The north bluff of Evans creek at this place exhibits a synclinal fold which is clearly due to settling of the overlying strata, consisting of the Buda limestone, into a cavernous hollow below. In the limestone on the slope of this bluff there was a vein of calcite not exceeding six inches in thickness. Its course is from east to west. The limestone corresponds to the Georgetown, and it is overlain by the Del Rio clay. Along the contact of these two formations pocket-like aggregates of calcite lie in the limestone, and these are stained by infiltrated ferruginous materials. An analysis of several samples disclosed no trace of any valuable ore.

In the lower hundred feet of the formation we find siliceous material gathered into concretionary lenses and sheets, as chert and flint. There are at least two horizons of chert exposed in the canyon above Pafford's crossing. These occur in the lowermost indurated ledges. On survey 80 in block D cherty seams lie about forty feet above the river in the east foot of the bluff. This ledge was seen at intervals for several miles to the north. Along the wagon road leading down to the river in survey 15 in block B, two cherty seams were noted. One of these consisted of concretions of somewhat irregular form. This lies only a few feet above the

water in the river. The other lies seventy feet above this and consists of lenses of more regular form, and these also run into continuous layers. Seams and geodes of quartz which is not cherty, but of crystalline structure, were also noted in these ledges. One such seam was followed for nearly a mile. This quartz is associated with calcite, some of which has a dark amber color. This has led to some desultory prospecting below Cedar creek in block D.

The siliceous segregations are characteristic of the Edwards limestone almost everywhere in Texas, and the chert is often found in greater abundance than is the case on Devil's river. It cannot be regarded as indicating mineralization of any consequence.

Frequently the ledges of the Devil's river limestone are bituminous. When crushed they emit an oily odor. In the dry bed of Pafford creek in survey 68, Block 1, about a quarter of a mile west of the river, I found one such ledge which contains small geodes filled with black and hard asphalt. These geodes have originally been empty cavities in the rock, and crystals of calcite have been formed on their walls before the filling of bitumen accumulated. This appears to have oozed in from the surrounding rock. Some of the geodes are still empty and only the calcite is present. The asphalt is quite scarce. The geodes vary in size from one to two inches in diameter, and one seldom finds more than two or three on a square rod of exposed surface. Nothing was seen suggesting bituminous accumulations in any valuable quantity.

Distribution.

The Devil's river limestone is exposed along the entire distance of the river from Camp Hudson down to the Rio Grande. North of Deadman's creek the overlying beds have been cut away by erosion on both sides of the river to beyond the limits of the New York and Texas Land Company's surveys, but south of this, owing to a low dip to the south, this limestone is less extensively bared and forms the surface rock for only two or three miles away from the river, or even less. In the region of Del Rio the formation disappears under higher beds, as we follow the river. The south border of its area of outcrop here turns to the east. In this direction it runs a sinuous course for fifty miles and more, following in a general way the north limit of the New York and Texas Land Company's surveys to the east of Turkey mountain.

North of this line the Devil's river limestone rises to form a hilly plateau, and southward it descends under later sediments which form a gradually increasing thickness of cover in that direction. That it extends far out to the south and east under the other formations there can be no doubt. It is not likely to change much in a hundred miles, for it consists of sediments formed in an open sea, whose nearest known shore was far to the north.

THE DEL RIO CLAY.

Above the Devil's river limestone there is a clay known as the Del Rio clay. It varies from forty to 150 feet in thickness, and averages probably 100 feet. In a conspicuous hill south of Del Rio, and in the bluff which runs in a northeast-southwest direction to the southeast of this town, several exposures occur, from which the nature of this clay was made out. The upper half consists of yellow clay, which is usually calcareous and which contains thin layers of calcareous material and sandstone. In these flags two fossils are invariably present and render this part of the clay always easy of identification, *Exogyra arietina* and *Nodosaria texana*. These are equally abundant in other places, from Comstock to Turkey mountain. Some fifty or sixty feet below the top of the clay at Del Rio it contains seams which are more or less impregnated with feruginous material, and the clay itself is of a dark brown or red color, which is due to the presence of hematite. The lower half of the formation is usually of a dark greenish-gray color.

Mineral Occurrences.

Gypsum and marcasite were both observed as occasional minerals in this clay. The latter has usually been changed to hematite, which often occurs in pseudomorphs having the cubic forms of the original mineral. This is the case in block "A" and 12 on Devil's river, where some prospectors have mistaken this mineral for galena (sulphide of lead), which has the same crystalline form.

East of Del Rio hematite occurs as a heavy infiltration in certain layers which are best exposed in the hills about one third of a mile south from the north corner of survey 604 of the G. H. & H. Railroad Company. About ten feet of the clays have been

exposed by an excavation, and here they are seen to be heavily charged with amorphous oxide of iron. Farther to the southwest a seam of practically pure hematite was noted, measuring from one to four inches in thickness. This was seen to extend for nearly a hundred feet in a recently cut gully. From a general examination of the vicinity it was, however, evident that this deposit is local, the ferruginous character of the clay diminishing in both directions from this place along the exposed outcrop of the Del Rio formation in this bluff. This red clay will make an excellent puddling clay.

Variations in Thickness.

On Deadman's creek, about five or six miles above its mouth, the Del Rio clay is absent and the Buda limestone directly overlies the Devil's river limestone. In the country about two miles to the east-southeast of California ranch it measures only thirty feet in thickness. From this point it increases southward to eighty feet near the centre in survey 20 in block A. Southeast of Del Rio it reaches its maximum thickness, which is probably not much short of two hundred feet. In the region of Turkey mountain it averages ninety feet. In general it increases in thickness southwards.

Geographical Distribution.

Consisting of clay, this formation yields very readily to erosion and has been promptly washed away, except where it is covered by the overlying Buda limestone. Under the edges of this limestone it everywhere forms the slopes and bluffs that limit the level and less elevated flats, from which the clay has been wholly or partly removed. In this way have been formed nearly all of the bluffs which follow on either side of the arroyos in block 1, and in block A west of Devil's river. Most of the tributaries of Evan's creek have cut through the Buda limestone cover, and their course is marked by broad valleys, washed out in the Del Rio clay. The wagon roads in the region usually follow these flats, which are comparatively even and free from rocks. In the south half of Block 12 the bluff which parallels the river about a mile to the east is of the same nature. This bluff follows San Pedro creek eight miles, then it swings around to the south side and returns

to within less than two miles of the Del Rio road, where it turns first to the south and then to the east, following more or less closely to the north boundary of block 4.

The low lands on the north side of this block are mostly underlaid by this formation. In block 5 only the larger streams, the two branches of the Sycamore, have cut through the limestone cover into the clay, but in block 11 the formations have been lifted a little higher and erosion has laid bare the Devil's river limestone everywhere in the north tier of sections, and in block 10, while extensive low flats mark the outcrop of the clay south of this for a varying distance of from one to three miles. Following these flats to the east we find them turning southeast toward Pinto mountain and then east along Pinto creek, until we reach the head of Grass valley. From here the outcrop of the Del Rio clay runs nearly south for about five miles and then east, making a short detour to the south around Turkey mountain.

Relation of the Del Rio Clay to Water Supply.

This clay is practically impervious to water. We therefore find water accumulating under it as well as above it. On the belt of lowlands just described, and for two or three miles south of them, many wells draw water from the limestones underneath this formation, the best water-bearing ledges being reached about a hundred feet below its base. These are exposed to view in the bed of Evans creek, in survey 19 in block A, west of Devils river. All the large springs of this region, such as the Cienega spring northwest of Del Rio, the San Pedro spring, the Las Moros springs, and even the Brackett spring, are evidently overflows over or near the north margin of this clay, which limits the deep underground seepage under the country to the south, and has caused the ground waters to flow over or to find outlets and establish open passages through the less well protected margin of this confining cover.

Accumulation of water on the upper surface of the clay has resulted in the making of a number of waterholes on the belt of flat lands over its area of outcrop. Such are the Javelin waterhole in survey 16 in block 11, and many other less important ones, more or less permanent.

THE BUDA LIMESTONE.

This name is applied to a limestone which extends from the central part of the state several hundred miles westward. It overlies the Del Rio clay. In its exposures this limestone sometimes resembles the Devil's river limestone. It lies in ledges from six inches to several feet in thickness and often weathers into steep bluffs, the ledges breaking off as the underlying clay is washed away. But it is different from all other limestones in this region in having a uniformly fine and compact texture. In composition it is a comparatively pure carbonate of lime, free from any considerable clayey ingredient. Its compactness prevents vegetation from gaining a foothold on its slopes, and in the Devils river region its contact with the overlying formation is frequently marked by a sharply defined horizontal line, above which the hillsides are nearly covered by verdure, while below it the bleak white surface of this limestone appears. The same physical peculiarity has prevented the ground water from penetrating this rock. Only in a few places have porous features developed. The most marked change in this respect was noted along the canal which has recently been cut south of Del Rio, where this rock has become known as the "rotten limestone", from the fact that it is traversed by numerous porous streaks and has in places acquired a yellow and rusty tinge.

The thickness of the Buda limestone varies but little. Where not effected by erosion it probably never runs short of fifty feet, nor much exceeds a hundred feet. Usually it measures from seventy to eighty feet.

Location of Outcrops.

On the south side of the lands underlaid by the Del Rio clay the Buda limestone is everywhere present and almost invariably exposed, usually forming a slope or bluff. It forms a narrow belt seldom more than two or three hundred yards wide. In crossing the arroyos this belt often makes long detours to the south, sometimes following the valleys for several miles on either side. In blocks 4 and 5 and in the west half of block 11 it forms the bed rock over quite extensive areas, and its outline on a map would be very sinuous, owing to the fact that the south dip of the

terranes is very low and in places even reversed. Mapping this region was out of question, except in a general way.

Possible Economic Importance.

The fine texture of the Buda rock would adapt it for use as lithographic stone were it not for the presence of occasional grains and streaks of calcite and numerous barely visible joints or incipient fractures which were seen to affect all the material examined. The joints would without doubt disappear some distance within the rock, if a quarry were opened in a suitable place, and it may be that the calcite grains do not exist in all the ledges, although no such ledges were observed in this survey.

The purity of the limestone makes it a suitable material for the manufacture of Portland cement. For this purpose similar limestones are mixed with a certain quantity of clay, and for this use the underlying Del Rio clay would answer very well. The limestone would be easy enough to grind, as it is rather less tough than the majority of rocks of similar kinds. Economic conditions limit profitable enterprises of this kind to localities where the raw materials occur in the immediate vicinity of transportation facilities, and such locations might readily be found along the Southern Pacific railroad just east of Del Rio, or between Devil's river and Comstock.

THE EAGLE FORD BEDS.

This formation, which takes its name from a locality in North Texas, overlies the Buda limestone. Its lower contact with the Buda limestone is invariably sharply marked, as already noted, but upward it very gradually and quite imperceptibly acquires the character of the overlying chalky limestone. For this reason no definite depth can be assigned to it, except when taken with this upper member. For practical purposes we may regard it as measuring 250 feet. Westward it exceeds this figure.

The main part of the Eagle Ford beds in this region consists of ledges of cream-colored limestone, measuring from a few inches to a foot in thickness. This limestone is not pure, but contains a varying amount of fine sand, which usually appears as bands of yellowish or light brown color on vertical fractures. The entire formation is somewhat regularly thin-bedded. The lower hun-

dred feet frequently include beds of marly shale and clay, in which a most perfect lamination appears. These may be greenish blue in color or dark gray or rusty red. At times they are black, from bituminous or carbonaceous materials, or there may be thin and flaggy straight layers of alternating lighter and darker color. The upper half of the formation is usually free from clayey layers, its stratification is more uniform and the ledges contain a less amount of the fine sand. The rock becomes somewhat softer and is more frequently white. In weathering, the Eagle Ford beds invariably break into long quadrangular blocks, whose length may ten times exceed their width or thickness, and whose square edges have a tendency to weather to acute angles. Ferruginous material is present in varying quantity. The lower strata are sometimes stained bright red by oxide of iron, while in the higher strata the same substance is present in clusters of cubic crystals which originally were pyrite. These vary in size from one eighth of an inch to three inches in diameter.

Geographic Distribution of Outcrops.

The silicious and ferruginous ingredients in the Eagle Ford beds render them somewhat more resistant to weathering than most of the Cretaceous rocks in the Rio Grande embayment, and we therefore often find them on the divides forming the highest ground in the uplands. In the Devil's river country they have mostly been worn away, but remnants of the basal part cap many of the hills in the divides between the upper branches of Deadman's creek, Evans creek, and Barranco Blanco creek and also on the plateau north and east of California creek. In this region the ferruginous material is quite abundant and the rock is often of a bright red color. East of Del Rio some patches were noted in block 4. In block 5 it is everywhere present on the uplands. In the south half of block 3 and in the north half of block 2 it forms most of the high divides. From the south half of block 11 the area of outcrop of this rock turns southeastward and passes a broad belt between Pinto mountain and Brackett, surrounding Elm mountain and extending on the south side of Turkey mountain into Uvalde county.

Bituminous Contents.

In the lower part of this formation the shaly ledges are occasionally impregnated with bitumen and oil. I find that some

black shale which is exposed in the south bank of Sycamore creek in block 2 and farther down in this stream, contain from four to nine per cent. of their weight of bituminous material. About two and one half mile north of Comstock, several feet of bituminous shale have been found in a well, and some of the pieces taken out contain nearly fifteen per cent, of bitumen. This is sufficient to support a flame when the shale is thrown in fire, and this shale as well as the darkest shale on Sycamore creek is sometimes locally spoken of as coal. When burned, even the best I found, leaves a residue of no less than eighty-five per cent of ashes. Oil which is reported to have been found in some well near Johnston siding evidently comes from this horizon. In a well made by Mr. Lester-jette near the northwest corner on survey 1 in block 9 at the west end of Anacacho mountain, these dark shales were penetrated at a depth of 810 feet. The samples taken at the time are still preserved and are found to be slightly bituminous. The drillers likewise reported a show of oil in the well at this depth.

The basal part of the Eagle Ford beds almost always contain a small amount of bitumen. In the calcareous ledges there is enough to cause the rock to emit an oily odor when it is thoroughly crushed. This is true for the entire state of Texas and beyond, north as well as south. But the formation has a compact texture. It is a rock with little porous space, and it can not be expected to yield any considerable flow of oil or gas. The small quantities of oil which have been discovered from these shales are heavy paraffine oils of high value as lubricators. Should any highly charged black shales be found, they might perhaps be profitably distilled for such oil.

THE AUSTIN CHALK.

The Austin chalk is named from the city of Austin, where it is frequently exposed in the streets east of Shoal creek. With the other formations already described it extends as a continuous belt almost across the state. It consists of white soft limestone, usually in ledges varying from six inches to two, or at times several feet in thickness. The rock is more indurated and stony than true chalk, but it consists of the same material, being composed of foraminiferal ooze. In its lower part there is a zone of heavy beds, which furnishes good building stone. This is

quarried on Pinto creek at the crossing of the Southern Pacific railroad, and also at Fort Clark in the west bank of Las Moras creek. The limestone ledges are quite often separated by seams of greenish gray clay, measuring from a fraction of an inch to two or three feet. Upward these clayey strata increase in thickness, and the formation terminates with alternations of clays and strata of limestone.

Area of Outcrop.

The outcrop of the Austin chalk covers a comparatively wide belt of land, which extends from the Rio Grande below the mouth of Sycamore creek and eastward into Uvalde county.

We find this formation on both sides of Pinto creek from the southwest boundary of the company's lands to north of the Southern Pacific railroad. It is the bed-rock underlying most of the lands drained by Cow creek and Tequesquite creek and extends to the east of Las Moras creek. It covers the south half of the Meliton Valdez grant, nearly all of the Dolores Soto De Reales grant, and all the land between Brackett and Spofford Junction. From here the area of this formation continues eastward with decreasing width north of the Anacacho mountains.

The upper hundred and thirty feet of the Austin chalk consist of a series of alternations of white limestone ledges with strata of clays and marls. These make a transition to the overlying formation, which consists of clays and marls exclusively. They were seen on Tequesquite creek, from its mouth to a mile and a half above this, and also on Las Moras creek, in its lower course. They are also exposed at a point a mile and a half northeast of Spofford Junction, in Lindsay creek, and at several points on both sides of the railroad bridge across Elm creek at the west end of the Anacacho mountains. I here append a section of these beds as they were measured on Tequesquite creek.

SECTION OF THE UPPER PART OF THE AUSTIN CHALK ON TEQUESQUITE CREEK.

	Thickness in feet.
7. Limestone.....	7
6. Shale.....	17
5. Thin ledges of limestone with some seams of shale.....	6
4. Stony marl with bands of limestone containing Gryphaea aucella.....	13

3. Clay and marl with occasional grains of glauconite and with bands of limestone, containing *Ostrea diluviana*, *Exogyra ponderosa* and other fossils.....22
2. Shaly chalk with some ledges of chalky limestone.....38
1. Hard chalky limestone with thin seams of marly clay.....20

Thickness of the Austin Chalk.

This formation measures not far from 750 feet along the Rio Grande. North of the Anacacho it is somewhat less than this. But as the division between the Eagle Ford beds and the Austin chalk is not well marked the combined measurement of these two formations may be more accurately given, and this is about 1050 feet. In the country north of the Anacacho mountains they measure about 950 feet.

THE UPSON CLAY.

The Upson clay is a deposit which takes its name from the old Upson postoffice in Maverick county.* It is the equivalent of the Taylor marls of the central part of the state. Where weathered and leached, as it usually is, it has a yellow color. When freshly exposed, it is dark gray or greenish gray. In many places it carries small flakes and crystals of gypsum and thin horizontal seams of this mineral. Crystals of barite were also found. Its characteristic fossils in this region are *Exogyra ponderosa* and *Ostrea larva*, the latter having been noted only in the upper part of the deposit, where it occurs in some sandy layers which were seen on Elm creek and on Imperialist creek, from two to four miles north of Paloma.

Distribution.

The country underlain by this clay is quite extensive. It comprises all of those flat lands which extend southwest, south, and southeast from Spofford. This includes most of the land drained by Canyon Grande, Hackberry creek, Cow creek, and Imperialist creek, west of the Eagle Pass branch of the Southern Pacific railroad. East of this road it includes all of the Snow Tank pasture, and the north half of the Jarita pasture and the west part of the Gilbeau pasture. East of Spofford it is seen in Lindsay creek as far north as to survey 18 in block 8 and in Elm creek to within a mile of the Southern Pacific railroad. From

* This name was first used by E. T. Dumble, Director of the Texas Geol. Survey.

here it is continued as a narrow belt under the north cliff of the Anacacho mountains.

Physical Properties.

These clays weather rapidly and their detritus is promptly carried away by erosion. As a result we find the lands they underlie, flat and low and with a fine and fertile soil. The draining streams have cut wide and open valleys. Their channels have in several places been gouged out by the freshets to hollows which are deep enough to hold water the year around. They are quite as impervious to water as is the Del Rio clay and afford everywhere suitable ground for the construction of tanks. On the other hand these clays yield no water in wells. The streaks of sand which they contain, are of small extent, and at best give only a small amount of seep water.

Thickness.

Owing to the scarcity of outcrops and fossils the thickness of the Upson clay can only be made out from the general dip of the formations and from well records. The mantle of soil is thin, but covers the formation everywhere, except at a few points in the arroyos, and one may travel for miles without seeing anything below this mantle. Fossils are likewise scarce and no attempt could be made to combine the exposures seen into a single section. Of the thickness of this formation I can hence only make an estimate based on the general dip of the bed rock for this region, which appears not to exceed seventy feet per mile along the Rio Grande. As the width of the belt of outcrop is about seven miles, this indicates a thickness of nearly 500 feet. In block 7 several wells have been bored in this clay, but the records are not of such a nature that it is clear whether they have gone through the formation or not. It is evident, nevertheless that there are some four or five hundred feet of clay in the country south and east of Spofford.

At all events the thickness of the Upson clay is not the same for different parts of this region. Approaching the Anacacho mountains it thins rapidly. Its upper part is here replaced by the Anacacho limestone and only the basal part continues as a rapidly eroding stratum in the foot of the Anacacho escarpment for a limited distance.

THE ANACACHO LIMESTONE.

This is the heavy-bedded yellow rock, which forms the Anacacho mountains. It consists of strong ledges of limestone, whose combined thickness measures about 400 feet. The rock is fragmental. It consists of broken particles of shells and plates and spines of various organisms, such as molluscs, sea urchins, and corals, and with these are mingled entire small tests of foraminifers. It may be called an organic sandstone, with some grains that consist of minute entire tests of marine organisms. The rock has been consolidated by the solution and introduction of carbonate of lime as a cementing material. It must be regarded as the material of a submerged bar, formed in the sea not far from a shore. The material is well sorted and washed, but not much worn. In many places the ledges exhibit a cross bedded structure. This is especially frequent in the west end of the Anacacho mountains, as in the west branch of Elm creek at a point about one and one fourth mile southwest of the Anacacho bench mark of the U. S. Topographic Survey, where the following section is seen in a nearly vertical wall of the limestone.

	Thickness in feet.
4. Heavy ledges of cross-bedded fragmental limestone.....	34
3. Thin-bedded limestone.....	9
2. Single ledge of solid limestone.....	8
1. Thin-bedded fragmental limestone.....	2

Equivalence.

The sudden thinning out of the Upson clay against the west margin of the Anacacho limestone and its entire disappearance under its formation farther east, shows that this limestone began to be formed in the region of the Anacacho mountains before the making of the Upson clay had come to an end farther westward. We must hence conclude that the two are at least in part of the same age. Stratigraphic relations indicate that the making of the Anacacho limestone continued for some time after the Upson clay had all been deposited and that the former is the equivalent not only of the later, but also of a part of the Eagle Pass formation, presently to be described.

Thickness and Distribution.

The resistance of the Anacacho limestone to erosion has caused it to remain as a capping of a plateau or low mountain,

while the soft clays and less durable limestone all around it have been washed away more rapidly and reduced to lower land. The Anacacho mountains are wholly due to this difference in resistance to destructive forces. The thickness of the formation is 300 feet in the west end of the mountains and about 400 feet in the east end. With the other rocks it is tilted to the south, about ninety feet to the mile. The steepness of the slopes on the north side of the mountains is due to the comparatively rapid removal of the underlying clays. The limestone, being more resistant, remains until its foundation is removed. The southward slope of the top of the mountain is due to the dip in that direction and in block 9 the limestone disappears under an overlying clay. In wells which have been drilled on this clay the limestone has been encountered at depths increasing with the distance from the mountain. The southernmost exposure noted was about a fourth of a mile northwest of the southeast corner of Kinney county. From this point and from the east end of the Anacacho mountains this limestone constitutes the bed rock as far east as to Turkey creek and beyond this. But in this eastern region it lies more nearly horizontal.

Asphalt.

The deposit of asphalt which has been worked at Carbonville, three miles south of Cline in Uvalde county, occurs in the lower part of the Anacacho limestone. I find, however, that the ledges which carry the asphalt are of a more coarse texture on Turkey creek than they are farther west. Near the asphalt deposits they have also been affected by volcanic agencies that probably were instrumental in rendering those agents effective, which brought about the concentration of the asphalt at this point. The only evidence of local disturbance noted in the region of the Anacacho mountains which may be due to a concealed igneous intrusion is a small, but somewhat abrupt upward fold, now marked by a valley, at a point three and one half miles south and three miles west of U. S. bench mark Cline. In the country where the asphalt occurs chert is frequently observed as an accompanying mineral. No such chert was observed in the Anacacho mountains. While all of this indicates dissimilarity of physical conditions, the presence or absence of asphalt in the lower ledges of these limestones, where these are not exposed, can only be determined by direct

exploration. But indications do not warrant drilling for this exclusive purpose. It would seem wise to closely watch any drillings which may penetrate this limestone, as in block 9 and in the north part of block 1 and block 3 in Maverick and Zavalla counties.

THE EAGLE PASS FORMATION.

Like all the sediments previously described, the Upson clays, when followed southward, disappear under later deposits. The sediment overlying the Upson clay have been called the Eagle Pass formation. This consists of a series of clays, marls, sandstones and limestones, which include the coal now mined north of Eagle Pass. The Eagle Pass formation presents two phases. East of Chacon creek it is much thinner than west of this stream, and contains but a few ledges of sandstone, while to the west and south of a line nearly coinciding with the course of this stream the formation is much thicker and sandstones and coal beds have a greater development. Three fairly well marked divisions have been made out along the Rio Grande, but these merge as we approach the Chacon. Clearly the belt which separates these two phases was a line which marked some geographical limit in the Cretaceous sea, already at the time when the underlying Upson clay and the Anacacho limestone were being formed. The country which is east of the Chacon must have been in a part of the sea where sediments were less copious than to the west. It was farther out in the sea than the region to the west, for here we find more sandy deposits and also coal seams which are derived from the vegetation near the adjacent land.

It will be convenient to describe separately the clayey sediments to the east. On the Nueces these are known as the Pulliam formation from their exposures near the Pulliam ranch. Beginning below, the three divisions of the Eagle Pass Formation west of Chacon creek are: 1) The San Miguel beds, 1) the Coal series, and 3) the Escondido beds.*

The San Miguel Beds.

In the bluffs on the south side of Hackberry creek in surveys 70, 70½, and 71½ in block 4, the lowermost ledges of sandstone of these beds cap the Upson clays. These sandstones are

* Designation first given by E. T. Dumble.

mostly composed of siliceous material, but they contain occasional ledges consisting of organic fragments. In this respect the formation resembles the Anacacho limestone, to a part of which these beds clearly are equivalent. Green grains of glauconite are also present.

But the best exposures of these beds occur in the bluffs of the Rio Grande all the way from two to six miles below the mouth of Hackberry creek, also called Canyon Chiquito. The sandstones are interbedded with clays or shales. These shales increase in thickness and frequency in the upper parts of the beds, which are exposed farther down the river. A section of the lower part of the beds seen in the river bluff near the old village of San Miguel is as below:

Sandstone.....	8 feet.
Clay.....	5 "
Sandstone.....	7 "
Clay.....	9 "
Calcareous sandstone.....	8 "
Clay.....	10 "
Soft sandstone.....	18 "
Clay, only partly seen.....	7 "

These same ledges were again seen near the old Stone ranch northwest of Paloma, and on survey 86 in block 7 northeast of Paloma. From the last place their outcrop was traced in a northeast direction for four miles, but beyond this they could not be identified.

Near Paloma a ledge of sandy limestone runs parallel with the outcrops just described, at a distance of a mile to the south of there. About 100 feet of clay separates these two ledges. The upper Paloma ledge is overlain by another heavy bed of clay and above this there is more sandstone, which is soft and friable and of a dark rusty brown color. On Elm creek the thickness of the San Miguel beds does not much exceed 400 feet. From the log of a boring which was made near Eagle Pass many years ago and which penetrated to the shales below these beds,* it is clear that the upper part of these beds consists of clays which measure some 250 feet. These might perhaps as well be classified with the overlying coal series.

* Thomas W. Vaughan, Bull. 164, U. S. Geol. Surv., p. 24.

The Coal Series.

These are the deposits which immediately overlie the San Miguel beds on lower Olmos creek and at Eagle Pass. The series consists of clays, shales and sandstones, with seams of coal and fireclay. One of the coal seams is thick enough to be profitably mined.

A continuous section of the coal series was made from the exposures in the country around Eagle Pass, and this measures 357 feet. This section is as below:

Section of the Coal Series.

	Thickness in feet.
20. Sandstone, tough and calcareous above and softer and more siliceous below. (A part of the basal sandstone of the overlying Escondido beds.).....	15
19. Shaly clay.....	40
18. Clay with yellow or dark concretions of carbonate of lime and of iron, measuring from a few inches to three feet in diameter, and having internal fissures filled with dark calcite...	1
17. Clay, sandy below and with a dark carbonaceous seam about 12 feet below top.....	32
16. Yellow and gray clay.....	3
15. Laminated soft sandstone.....	1½
14. Coaly shale.....	1½
13. Sandy fire clay.....	1½
12. Impure coal.....	½
11. Fireclay.....	2
10. Coaly clay.....	1
9. Laminated sandstone.....	3
8. Dark gray clay.....	1
7. Laminated soft sandstone.....	3
6. Coaly clay.....	2
5. Clay, dark above and sandy in lower part.....	33
4. Sandstone, in places cross-bedded, with occasional seams of conglomerate of small pebbles, slightly micaceous along some seams, in its upper part containing silicified trunks of trees.....	40
3. Clay, with seams of sandstone and occasional seams of coal.....	160
2. Coal.....	6
1. Fireclay and sandstone.....	15

Numbers 1, 2 and 3 are not exposed in a continuous section but were penetrated in such a section by an exploration shaft not

far from the Olmos creek mines. Other explorations show that this part of the section is variable. Numbers 4 to 16 inclusive outcrop in the hills to the north of Eagle Pass on the west side of the railroad, and numbers 17 to 20 were measured and traced for several miles in the bluffs east of the railroad. Number 20 caps the bluffs east of Eagle Pass.

Thickness.

No fast limits can be assigned to the three divisions of the Eagle Pass formation. If we designate the lowest sandstone in the above section (number 1) as the basal member of the coal series and the uppermost clay (number 19) as its highest part, we find that the total thickness is 372 feet.

Distribution.

The coal series are exposed in the valley of the Rio Grande from some five miles below Eagle Pass to about three miles north of the mouth of Olmos creek. The area of their outcrop forms a belt about four miles wide, which follows the Olmos valley from the points indicated on the river to about three miles north of Olmos station (Thompson's ranch). Beyond this the belt turns to the east around Chapotal hill and then to the southeast. The sandstones of the Eagle Pass formation are seen in Olmos Grande, Olmos Chiquito and in Chapotal creek. Again this belt turns east and then northeast and north, as appears from exposures of soft sandstones, carbonaceous clays, ferruginous concretionary materials, and silicified wood, such as characterize these sediments north of Eagle Pass. Materials of this kind are met with on Surveys 209, 186, 177, 178, 155 and 145 in block 7. Beyond this the coal series has not been identified. Its sediments are in all probability reduced in thickness farther east and go to make up a part of the as yet unclassified complex presently to be described as the Pulliam formation.

The Eagle Pass Coal.

Thin seams of coal, measuring a few inches in thickness, have already been noted in the sections of the Coal series. But neither well records nor outcrops have so far shown more than one work-

able seam, and this is the seam which is now worked by the mines on both sides of the Rio Grande. The vein is exposed in the bluffs of the Rio Grande north of Olmos creek, and also in the bed of this creek north of the mines.

This coal was carefully examined and measured at four points in order to make out whether there was any successive change in its nature, from which an inference might be made as to its nature under the country lying to the east of Eagle Pass. The measurements were made in Shaft number 4 in the Fuentes mine, Mexico, in the Dolch mine and in two pits on survey 166 in block 17, and are as below:

1.

A SECTION OF THE COAL IN SHAFT NUMBER 4, FUENTES, MEXICO.

	Thickness in inches.
9. Cap rock, shale and sandstone.....	-
8. Bone coal.....	6
7. Impure coal.....	6
6. Good coal, containing occasional small lentils of bone coal.....	30
5. Mixture of fireclay and bone coal.....	3
4. Good coal.....	14
3. Shaly fire clay.....	30
2. Coal.....	6
1. Fire clay.....	-

2.

A SECTION OF THE COAL IN THE DOLCH MINE, NORTH OF EAGLE PASS.

	Thickness in inches.
8. Cap rock, dark shale.....	-
7. Coal of good quality.....	22
6. Bone coal.....	5
5. Fire clay.....	1½
4. Coal.....	24
3. Fire clay.....	20
2. Coal.....	6
1. Fire clay.....	-

3.

SECTION OF THE EAGLE PASS COAL IN A PIT ON THE EAST BANK OF OLMOS CREEK
NEAR THE WEST LINE OF SURVEY 166, BLOCK 7.

	Thickness in inches.
11. Cap rock, gray sandy shale.....	-
10. Bone coal.....	9
9. Bony shale with pockets of coal.....	12

8. Good coal, slightly weathered.....	14
7. Bone coal.....	3
6. Fair coal, with some half inch lenses of fireclay.....	14½
5. Clayey bone coal.....	3
4. Fire clay, dark and slightly bituminous, with white seams above.....	48
3. Bone coal.....	2
2. Fair coal, becoming bone coal above.....	13
1. Fire clay.....	2

4.

SECTION OF THE EAGLE PASS COAL IN THE EAST BANK OF OLMOS CREEK, ONE HALF MILE NORTH FROM THE SOUTH LINE OF SURVEY 166, BLOCK 7.

	Thickness in inches.
17. Cap rock, gray shale.....	--
16. Coaly shale.....	2
15. Fair coal, weathered.....	6
14. Fire clay.....	½
13. Black fair coal.....	1
12. Impure brown coal.....	6
11. Bone coal.....	4
10. Fair coal, slightly weathered.....	14½
9. Fire clay.....	½
8. Fair coal.....	6½
7. Fire clay, light above, dark below.....	40½
6. Very good coal.....	3
5. Fire clay.....	2
4. Fair coal.....	13
3. Fire clay.....	3
2. Fair coal with some streaks of bony coal.....	7
1. Fire clay.....	2½

The points where these sections were taken lie in the line of the strike of the coal seam, extending from the northeast to southwest a distance of ten miles. It will be seen that in two respects there is a gradual change in the coal to the northeast. The vein is split up into progressively more and smaller parts. The total thickness of the coal does not perceptibly decrease to the northeast, for there is at Fuentes fifty-six inches, in the lower pit forty-one inches, but again in the upper pit fifty-four inches. Along with the splitting of the vein there is a decrease in the degree of purity of the coal (See plate 2). Irrespective of the weathering of the coal exposed in the upper pit, most of the coal was slightly impure from the presence of original clayey sediments. The significance of these changes is clear. The northern exposures are

nearer to the margin of the basin in which the coal was made. But we have no knowledge of the shape of the original basin. There may have been irregularities in its outlines and areas may exist in its marginal region where the vein is better. Rapid changes of this kind are indicated by the differences in the sections of the two pits made on the Olmos creek. There can be no doubt that the vein is workable in many places in block 16 and also in the surveys adjoining survey 166 in block 7. Changes in the seams are characteristic of the outer margin of most coal basins.

The eastward extent of the coal beyond this can only be determined by drilling, as exposures in that direction show only the presence of the sediments which contain the coal. If prospect holes were made near the tank on survey 193 in block 7, and near the centre of survey 145 in the same block, and if no workable coal were found within 400 feet of the surface at these points, the question would be settled. Eastward from the latter point the sediments change to such a degree that it is not likely any considerable veins of coal exist. The limits of the coal basin does not extend farther than this. The sea was apparently too open for the accumulation of vegetable material in that direction.

The Escondido beds.

This name has been applied to all of the sediments of the Eagle Pass epoch overlying the coal series and beginning below with the ledges which cap the bluffs a half mile east of Eagle Pass. The thickness of these beds on the Texas side of the Rio Grande is about 800 feet. They consist mainly of clays and marls of dark color, interbedded with more or less extensive strata of sandstone, limestone, and layers of oyster shells. The area where this division of the Eagle Pass formation is exposed may be roughly indicated as being the country east from Eagle Pass, nearly reaching to Zavalla county and southeast as far as to Comanche creek and a little beyond the north limit of the Antonio Rivas grant.

An examination of the country shows that the sandy and calcareous stony ledges are arranged in essentially three groups: 1) the basal sands, 2) the middle sands and 3) the upper sands, and that each of these is overlain by more or less persistently developed clay deposits, which may respectively be designated as the lower, the middle, and the upper clay. It is also evident that this group-

ing of the different rocks is not equally marked everywhere. Ledges of sandstone occur in the clays wholly isolated from other sandstones, and clay beds are nearly always present between the sandy and the calcareous strata. The oyster shell breccias are especially irregular in their behaviour and occur in association both with the clays and with the sands. They are also more apt to run out and to undergo more rapid changes in thickness than the other rocks.

1. The basal sandstone is exposed in the banks on the bluffs of the Rio Grande on the three surveys of Samuel Sanders. It caps the bluffs which extend in a north and south direction from three miles south of Eagle Pass to Arroyo Seco, three miles north of the city. North of this creek the escarpment formed by this sandstone turns to the northeast, passing through surveys 6 and 4 in block 16 and through surveys 199, 200, 196, 197, 168, 169 in block 7, and rising to form the capping of a low hill known as Chapotal hill in survey 170 in the same block. From this point it can be followed for several miles to the south and east, but beyond that its course is doubtful. It should be added that this sandstone is not a unit, but consists of different ledges separated by strata of clay. At times it is broken up into two or three members. In composition it varies from a siliceous sand to a fairly pure limestone, containing a considerable amount of shell fragments. It is mostly fine in texture, but there are occasional seams of gravel. *Exogyra costata* is sometimes seen in the clay immediately below it. Ripple marks were noted in several places, and fragments of bones of reptiles are not unknown. Barite is a frequent mineral.

The thickness of this sandy zone varies from thirty to one hundred feet.

2. The lower clay comes up to the surface in a swale of low upland which follows the sandstone just described, on its east and south side. The average width of this swale, or shelf, is two miles, and the thickness of the clay is about 275 feet. In its upper half the fossil shell *Exogyra costata* can be found almost wherever the clay is exposed. By this fossil the belt was traced eastward from Muerto hill to the John Foster survey, and from there northeastward as far as to near Chilpotin tank on survey 119 in block 7. Fibrous barite was noted in several places in this clay.

3. The exposed west ledge of the middle sandstone group forms the second range of hills extending from north to south, three miles east of Eagle Pass. In survey 1 in block 16 the escarpment formed by this sandstone makes a turn to the south-east and reaches its highest position in the rock capping Muerto hill, where again it turns to the east, or a little south of east, to survey 8 in block 6. From this point it was traced with some interruptions northeast and then north to Chilpotin tank and northwest to the Vela Ramos survey on Salado creek. It is probable that this same horizon is represented by some ledges which run from here north and west, to survey 25 in block 7, and from there north and east across Chacon creek, and then east on the south side of the Anacacho mountains.

While apparently more persistent than the lower sandstones this middle group is more variable in its nature than the former. It is frequently slightly coarser and more open in texture. Quite often it is calcareous and contains an appreciable ingredient of organic fragments. In places it is wholly composed of entire and broken pieces of the valves of an ancient oyster, *Ostrea cortex*. Near the northwest corner of survey 225 a breccia of this shell measures nearly forty feet in thickness.

The thickness of the strata belonging to this sandy group, including the sands, the interbedded clays, and the shell breccias, is in the neighborhood of 130 feet.

4. The middle clay underlies the basin of Lampasitas creek and is also found on some of the high divides on either side of Rosita creek. Occasionally it is of light gray color and contains seams with small flakes of gypsum. Shells of *Ostrea cortex* are frequent throughout. In its upper part I found large concretions of yellow carbonate of lime and many of these contained the fossil *Sphenodiscus pleurisepta*. It contains some ledges of shell breccia locally known as shell rock, but these are absent in many places. Some of these are seen near Stone Ranch on Willow creek.

5. The upper sandstone was traced in a continuous outcrop for fully ten miles on the east side of Palo Blanco and Willow creeks. It forms a very sinuous line of bluffs from survey 116 in block 6 northwestward to survey 98 in the same block, and thence northward to the head of Palo Blanco creek. In this region it measures from five to thirty feet in thickness. In texture it is usually fine grained.

6. To the upper clay I refer provisionally all of the Cretaceous sediments which lie above the upper sandstones. In the south half of survey 116 in block 6 these beds were made out to be as in the following section.

SECTION OF THE UPPERMOST CRETACEOUS BEDS IN SURVEY 116, Block 6.

	Thickness in feet.
5. Soft sandstone of fine texture, yellow, with some layers of more calcareous material, containing <i>Sphenodiscus</i> and small bivalve shells, preserved mostly as casts.....	15
4. Clay with cakes of fibrous barite.....	20
3. Breccia of broken oyster shells with sandy material	2
2. Clay with shells of <i>Ostrea cortex</i>	52
1. The upper sandstone.....	5

On the south side of Peña creek, four miles south of the hill where the above section was noted, the sandy member (number 5) has a considerably stronger development, and measures some 40 feet. Above it was a clay of at least the same thickness. This clay is characterized by the presence of *Ostrea idriensis* and by an assemblage of other bivalves and some tall-spined gasteropods. The same clay, with the same fossils, was noted in the northeast quarter of survey 153 in block 7 and also in the southwest quarter of survey 121 in the same block. It is overlain at all three places by sandstones belonging to the Tertiary age.

THE PULLIAM FORMATION.

The Pulliam formation takes its name from the Pulliam ranch on the Nueces river, where some of its ledges of soft sandstone are known to contain from ten to thirteen percent of asphalt. This formation is by some regarded as the attenuated eastern equivalent of most of the Eagle Pass beds. It consists of clays and marls, with some ledges of sandstone, limestone, and shell beds. One of the sandstone ledges forms the divide between the upper branches of Chaparrosa creek, and Mula and Palo Blanco creeks. It is also exposed in places in the north half of block 3 south of the Anacacho mountains. South of this it is covered by the Tertiary deposits, which deepen to the south and east. The thickness of the formation on the Nueces river has been estimated at from 100 to 200 feet. This clearly increases to the westward and along the Chacon creek and south of the west end of the Anacacho

mountains in the Mula creek basin, it is certainly not less than 500 feet.

The bituminous sandstones noted on the Nueces river in this formation no doubt underlie some of the lands in the northwest part of Zavalla county, but the presence of the bitumen cannot be ascertained except by exploration. Wells made on these lands merit attention for the detection of this product at reasonable depths. The synclines, or downward folds, in which the asphalt is most apt to have accumulated, are concealed, if there be any, by the overlying Tertiary deposits.

THE TERTIARY SEDIMENTS.

The deposits belonging to this age cover the older sediments on most of the lands in Zavalla and Webb counties and also in the east and south part of Maverick county. They consist of clays and sandstones, and in places contain seams of lignitic coal and occasionally some ledges of yellow calcareous rock. In general appearance they differ but little from the sediments which make up the Eagle Pass and the Pulliam formations. The boundary between these two divisions were made out with fair accuracy by a study of their physical characteristics. The sandstones of the Tertiary age are more heavily impregnated with oxide of iron than the Cretaceous beds, and this frequently gives them a deep red, a brown, or a yellow color. They are also more variable in their texture and contain coarser grains of quartz, that may sometimes be known by their bluish white translucency. This is especially true of the basal sandstones of the group. The clays also are inclined to exhibit brighter distinctions of color, and from layer to layer there are apt to be somewhat rapid changes from one to the other of grayish white, yellow, red, purple, brown and dark lead-gray. These colors are due to different degrees of oxidation of the iron which they contain.

The thickness of the Tertiary deposits it was not practicable to make out except from such records as could be secured from well-drillers in the Carizzo Springs artesian basin. There was no opportunity to see any continuous set of samples of drillings, and verbal descriptions by drillers are always unsatisfactory. The following section is given as an average of the results obtained. It is quite evident that these clays and sandstones are even more variable in their development than the Escondido beds.

CENTRAL SECTION OF THE TERTIARY DEPOSITS IN THE CARIZZO SPRINGS
ARTESIAN BASIN.

	Approximate thickness in feet.
6. Clays of varying color and texture, with some sand above and occasionally lignitic below.....	250
5. Sands of somewhat fine texture, sometimes yielding water....	50
4. Clays partly of dark color and containing occasional streaks of bituminous and lignitic or peaty material.....	150
3. Sands giving the principal flow of water, somewhat coarser than the upper sand.....	125
2. Clays, with some seams of lignite.....	50
1. Sands, yielding water in some deep wells.....	30

Lignite.

The seams of lignite which have been found in the lower part of this section have also been noted in other places. As we proceed to the north and to the west from Carizzo Springs the lower strata rise until we find them exposed in the belt adjoining the area of the Cretaceous sediments, on which they rest. In this belt lignitic coal is reported in several wells, and a small seam has been observed in an outcrop on a hilly slope east of section 122 in block 7. One of the wells going through thin seams of lignite at shallow depth was made near the junction of Salado and Chacon creeks on the F. Wucherer survey. At this place there were two seams, each about six inches thick, one forty and the other sixty feet below the surface. One of the same seams was penetrated at a somewhat greater depth in a boring about a mile and a half northwest of this place. Some years ago a lignite bed was reported from some wells south of survey 1 in block 6, and more recently a seam reported to measure four feet was penetrated in a well far to the south near the northwest corner of survey 7 in block 9 at a depth of 220 feet.

These occurrences of lignite in the belt of outcrops of the Tertiary sediments are no doubt only some of the many instances of the same kind, of which no record is known. This lower lignite horizon characterizes the earliest tertiary deposits in the eastern part of the state and in Louisiana; but in that region it has not been found to contain lignite in commercial quantity. The probability is that they will prove equally unprofitable here. Judging by such explorations as have been made, they are best developed in the Farias and the Camanche pastures in blocks 9 and 11.

The lignite seams which have been found in the clays above the main waters and in wells made west of Carizzo Springs, and in the region of the Wilderness Lake and the Beef Hollow pastures are apt to have a less variable development, for they were formed in the Tertiary coastal waters at a time when the shoreline was more distant and when the lagoons were more extensive and uniform in their physical features. The upper lignite beds contain the productive deposits, but they are not productive in every locality. In Zavalla and Dimmit counties the beds to which they belong do not extend farther west than to within six miles of Maverick county, and usually they do not extend that far west. So far as I could learn, nothing is known of these lignites on the Company's lands except from explorations made by churn drills, and no reliable estimates on the thickness of such seams can be made except by the use of core drills. In Webb county these clays underlie the east part of block 7 and all of blocks 8 and 14. It is not likely that lignite beds of this horizon anywhere lie deeper than 400 or 500 feet on any of the Company's lands west of the Nueces river. A vein reported to be three feet thick was found in a well made on the Trinidad Sanches survey at a depth of 75 feet.

PLEISTOCENE DEPOSITS.

The surface of the uplands in the upper part of the Rio Grande embayment sometimes consists of the bare outcrops of the country rock, with thin patches of scanty soil. More frequently the bed rock is covered by a continuous thin land drift with a mantle of dark soil. In a few places this land drift rests on sediments which are evidently much later than the early Tertiary rocks just described. The springs on Tequesquite creek, four miles above its mouth, issue from such a deposit. Its lower part is a coarse gravel which changes upward into cross bedded sand and then to clays and fine sands of yellow color. These gravels and sands are probably not very extensive, but they are clearly the cause of the springs, which result from a slow seepage of water retained and stored in the porous sand.

Material unlike this, but of nearly the same age, forms a vertical bluff on the east side of a creek known as Agua de Fuera at a point a mile and a half northeast of Spofford. It rests on clay and stony ledges of the Austin chalk. Below it consist of a con-

glomerate of rounded limestone pebbles. Above this there are several heavy ledges of a white laminated and hard calcareous tufa, from ten to twenty feet thick. This tufa must underlie the land for more than a mile to the south, for it is exposed in the sides of the cut along the Southern Pacific railroad from a half to one mile east of Spofford. It is a rather pure carbonate of lime and with the Cretaceous clay that underlies, it could be used in the manufacture of good Portland cement. A suitable site for a mill could be found next the road and no carting would be needed. Both the limestone and the clay would be right at hand. This same stony tufa was also seen in the south bank of a creek near the north line of survey 27 in block 9, south of the Anacacho mountains.

ALLUVIUM AND SOIL.

Excepting the land where the Cretaceous limestones form the bed-rock, and in a few other places, as in the Anacacho mountains, where the weathering rocks are resistant, all streams have wide valleys with well developed flood plains. These are built up from a loamy alluvium, which has developed deep and rich black soil. In many places these valleys may be said to be in a measure sub-irrigated, for as the surface is desiccated under the summer sun, capillary moisture ascends from the more humid alluvium below. The supply is sufficient for a luxuriant vegetation of mesquite, pear, grass and various shrubbery. It seems to me that much, if not all of these alluvial lands, will in time have a greater value as cultivated land, than as pasture land. With a rainfall averaging twenty inches a year and with thorough cultivation, the soil ought to be very productive. The quality of the soil is such that it might even in time warrant the construction of tanks, or reservoirs, for purposes of irrigation. I believe that the time will come when this will be tried on some of these lands. It is clear that all of the Company's lands east of Del Rio have been selected for the excellence of the soil for pasture vegetation. The surveys everywhere follow those tracts where clays and marls form bedrock and subsoil. This is most notably the case north and west of Fort Clark, where the surveys follow the outcrop of the Del Rio clay, from Del Rio to within a short distance of the Nueces river.

One circumstance which increases the fertility of the soil south of the belt of the Austin chalk is the presence in the Cretaceous

marls and sandstones of small grains of glauconite. This is a phosphatic mineral, which has been worked extensively for the market in beds of the same age on the Atlantic coast and used as a fertilizer. In the upper part of the Austin chalk formation, in the Upson clay, and in the San Miguel beds, this mineral is present in small grains as an original ingredient, which is continually yielded to the soil forming on the surface.

IGNEOUS ROCKS.

During the tertiary age, while the Upper Cretaceous strata extended uninterrupted far to the north and before the land had been elevated to its present level, some volcanic disturbances resulted in the injection of what must have been extensive sheets of basaltic rock, chiefly among the strata of the Eagle Ford beds. At least two or three thousand feet of sediments have since that time been removed by erosion from the country north of Eagle Pass, and the land has been cut down to a level mostly below the intruded rock, in the country north of the main line of the Southern Pacific railroad. It seems probable that there was only one sheet originally injected. This may have extended as one continuous body from east of Turkey mountain to west of Pinto mountain. But the greater part of this sheet has been cut away with the formations in which it lay, and at the present time we find only a few small remnants of the original intrusive. These remnants are left on account of their effective resistance to weathering and erosion, and we find them capping the highest points in the region. They are the dark rocks found on seven peaks which rise as prominent landmarks on the uplands around Fort Clark: Turkey mountain, Elm mountain, Las Moras mountain, Pinto mountain, Little Pinto mountain, Palmer hill, and another low hill two miles north of Las Moras mountain.

The rock is alike in all of these places. It is a dark basalt, composed chiefly of plagioclase feldspar, olivine, augite, and magnetite. It usually has a somewhat porphyritic structure, but varies considerably as to coarseness of texture. In some cases the crystals are readily visible to the unaided eye, while at other points the rock appears compact and the crystals are microscopic. Everywhere the rock is fresh. It has undergone practically no change from its original condition. This makes

it certain that no mineral deposits of any consequence will be found associated with it in these localities.

It is probable that the intrusives come from the Uvalde country on the east. In that region similar rocks have a much greater development and the fissures through which the molten masses rose, are no doubt to be found in that direction. This hypothesis would also account for a westward thinning which is evident in the remnants of the flow found in Kinney county. The measurements taken are given in the following table.

TABLE SHOWING APPROXIMATE THICKNESS OF THE IGNEOUS ROCKS IN KINNEY COUNTY.

	Thickness in feet.
Turkey mountain.....	200
Elm mountain.....	35
Las Moras mountain.....	90
Hill two miles north of Las Moras.....	70
Little Pinto mountain.....	15
Pinto mountain.....	30
Palmer hill.....	30?

In all probability other exposures of this intrusive are found at some points to the south and west of Palmer hill, for small boulders of it are present in the land drift between Fort Clark and Spofford.

GEOLOGICAL STRUCTURE.

In its great features the structure of this whole region is quite simple, as will be apparent from the facts already presented. There is a general slow descent of the formations to the southeast. In the distance of a hundred miles, from Del Rio down the Rio Grande, 3872 feet of stratified rocks go under the river. The descent of the river itself in this distance amounts to nearly 200 feet, and thus the dip averages some forty feet to the mile.

The whole region must be regarded as a single structural unit, a wide and low monocline tilted to the southeast. This monocline is however itself affected by minor flexures and by some small faults. Thus we find a rather abrupt reversal of the general southward dip in Devils river about one mile north of the bridge of the Southern Pacific railroad. At this place there is a small anticlinal fold with its axis extending from east to west for several miles. To the north of this axis the ledges of the Devil's

river limestone dip northward for a few hundred yards, descending as much as fifty feet, before again resuming their slow climb in that direction. Another fold of about the same size and direction was noted two miles north of Del Rio. This latter fold extends several miles to the east, so that the dip at several points east of Del Rio is to the north even as far out as near the railroad bridge over Sycamore creek. Between Pinto creek and Las Moras creek the ledges of the Austin chalk are at several points in a horizontal position and in a few cases they dip north. On Tequesquite creek, from one to three miles above its mouth, there are several abrupt small folds and some small faults. One of these faults crosses the creek about a hundred and fifty yards above the main wagon road following the river. The downthrow of this fault is to the north and amounts to about seventy feet. The trend of the fault is some five degrees north of east. About the same distance below the road there is a small, short, and abrupt monoclinical fold with dip to southwest and a downthrow of only ten feet. In following up Las Moras creek from the same road a reversal of the south dip was noted for a half mile on the Samuel Blair survey.

Several irregularities of this kind were also noted on the lands north of the Anacacho mountain.

THE LAMPASITAS ARCH.

If we project a straight line from the centre of Survey 97 in the Lampasitas pasture in block 6, due north, or a little west of north, we find that this traverses a region where dips are very gentle and more often to the south than to the southeast. In the east part of the Paula pasture, in the Lampasitas, and in the Sauz pastures, dip is either absent, the ledges lying horizontal or with a slight tilting to the south, or there is a noticeable dip to the west or southwest. Only at a few points is the dip normal to the general structure, to the southeast. Thus the horizontal position was noted in the following places:

1. S $\frac{1}{2}$, survey 251, block 7.
2. E $\frac{1}{2}$, survey 20, block 6.
3. Survey 18, block 6.
Survey 19, block 6.
4. Sw $\frac{1}{4}$, survey 22, block 6.
5. Sw $\frac{1}{4}$, survey 23, block 6.
6. E $\frac{1}{2}$, survey 24, block 6.

7. N $\frac{1}{4}$, survey B S & F survey 65.
8. S $\frac{1}{2}$, Miles Bonnet 74 survey.
9. South end Guadalupe de los Santos survey.
10. W. Owen's survey.
11. Centre, Survey 56, block 6.
12. Sw $\frac{1}{4}$, survey 57, block 6.
13. Centre, survey 58, block 6.
14. Nw $\frac{1}{4}$, survey 103, block 6.
15. W $\frac{1}{2}$, survey 119, block 6.
16. N $\frac{1}{2}$, survey 93, block 6.
17. S $\frac{1}{2}$ survey 47, block 6.

Dips to the west, northwest, or to the southwest were noted as follows:

1. Nw $\frac{1}{4}$, survey 225, block 7.
2. Se $\frac{1}{4}$, survey 18, block 6.
3. Near S. line, survey 22, block 6.
4. Near N. line. Serena Goodman survey.
5. W. line, Thomas Weeks survey (on Rio Grande).
6. E. $\frac{1}{2}$, survey 12, W. of Anton Handauer survey.

It is clear that from the north end of this area of variable dip there is a general descent of the beds to the south, probably equal to some 30 feet to the mile. But there are minor folds which frequently reverse this dip. The frequency of the horizontal attitude on the west side of the stated line and no less the occasional tilting to the west, clearly show that the strata are affected by a flexure, which has the form of an arch whose crest extends in a north and south direction. But owing to the general inclination of the terranes to the southeast, the west limb of this arch is slightly more raised in its position, as compared to the east limb (see plate 3),

The presence of the arch is clearly shown at its northern extension in the southward detours made by lines indicating the north limits to the three members of the Eagle Pass formation. It also appears from these curves that the arch is more narrow and pinched at its north end and wider and perhaps not as high or as well defined at its south end. South of Mula creek, in the Sauz pasture, it is lost in a general dip to the southeast which again becomes the ruling structure. The highest dips referable to this arch were seen on its east side as far north as the Salado tank in the Salado pasture. Near the old Salado tank there is an eastward dip of some five or six degrees and at a point south-

east of Chilpotin tank a dip to the east-northeast measures seven degrees.

MINOR FOLDS.

There is a minor class of structures which are frequent in the country covered by the Eagle Pass formation. These consist of abrupt and small folds where the more indurated members, such as the sandstones, limestones and shell breccias assume a high inclination for a short distance and appear with their edges on the surface of the ground as low and straight hog-backs. The indurated member is sometimes unbroken and the fold is seen as a well marked crest, with the rock changing its dip along the crest. But at other times only one side of the fold is seen. In the latter case these folds probably are to be regarded as small overthrusts. These folds are due to lateral pressure. The more plastic clays have yielded to this pressure by shortening in the direction the pressure has been applied, while the indurated and rigid ledges imbedded in the clays have been fractured and folded. The direction of the force was northwest and southeast, for the prevailing trend of the folds are from southwest to northeast. A list of the more important places where these structures were noted is as below:

1. NE $\frac{1}{4}$, survey 20, block 6. Trend N. 25° E.
2. Near centre, survey 22, block 6. Trend N. 45° E.
3. SE $\frac{1}{4}$, survey 18, block 6. Trend E NE.
4. South of centre, survey 98, block 6, Trend N—S.
5. $\frac{1}{4}$ mi. WNW of SE corner, survey 100, block 6. Trend N 68° E.
6. NW of centre of survey 98, block 6. Trend NE—SW.
7. Near centre survey 116, block 6. Trend N. 48° E.

ECONOMIC FEATURES.

ARTESIAN WATER.

Water in the Cretaceous Rocks.

In describing the Devils river limestone reference was made to the fact that there are two water-bearing horizons in this limestone, one about a hundred feet below its upper surface and the other some two hundred feet below this level. There is no doubt that the large springs north of the Southern Pacific rail-

road come from these water-bearing strata. The San Pedro springs at Del Rio have a head of some 930 feet above the sea and the head of the other springs ranges up to 1075 feet above the sea. If the waterbearing strata can be tapped at points where the level of the ground is below these heads, the water will flow. This is the simple principle of all Artesian basins. The question of such water supply in this case is a question of depth to the water-bearing stratum, a question of elevation of the land surface, and of probable height of the head.

The head of these waters is not likely to be much lower than the head of their lowest known outlet at Del Rio. Farther to the east it must vary somewhat with the known heights of the natural flows in that direction. For the lands south of the Southern Pacific railroad we must infer that the head of the obtainable flow will range between the two figures given. Comparing these elevations with the elevation of the land, I find that nearly all of the land east of Canyon Grande west of Eagle Pass railroad and south of the Imperialist pasture, must be lower than 930 feet. The alluvial bottoms in the two Imperialist pasture must also fall below this elevation in their south halves. On these lands the water can be expected to flow. The question of depth is answered by the measurement already given of the several formations that have been described. If a well were made on the bottom along Cañon Chiquito on survey 62, in block 4, the formations to be penetrated would be the following:

	Thickness in Feet.
Upson clay.....	400
Austin chalk.....	750
Eagle Ford rock.....	250
Buda limestone.....	75
Del Rio clay.....	100—200
Devil's River limestone.....	300
Total.....	1925

While absolute accuracy cannot be claimed for these figures the error is not believed to exceed 300 feet either way, and at most the main water-bearing rock cannot lie deeper than 2200 feet. For other points the same rock will be found to rise northward and to go down to the south at the rate of about 50 feet to the mile.

On the bottoms in the east part of Snow Tank pasture the conditions for a flow is even more favorable, owing to the lesser elevation of the land, which is in some places below the 900 feet level, and also on account of the almost certain rise of the head in this direction, the head of the Brackett springs being 1075 feet. But the depth would probably be more than 1925 feet. It cannot be estimated with quite as great certainty as for the country to the west, owing to an absence of sufficient opportunity of noting the dips in this eastern region, outcrops being few. But the additional depth of the drilling necessary to reach the water would not be likely to exceed 400 feet. To the east of the Chacon the depth would be still greater.

It remains to be added that there are fair chances for securing flows of this water in the lower bottoms of Cow creek and Pinto creek on the Company's lands, if this should be desirable. On Pinto creek the depth to the water would be about 1200 feet and on Cow creek it would be about 1500 feet.

Water from the Tertiary Rocks.

The artesian water which flows in the basin of Camanche, Live Oak, and Turkey creek and in the valley of the Nueces river, comes from the sands in the tertiary system. The intake area of these water-bearing sands lies between Carizzo Springs and the Anacacho mountains. In this region the water-bearing strata come up to the surface and form a sandy rolling belt of land, as in the Chaparrosa pasture, in the west part of Palo Blanco pasture and in the Turkey creek pasture. As in other Artesian basins it has been noted here also that the deepest lying sands have the highest head of flow. This is because their intake area lies farther north and higher up, than that of the upper sands.

In the absence of definite data on the elevation of the lands in this basin, the extent of the available flow can be inferred only from the distribution of the wells now in existence. For this purpose a list was secured which gives the name of the owners of wells with some data on the depth of the wells, their flow, etc. The list does not give the location of all the wells, and it is defective in other respects, but it is given for what it is worth, as the best that could be secured at the time.

LIST OF ARTESIAN WELLS NEAR CARIZZO SPRINGS.

Owner's name.	Location.	No. of wells.	Diameter in inches.	Depth (Average).	Flow in gallons per hour.
A. Richardson,	Survey 50, bl. 1, G. N. R. R.	10	7	600	120,000
T. A. Coleman,	.....	2	6	500	30,000
F. M. Shaw,	.....	3	5 $\frac{3}{16}$	450 to 850	45,000
G. White,	.....	1	5 $\frac{3}{19}$	400	18,000
Schimmelpfenning Bros.,	.....	2	6	350	2,000
Dr Decker,	T. T. R. R. Survey 55	1	8	537	40,000
C. J. Pollard,	T. & N. O. R. R. survey 3, bl. 3.	1	10	650	20,000
F. J. Arnold,	Survey 55, T. T. R. R.	1	8	500	16,000
Wm. Knight,	Survey 3, bl. 3, T & N. O. R. R.	2	8	625	32,000
Dr. Hughes,	Survey 4, T. & N. O. R. R.	1	5	500	50,000
Patterson,	.....	2	7	625	40,000
A. Eardly,	J. T. Camble survey	1	12	735	72,000
Shaw & Berry,	.....	2	5 $\frac{5}{8}$	650	40,000
J. W. Campbell,	.....	1	5 $\frac{5}{8}$	680	40,000
J. C. Owen,	.....	1	5 $\frac{3}{16}$	630	14,000
Burnet,	.....	1	5 $\frac{5}{8}$	525	16,000
Parmlee,	.....	1	5 $\frac{5}{8}$	450	16,000
Moehrig,	.....	2	6	500	30,000
Foster,	.....	2	5 $\frac{5}{8}$	500	32,000
Smith,	.....	1	5 $\frac{5}{8}$	500	16,000
Rector,	.....	1	5 $\frac{5}{8}$	500	20,000
Skivington,	.....	1	5 $\frac{3}{16}$	500	14,000
Thorpe,	.....	3	5 $\frac{3}{16}$	400	30,000
Thorpe. (new well)	.....	1	8	411	20,000
Jeffrey,	.....	1	5 $\frac{3}{16}$	364	14,000
J. White,	.....	1	5 $\frac{5}{8}$	500	20,000
M. J. Denman,	.....	4	5 $\frac{5}{8}$	450	72,000
Kendall,	.....	2	4	500	36,000
McCaleb,	.....	2	5	600	40,000
Lavin,	.....	1	4 $\frac{1}{4}$	850	200
Cragg,	.....	1	5 $\frac{3}{16}$	500	15,000
J. S. Taylor,	Near Bermuda,	1	5 $\frac{3}{16}$	816	60,000
Shipp,	.....	1	5 $\frac{3}{16}$	400	18,000
Moore,	.....	1	8	526	20,000
Pratt & Hayes,	.....	1	8	900	50,000
Asher Richardson,	in Moro valley,	.....	.....	.....	50,000

The head of the waters in this basin will no doubt be found to vary at different points to some extent. Such variations are not unknown in regions with a more regular geological structure than this basin. The deepest water can be expected to exhibit the least variations in this respect. A well which was recently made at a point about three miles west of the "Cross S" ranch by Mr. Archibald gives us an approximate measure of the height of the head of this lowest water. Four measurements by the aneroid barometer make the elevation of the curb of this well 54 feet above low water of the Nueces river at the ranch. The elevation of the Nueces low water at this point is estimated at 667 feet above the sea level. The curb of the well is therefore about 721 feet above the sea. The water is said to rise ten feet above the curb, and its head must be near 730 feet. At present the well is tapped through a ditch fifteen feet below the curb.

All the lowlands belonging to the Company in the northwest part of Webb county are below this level and there is good reason for believing that flowing wells may be made by sinking wells into the lowest tertiary sands under these lands. An estimate of the thickness of the tertiary beds on the Rio Grande on these lands indicates not less than 1,000 feet and not more than 1,500. This thickness would have to be penetrated in order to make a fair test.

Waste of Flowing Water.

The unrestricted waste of water in the Carizzo Springs' basin will soon be a matter of concern to land owners north and west of the wells as well as to owners of land irrigable by this water. As has been indicated already, the intake area of this water is on the sandy lands between Chacon creek and Turkey creek south of the Anacacho mountains, extending about as far south as to Wilderness lake. With such a limited intake area a too liberal draught on the supply will certainly reduce the head, and not only will the wells with the lowest pressure cease flowing, but the underground water level in the intake area will sink and with this must follow a general scarcity of water in shallow wells and in tanks dependent on surface supply in this region. For with a lowering of the level of the ground moisture the water which supplies the vegetation, the tanks and natural water holes, will be less, and the general seepage downward will be more rapid.

A reliable well man, who has had the best opportunities to keep informed on the yield of the wells in the Carizzo Springs basin, gives the information that the head of most of the wells has been reduced, and he estimates that on an average the head has gone down twenty five feet since the flow was first tapped. Whether there is a perceptible increase of droughty conditions in the Chaparrosa, Palo Blanco, and Gato Creek pastures is not known, but it is to be expected that a greater part of the rainfall on these lands will be lost to the surface and to the vegetation, and will more rapidly than before sink to replenish the lowered head of the ground water tapped by the Carizzo Springs wells.

At the present time wells are permitted to flow to waste without restriction. Economic considerations suggest prompt legislation to prevent this senseless waste. It will necessarily reduce the area of irrigable lands. It is clear that the loss will first affect those lands that lie toward the periphery of the basin.

GAS AND OIL.

The inquiry regarding the probable quantity of natural gas in the country southeast of Eagle Pass resolves itself to a question of geologic structure. The history of the well made some years ago shows that gas was present under high pressure, and the only doubt there can be as to the existence of commercial quantities is as to the size of the reservoir which was then tapped. To estimate this factor the structure of the formations was made out in as much detail as was possible. The results of this study have been given in the description of the structure.

Natural gas occurs in folds where clay or shale or other impervious strata form what we may call inverted troughs, or anticlines that prevent the accumulated gas from escaping upward. A few instances have also been known where gas has accumulated against a shoulder on an inclined stratum of impervious cover, a so called arrested monocline. In every case the gas is held in some porous rock.

In the wells made on section 116 in block 6 the gas was found in a sandstone that measured 57 feet in thickness. The whole section of the well as given to me by Mr. W. L. Evans, is as below.

SECTION OF THE GAS WELL ON SURVEY 116, BLOCK 6.

	Thickness in feet.
26. Yellow Clay.....	10
25. Hard rock.....	4

24. Blue clay and soapstone.....	166
23. Coarse white sand.....	10
22. Blue clay.....	10
21. Common sand with some salt water.....	10
20. Blue clay.....	25
19. Brown sandy clay.....	3
18. White sand and shells.....	6
17. Fine sand and white clay, the sand yielding some salt water, some gas and some oil.....	20
16. Hard rock.....	3
15. Fine white sand.....	3
14. Brown sandy clay.....	4
13. Fine hard sand.....	2
12. Blue sandy clay.....	15
11. Hard rock.....	3
10. Blue clay and hard rock.....	10
9. Blue clay.....	296
8. Hard rock.....	3
7. Coarse brown sand with pronounced odor of oil.....	30
6. Blue clay.....	10
5. Brown coarse sand with some oil and heavy pressure of gas spouting 60—80 feet.....	57
4. Blue clay.....	5
3. Asphalt.....	5
2. Blue clay.....	15
1. Chiefly clay, with some porous, easily drilling rock at 745 feet below the curb of the well.....	265

The strata penetrated are clearly of the kind which is required for the retention of gas and oil. Each of the two gas-bearing sands have an impervious cover of clay, the lower of which is nearly 300 feet thick and the upper 166 feet. The presence of asphalt below the lower sand indicates that distillation of hydrocarbons have taken place in this sand at some earlier time, for solid hydrocarbons are the natural residues of this process. The thickness of sandstone makes the porous stratum quite ample to hold a very considerable quantity of gas, if the stratum has the necessary shape and capping.

The local structure which contains the gas in this well is in my opinion a low arch, whose axis trends northeast and southwest, and is at about a third of a mile south of the well. The height of this arch must be near fifty feet. The outcrops from which this structure was made out are not as clear as might be desired. A sandstone which appears in the creek rises about fifty feet for the first half mile on a line running south

and nine degrees west from the well. At this point there is a change in the dip and the same sandstone descends at one point at a rate of 160 feet per mile to the south, and at another point, farther east, about 80 feet per mile to the southeast. The sandstone has been partly cut away on the north side of the crest to the southwest of the well. To the northeast the arched structure is not indicated clearly. The arch probably flattens out somewhat in that direction. The sandstone from which this structure was made out is the same ledge that forms the bluffs on the east side of Sauz and of Palo Blanco creek to the north. Northward from the well this structure again rises to the northwest for a mile or more and then continues horizontally and evenly, with a small dip to the northwest for a mile and a half in the same direction.

From this it appears that the well is near the outer north margin of a small anticline which is itself a part of a larger and more flat anticline. Or, probably it would be nearer to an accurate description to say that the well is at the foot of a small anticline, which is itself at a point on the upper edge of a low arrested monocline, where the strata gradually are flexed into a horizontal position. My observations also indicate that the main axis of the anticlinal arch is limited in length and that the arch is rather to be regarded as a lengthened dome. It will be convenient to refer to this structure as the Mula dome, for its crest runs somewhat parallel with Mula creek, on the south side of its valley. The larger anticline or the region of the horizontal structure which lies to the north and west of the well, is the south end of the flattened crest of the Lampasitas arch, which has already been described.

Quantitative Estimate.

To estimate the quantity of gas held in this reservoir, we must estimate the volume of the porous space in the 57 foot sandstone included in the Mula arch. The known height of this arch is about forty-five feet. The width of its north limb is one third of a mile, and that of its south limb is a half mile, as near as could be made out by measurements on exposed strata. Let us say the whole width is two thirds of a mile. Its length is not known, but it is at least as great as its width. To be within safe limits we may then regard the arch as a cone having a height of 45 feet and a diameter of two thirds of a mile at its base, or 3520

feet. What is the volume of the porous space in a cone of sandstone having a basal diameter of 3520 feet and a height of 45 feet? The porous space of sandstone ranges from twenty-seven to forty-five percent of the volume of the rock. In this case it is not less than thirty percent. The pressure under which the gas was held, judging by the depth of the well and the height to which water and debris was spouted (60–80 ft.) by the well, is estimated at 230 pounds per square inch, or about fifteen atmospheres. The quantity of gas should hence be equal to the volume of the porous space multiplied by fifteen. This will make about 220 millions cubic feet of gas.

On the flattened south end of the Lampasitas arch it would seem almost a foregone conclusion that there should be other minor folds like the Mula dome, and it seems likely that some of these may prove to be gas bearing also. Some of the places showing a dip to the west may prove to be on the west side of such folds. A list of these have already been given (see page 89). The three places where crests of minor anticlines are most strongly indicated are (1) about one third of a mile west-northwest from the southeast corner of survey 18 in block 6, (2) on the central tract of survey 118 in the same block, and (3) near the central part of the south half of survey 22 in the same block.

Petroleum.

With the gas that is at present escaping from the Mula creek well there is also a small quantity of oil, which accumulates on the top of the water that now fills the well. A sample of this oil was submitted to Messrs Edgar and Carr of the Dearborn Laboratories in Chicago, who reported to Col. W. L. Evans, Jan. 27, 1906, as follows:

REPORT ON THE QUALITY OF OIL FROM THE MULA CREEK WELL.

Gravity, 23.4 Baume.

Flash point, 280° Fahr.

Burning point, 330° Fahr.

Heat value (Parr calorimeter per pound of oil) 17808, British thermal units.

The analysts add the following comments: "From the above results to tests made upon the sample at hand, we conclude that this is not a desirable crude from a refining point of view. It shows very similar to other crudes from Texas, except that the

gravity is about 2 degrees lighter. The flash and burning points are much higher than those of crudes which are being refined upon a large scale with absolutely satisfactory results. We do not mean to say that it could not be refined and a moderate amount of light oils, such as kerosenes, naphtas, etc., be obtained. However, as is almost invariably the case with this class of oils, some would need special treatment before refining, and even with this the lubricating or heavy products obtained would not be of the high quality desired for this class of oils.

While the heat value of the oil is not high for crudes, it is sufficiently so to make the oil desirable for fuel purposes. The price which could be had for the oil, would probably be proportionately lower than that of some other oils, as the heat value is proportionately lower than of other oils on the market. We do not mean to say that this is lower than any other on the market, as many are being used which is no better than this one." The above quotation is from a letter written by the analysts to Col. W. L. Evans, who submitted the sample.

Probability of Existence of Oil.

As to the existence of petroleum in commercial quantities in this field, it would be hazardous to venture a definite opinion. It is a well known fact that the first explorations in most oil regions have been made on the basis of much less promise. The accumulations of oil require the same kind of structures as are found to hold gas. There must be present some impervious stratum to arrest the rise of the oil under the pressure of ground water. The structures which hold gas are just as efficient to hold oil, if it be present. And usually the two are associated, though one or the other is apt to prevail. When present in the same well, oil is usually produced only after the gas has escaped. Gas wells may thus sometimes turn into oil wells. Both gas and oils are to be regarded as products of a natural distillation and the presence of one may be taken as a certain indication of the production of the other. But the products of the same distillation may have become separated and may not now be in the same reservoirs. As a rule the oil is held lower down in the reservoirs than the gas. Oil might hence be rather looked for south and east of this gas well than in any other direction.

In this connection attention should be called to the fact that the strata which contain the gas in the Mula creek well are sediments of the same or of very nearly the same age as the strata which yield oil in the Boulder district in Colorado and at Corsicana in Texas. In both of these places the oil is associated with gas, though this has been only occasionally found at Corsicana. In the Boulder district gas is of somewhat more common occurrence than at Corsicana. In the Boulder field the formations are more strongly folded than in the country southeast of Eagle Pass, but at Corsicana the structure is about the same. Everything considered, the prospect of finding oil on that part of the Lampasitas arch covered by the Escondido beds can not be regarded as altogether unpromising. Prospect holes should go down to the Upson clay. Below the top of this clay there is no rock sufficiently porous to warrant exploration.

SALTPETER.

The saltpeter which has been found in a cave on Devil's river is a rather exceptional mineral occurrence. It has been formed in its present place by a natural process from human excrements and food waste, originally left in the accumulating earth and rubbish on the floor of an aboriginal dwelling place. Saltpeter of commerce is in part manufactured by mixing refuse animal substances with lime and earth and leaving the mass to decay. The lime in these caves was produced in connection with the heating of limestone rocks in the preparation of food. Great heaps of these partly calcined stones are seen on the ground. The accumulated rubbish which is found on the floor of the old dwelling place averages about five feet in thickness and covers an area 136 feet long and about 34 feet wide, or 2,890 square feet. From samples taken at respectively one, two, three, four, five and six feet below the surface, it was ascertained that the saltpeter is present only in the upper three feet. Into this stratum it has evidently been brought by capillary rise of moisture, drawn from a limestone shelf below and dissipated by evaporation from the surface of the debris. Rough analyses of each of the samples taken are as follows:

	Percent of Saltpeter.
Uppermost foot	20
Second foot below surface	7

Third foot below surface	1
Fourth foot below surface	less than 1
Fifth foot below surface	less than 1
Sixth foot below surface	practically absent.

From these figures it appears that some thirty or forty tons of crude saltpeter might be extracted from the deposit in this cave. A part of the richest upper crust has been removed, and this would reduce the quantity by several tons. At all events twenty tons crude saltpeter, probably containing ten percent of salt, appears to be a fair estimate of the quantity remaining. It would have to be hauled about eighteen miles over a bad road to the nearest marketing place.

This cave is located under an overhanging cliff of limestone on the north side of a creek emptying into Devil's river from the west. The cave is about five-eighths of a mile north from the mouth of Indian creek. A small spring issues from the bottom of the creek immediately below the cave. Implements of flint and other rock, such as arrow-points and fragments of metates (small hand-mills) occur throughout in the debris containing the saltpeter. These relics, as well as the calcined stones, indicate the origin of the debris.

BAT GUANO.

In the Devil's river limestone caverns are quite frequent. These have been produced by the solvent action of underground water, and they are common in all limestone regions. Some of these caves have for long periods been inhabited by bats, and contain considerable deposits of guano. At least two are known by the stockmen on the lands of the company. One is said to be in the hills on the west side of Devil's river on or near survey 16 in block B., and was spoken of as a small cave. The other cave was entered by the writer and examined. Its entrance is on the north slope of a hill adjoining a branch of an arroyo which runs into Devil's river from the east on survey 15, block D. There is a vertical hole about thirty-five feet deep and this leads into the main chamber of the cave. This is a hundred feet long, fifteen feet wide, and thirty feet high. The floor of the inner part of this cave is covered by from two to four feet of porous and dry guano, which settles deep under one's feet. There are about 60 tons of guano. If this were to be marketed, it would have to be hauled twenty

miles by wagon over a very bad road which crosses Devil's river at an almost impassable ford. In all probability there are other bat caves on these lands.

CONCLUSION.

The survey of these lands shows that the region has nowhere been affected by those relatively more efficient volcanic agencies of circulating moisture and of pressure and heat, which bring about the concentration of such minerals as gold, silver, copper, or their ores, and the ores of lead, zinc, or quicksilver. The rocks are but little changed from the condition in which they were originally deposited. Violent folding, crushing, or dislocation is absent. Volcanic products are only seen at a few places, and consist of a few remnants of intrusives from extraneous sources. But there are deposits of other minerals. They are of the kind which occur in regions not greatly affected by metamorphic agencies. Enumerated in the order of probable importance these are as follows:

1. *Coal*, certainly found on surveys 166, 198, 199, block 7, surveys 5, 4, 6, 7, block 16, and probably worth exploring for on a belt extending several miles farther east.
2. *Gas*, known to exist in valuable quantity on survey 116, block 6, and indicated as more or less probable for scattered points on an area of twenty-five square miles to the north and west of this survey.
3. *Artesian water*, indicated for some tracts north of Eagle Pass on the Upson clays and partly known and also indicated on some of the lands north from Carizzo Springs. Also indicated for some of the land in Dimmitt county.
4. *Oil*, quite likely to be found in association with the natural gas. Possibly also may some time be distilled in commercial quantities from certain black shales in the Eagle Ford formation from Sycamore creek, northward and westward.
5. *Lignite*, found in the region of greatest thickness of the tertiary rocks, and existing in the west edge of the same formation, possibly in valuable quantity at some points.
6. *Cement material*, found along the Southern Pacific railroad near Spofford, also at points from Sycamore creek and westward.

7. *Puddling clay* of good quality exists in the Del Rio clay near Del Rio.

8. *Asphalt*, known to exist in limited quantities, and in impure state in the Pullian formation near the company's lands, but not believed to warrant the expense of special search.

9. *Saltpeter*, known in small and commercially unimportant quantity.

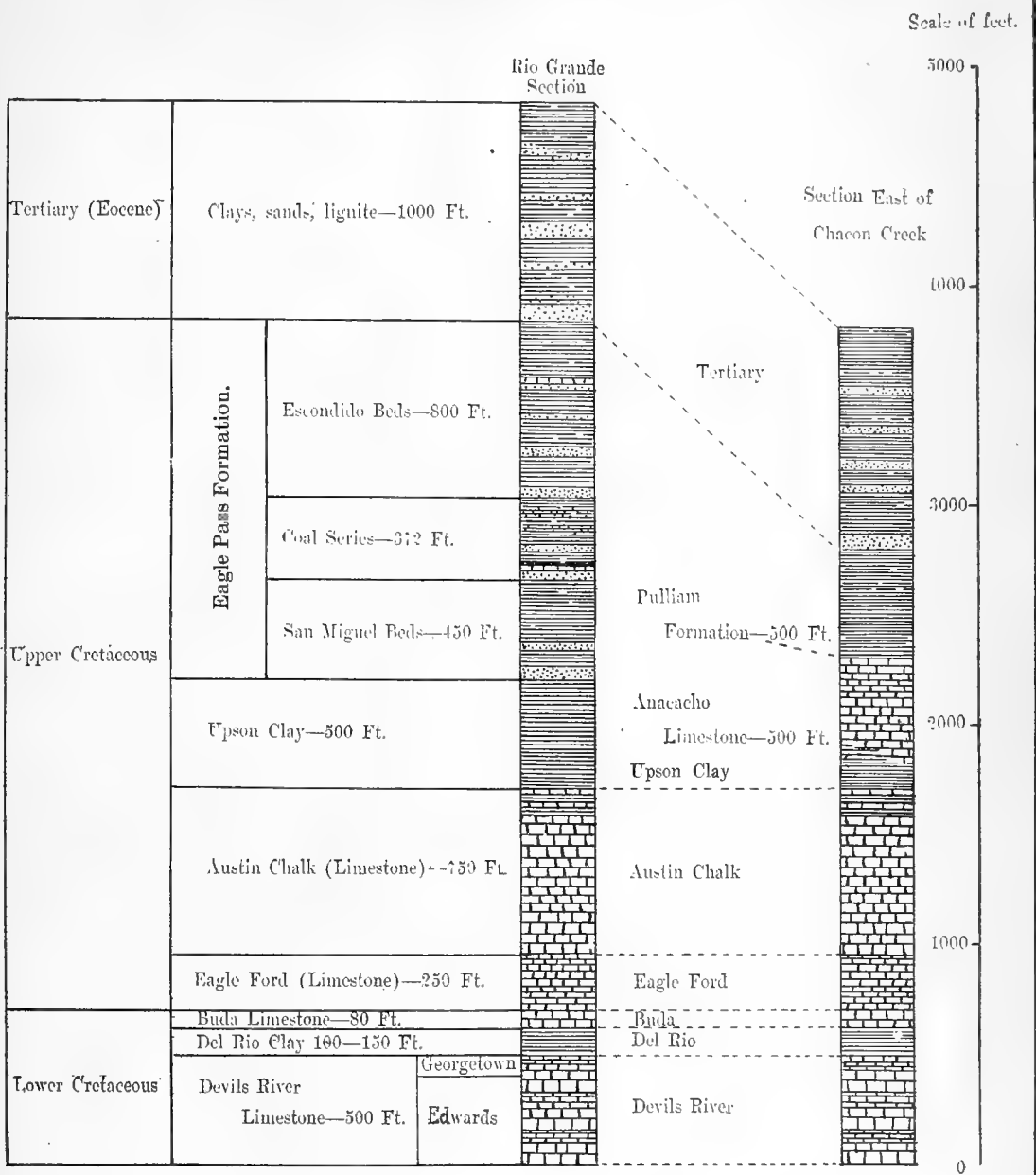
10. *Bat guano*, known in small and commercially unimportant quantity.

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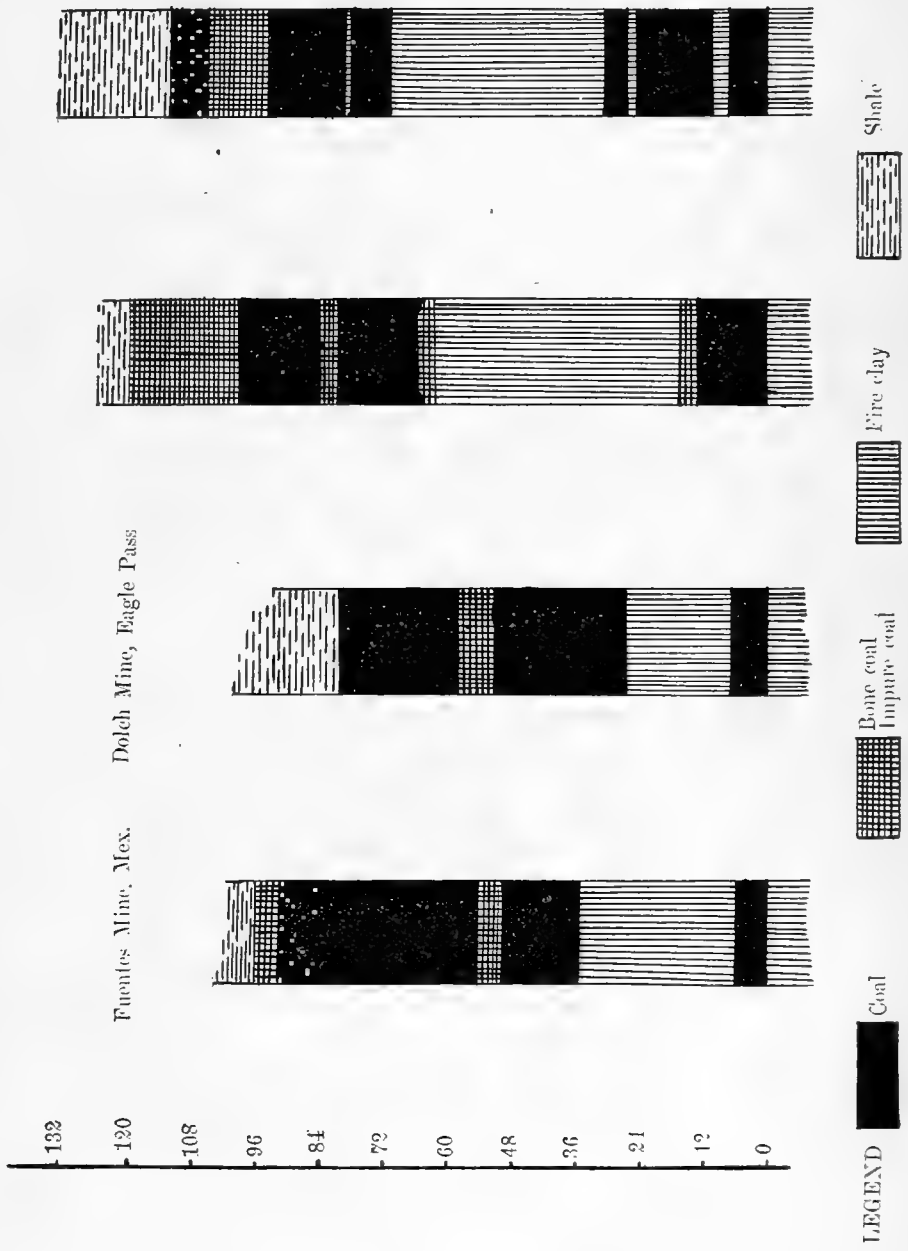


SECTION SHOWING THE GENERAL CLASSIFICATION OF THE SEDIMENTARY ROCKS IN THE UPPER PART OF THE RIO GRANDE EMBAYMENT, TEXAS.

Scale of Inches

Lower Pit, Survey 166 Upper Pit, Survey 166

Fuentes Mine, Mex. Dolch Mine, Eagle Pass



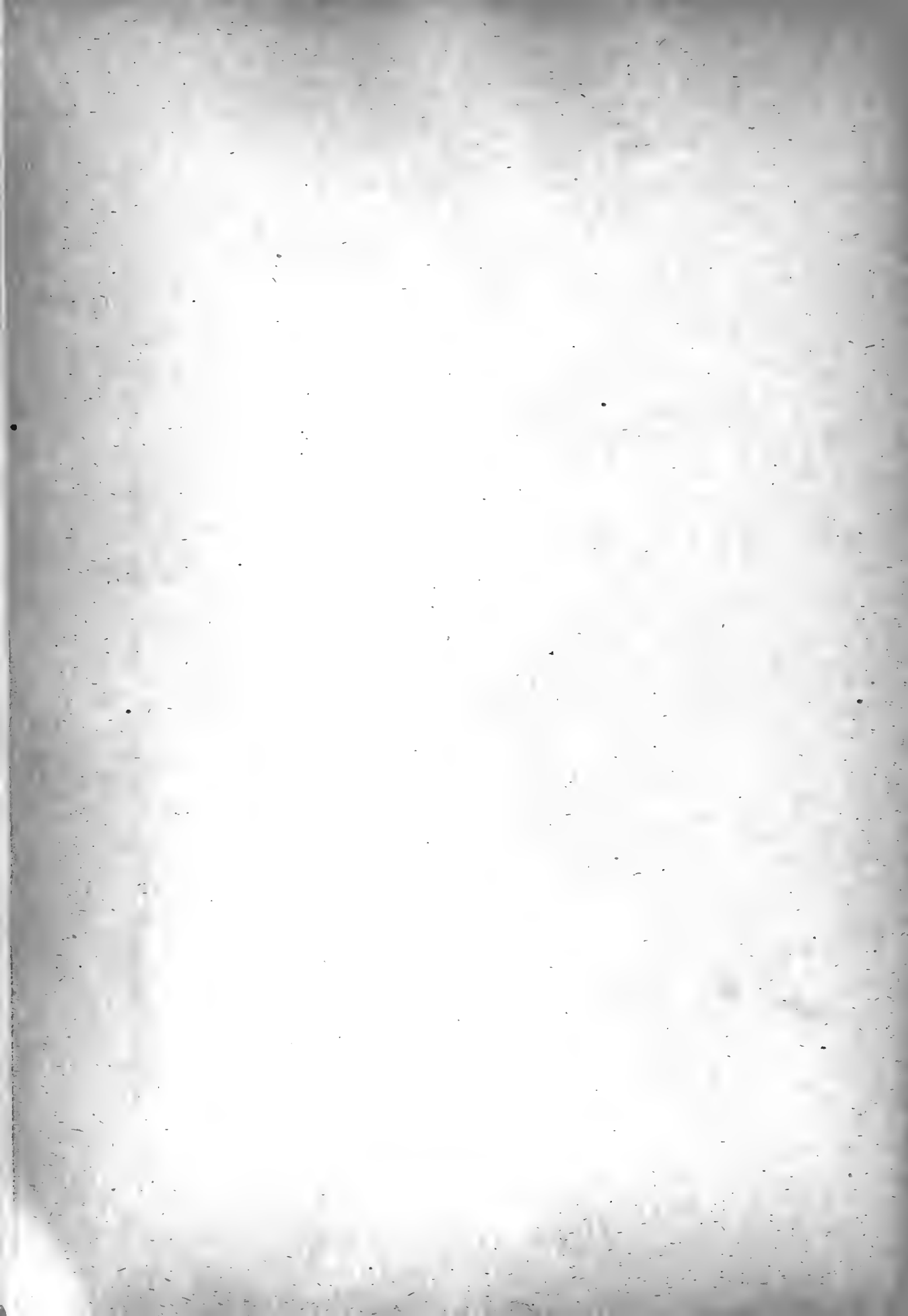
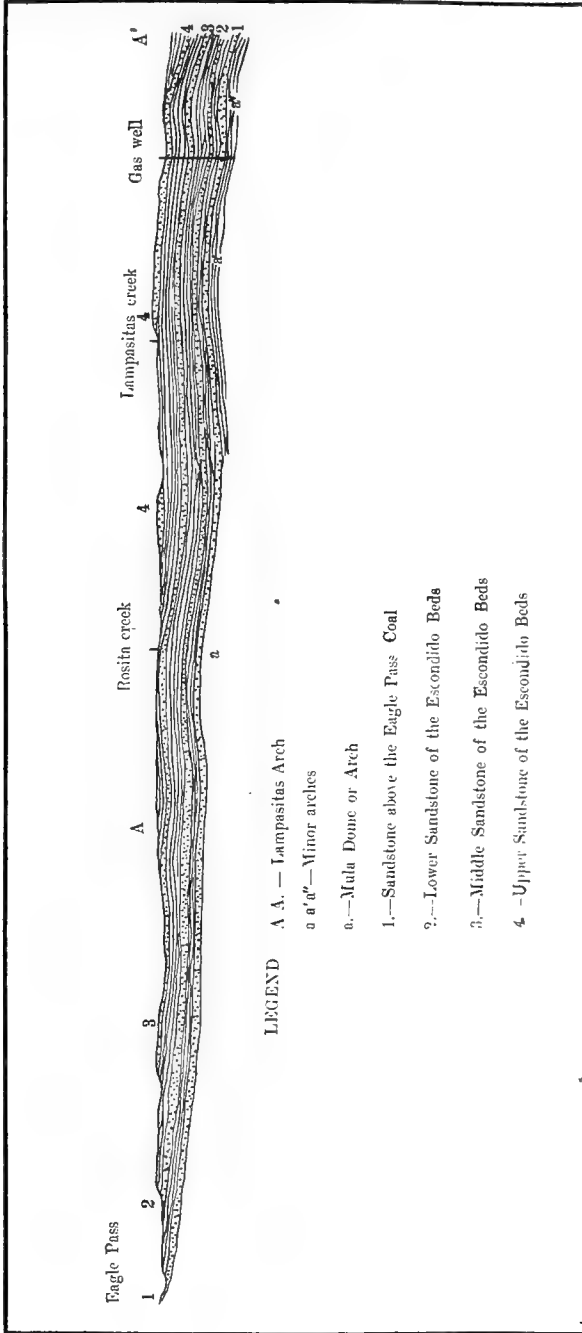


PLATE III.



LEGEND

A A. — Lampasitas Arch

a a' a'' — Minor arches

a. — Mesa Dome or Arch

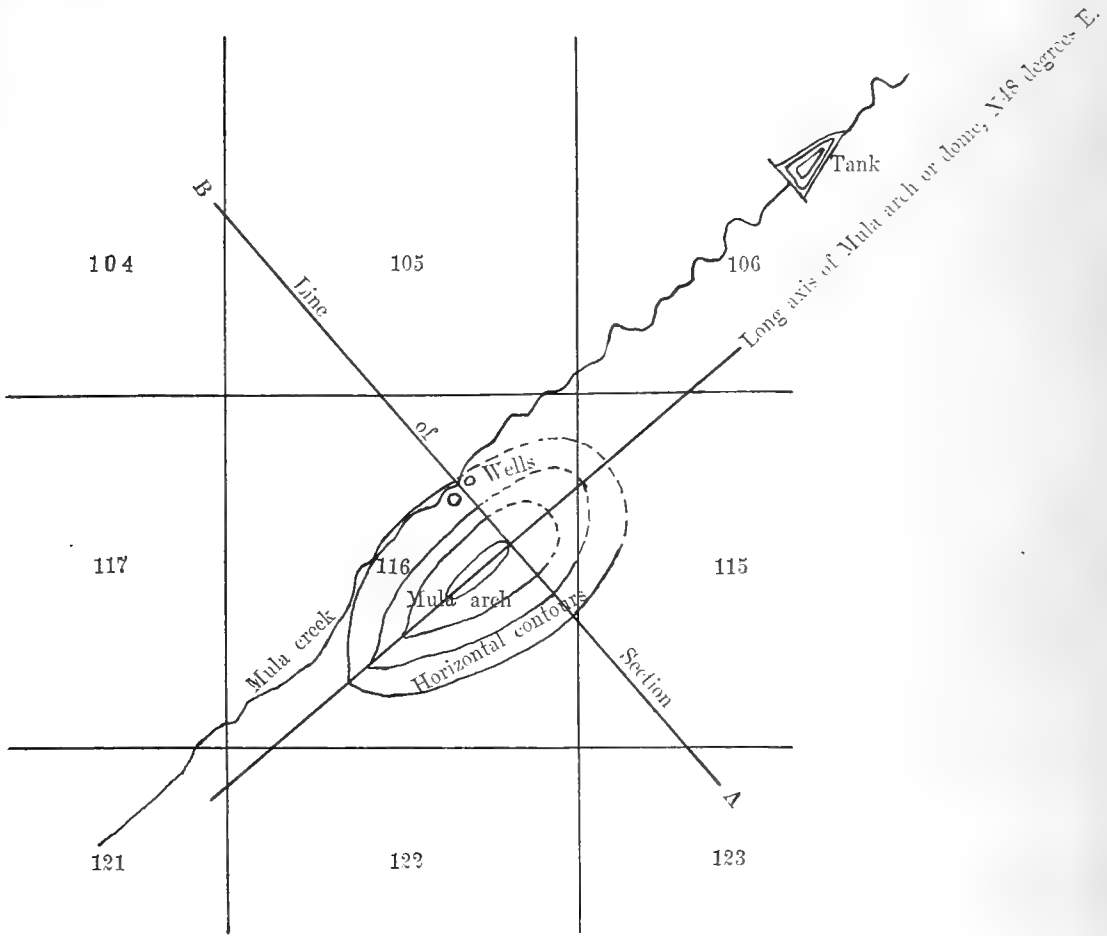
1. — Sandstone above the Eagle Pass Coal

2. — Lower Sandstone of the Escondido Beds

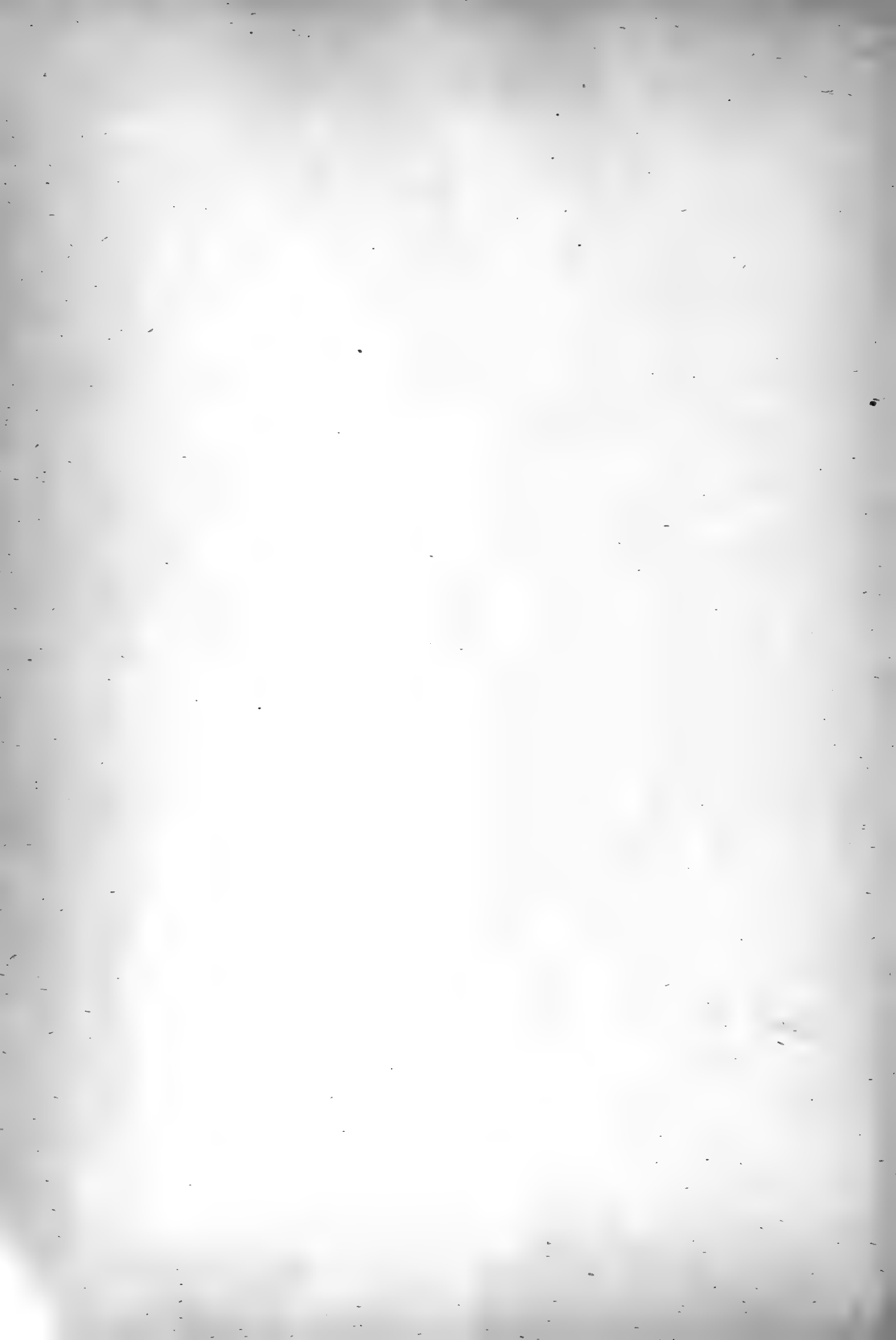
3. — Middle Sandstone of the Escondido Beds

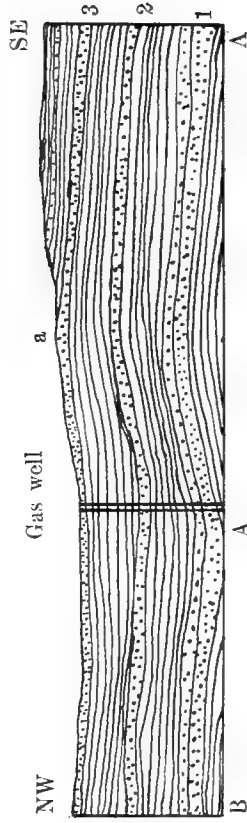
4. — Upper Sandstone of the Escondido Beds

DIAGRAMMATIC SECTION OF THE LAMPASITAS ARCH.



POSITION OF THE MULA ARCH. THE LINE A—B SHOWS THE POSITION OF THE SECTION IN PLATE VI.





LEGEND

A. A. — Mula Arch

1. Gas bearing Sand (basal sand of the Escondido beds and sandy member of the Coal series?)

2. Middle Sands of the Escondido beds


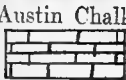
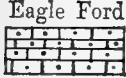



3. Upper Sandstone of the Escondido beds

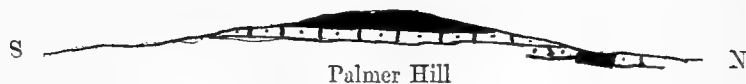
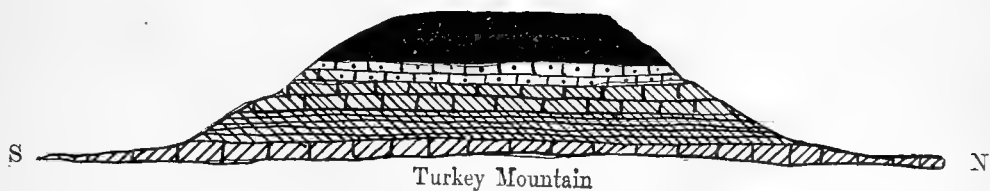
a. Axis (longitudinal)

STRUCTURE OF THE MULA ARCH.



LEGEND

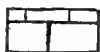
- Igneous

- Austin Chalk

- Eagle Ford

- Buda

- Del Rio

- Devils River




RELATION OF THE IGNEOUS ROCKS TO THE SEDIMENTARY ROCKS. SECTIONS
RUNNING FROM NORTH TO SOUTH.

LEGEND

Devils river Limestone



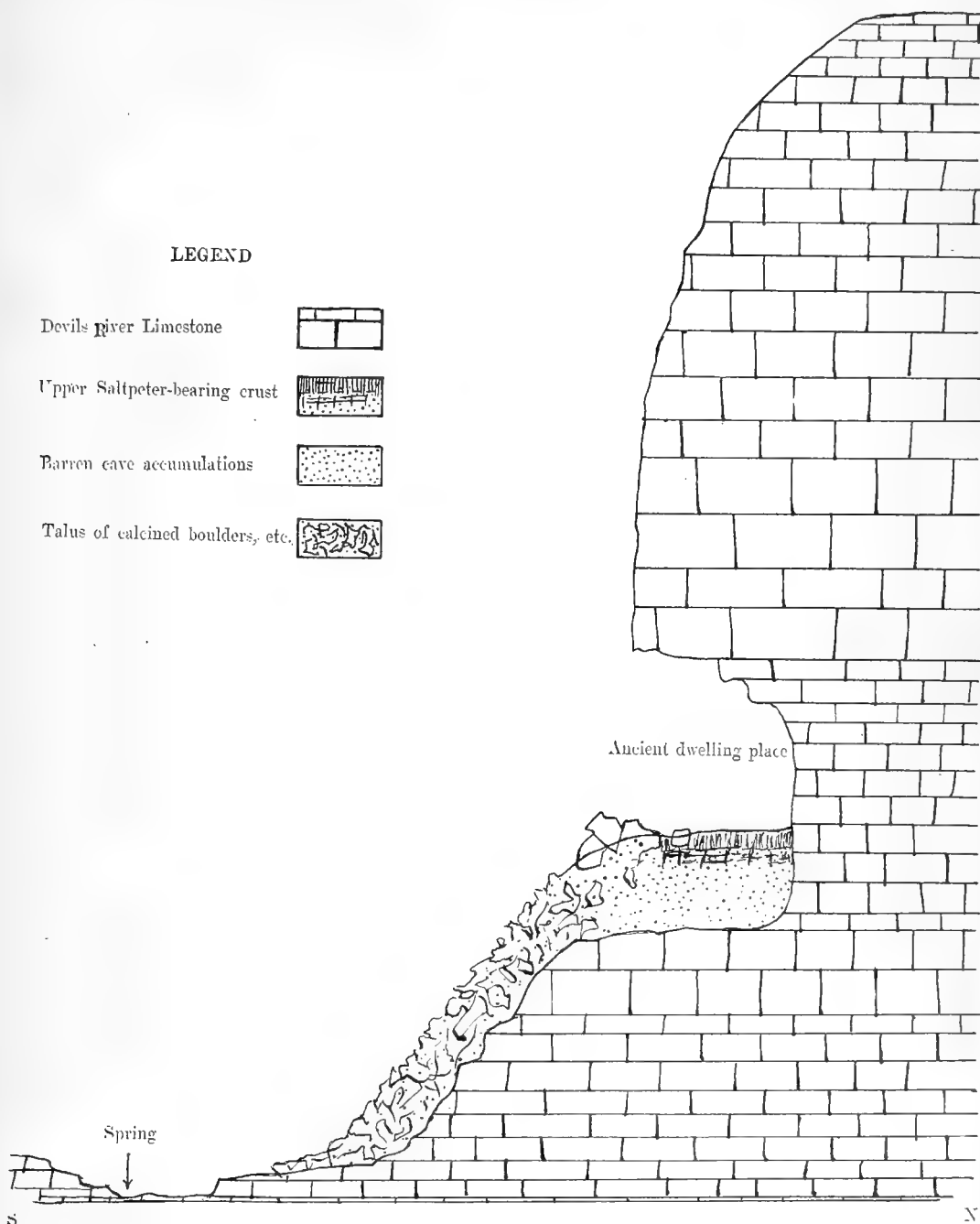
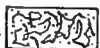
Upper Saltpeter-bearing crust



Barren cave accumulations



Talus of calcined boulders, etc.



SECTION OF THE SALTPETER "CAVE," $\frac{5}{8}$ MI. NORTH OF THE MOUTH OF INDIAN CREEK,
ON DEVIL'S RIVER.

A GEOLOGICAL MAP
OF THE
LAND BELONGING TO
THE NEW YORK AND TEXAS LAND COMPANY LTD.
In the upper Rio Grande Embayment Texas

BY
J. A. UDDEN Geologist
1906.



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NUMBER 7

Genesis and Development of Sand Formations on Marine Coasts

BY

PEHR OLSSON-SEFFER, PH. D.

The Sand Strand Flora of Marine Coasts

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PUBLISHED

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The building is a modernized version of the Italian renaissance, built most substantially of Missouri limestone of a beautiful texture and extremely hard quality. The foundation is of concrete. The roof is tile. The first story is treated as a base to the upper story, which contains the large reading room extending across the front. In this reading room are five windows on the front, which is 120 feet, giving the structure a massive appearance. In the first story are located the administrative offices, a memorial hall, and a lecture room. The building is ninety-six feet deep through the middle part, the rear being an addition containing the book stack which will hold 120,000 volumes, the librarians's room, and several seminar rooms. In the basement are stove rooms and a rest room for girls. In the attic is a museum room.



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Genesis and Development of Sand Formations
on Marine Coasts

by

Pehr Olsson-Seffer, Ph. D.

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Genesis and Development of Sand Formations on Marine Coasts.

By Pehr Olsson-Seffer, Ph. D.

Since the year 1891 I have been studying the sand formations on marine coasts and their flora and vegetation. During the years 1891 to 1899 my investigations were confined to the coasts of the Baltic. The last mentioned year I also investigated the dunes on the Danish North Sea Coast, in Holland, and in certain parts of Scotland and France. In 1900—1901 observations were made in Southern Sweden, in various places in Denmark, on the South Coast of England, in Southern Italy, at Port Said, in Egypt, in Western Australia, and in Queensland.

Various coasts in Australia, from Central Queensland to Western Australia, through New South Wales, Victoria and South Australia, were visited and re-visited during 1902. In New Zealand only part of the North Cape was made subject to a brief and hurried visit and notes of the strand vegetation were taken during stays in various islands of the Pacific, such as the New Hebrides, Solomon Islands, Samoa and Hawaii.

On the Pacific coast of North America the dunes at San Francisco and Monterey Bay were studied in 1903—05. During 1905, I also visited the coastal sands at Santa Barbara and Santa Monica, in Southern California, as well as several sand dune districts on the Pacific coast of Mexico, such as Salina Cruz, in the innermost part of the Gulf of Tehuantepec, and San Benito, near the Guatemalan border. The extensive sand dunes near Vera Cruz, in Mexico, on the Gulf side, were investigated in August of the same year. In December, sand strands were studied at Mazatlan, a Mexican port on the eastern shore of the Gulf of California, as well as at San Blas in Mexico and Champerico in Guatemala.

The large field these observations cover have given me ample opportunity to make comparisons of the coastal sands in various climates

and under the most different natural conditions. In the present paper I propose to deal briefly with some of the marine sand formations, their origin, development, and classification, so far as it is necessary to demonstrate the most fundamental facts of this subject and the principles on which they are based. I also give short comments upon the principal dune districts visited in the course of my studies.

To PROFESSOR WM. R. DUDLEY of Leland Stanford Junior University I am greatly indebted for many favors in connection with my work, and I have also to express my acknowledgments to DR. JOHAN ERIKSON, Karlskrona, Sweden, DR. K. R. KUPFFER, Riga, Russia, DR. W. J. SMITH, Leeds, England, B. H. WOODWARD, Esq., F. R. G. S., Perth, Western Australia, C. E. BENBOW, Esq., C. E., Sidney, New South Wales, DR. L. COCKAYNE, Christchurch, New Zealand, and various other persons, who have assisted me with information and photographs.

SAND FORMATIONS IN GENERAL.

When we consider the factors which have given rise to the formation of sand, the principal ones are the atmospheric and the aqueous agencies, which also are the most important in transportation and distribution of the material. It will therefore be convenient to distinguish between the following general classes of sand deposits:

1. Eolian sand formations.
2. Neptunian sand formations.

The term eolian in this connection was to my knowledge first used in 1835 by *R. J. Nelson*¹⁾ and it signifies the agency of wind. Eolian deposits exhibit a different composition and structure from the neptunian, those sediments which have been built up by the water. The transporting power of water being considerably greater than that of wind, it necessarily follows that the material moved by aqueous agencies varies more in size than that which is carried by the wind. We will have ample opportunity to note this difference as we proceed in our inquiry.

No rational nomenclature for the different kinds of soil constituents, neither of inorganic nor of organogenetic origin, has yet been agreed upon, and it will thus be necessary to give here the designations which have been used during my observations in the field.

1) Proceedings of Geological Society of London, Vol. II., p. 160.

Diameter of grains in millimeters.	
Fine dust or silt.....	0.02— 0.03
Medium dust or silt.....	0.03— 0.05
Coarse dust or silt.....	0.05— 0.1
Finest sand	0.1 — 0.2
Fine sand	0.2 — 0.3
Medium sand	0.3 — 0.5
Coarse sand	0.5 — 1
Grits	1 — 2
Gravel	2 — 4
Coarse gravel	4 — 6
Pebbles	6 — 10
Coarse pebbles	10 — 20
Shingle	20 — 50
Stones	50 — 250
Boulders	250 — Upwards.

The limit of the coarseness of sand grains is here considered as 0.2—0.1 mm. When the grains are finer than 0.05 mm., the soil¹⁾ has lost the physical properties of sand. It does not feel gritty to the fingers, and if it is dropped on a level and hard surface the grains will not separate but congregate in small heaps. It needs several minutes to sink in water to the bottom of a test tube. When over 0.05 mm. the soil has, however, more of the characteristics of real sand. It is then gritty, when pulverized between the fingers. If scattered dry, it will separate into grains conspicuous to the naked eye. When mixed with water in the test tube, it sinks rapidly, usually in less than one minute, and it is to a noticeable degree conductive of water. It is difficult in practice to draw the lower limit for sand of a certain coarseness, because the soil is more or less mixed. On account of the difference in specific gravity of the grains many samples contain grains of different grades.

In the above table the measurements of diameter refer to the average sized grains in each class. The term sand has here been applied to soil, the grains of which are under 1 mm., while a coarseness of 1—2 mm. has entitled the soil to the name of grits. When the chief ingredient is particles larger than 2 mm. and below 6 mm. the soil has been designated as gravel.

Common sand is 2,100 times heavier than dry air, while only 2.5 to

1) The term soil is in this paper used in its broadest technical sense to designate the loose material constituting the disintegrated superficial layers of the earth's surface.

2.7 times heavier than water. A strong breeze is therefore required to raise the dust of a road for transportation by the wind, and a still stronger breeze to raise quartz sand; while large pebbles are seldom lifted from the ground. The winds are also extremely irregular in their movements and action. The trades over the ocean have a higher degree of uniformity than other winds, but the velocity is generally only 10 to 20 km. an hour. The winds that do the chief part of eolian geological work are those of storms, whose velocity per hour is from 50 to more than 100 km. Such winds are very unsteady in their action, blowing in gusts, in which there is a sudden increase to a maximum and a slower decline to a minimum. There is no constancy in force even for an hour, and no uniformity over large areas.

The transporting power of water, on the contrary, is very great; strong waves or torrents being able to move rocks weighing hundreds of tons. By experiments it has been found that a current moving at the rate of 25 cm. per second is able to carry fine sand, while a velocity of 50 cm. is sufficient to transport coarse gravel. The action of water is, moreover, very constant as a rule, and the waves on a long coast, for instance, exert their uniform influence over a considerable area.

We must not, however, confound the transporting power of these agencies, wind and water, with their erosive power. In one case it is the weight, in the other the cohesion, that offers the resistance. Neither wind nor water has any greater erosive power by itself. It is where mud or sand is carried by the wind or water, that a friction arises which removes the particles, loosened by decaying and other processes, from their original place.

Water is efficient in denudation by 1) dissolving of rocks; 2) transportation of the material which assists in the eroding work, and 3) carrying away the debris. The analogous functions of wind are: 1) transportation of the material which triturates and erodes all substances in its way, and 2) distribution.

A water current when overloaded with solids will deposit; when underloaded it will erode. A sandladen wind always both cuts and deposits. Dry sand, wind borne, is an unobtrusive agent, working silently but diligently on the task of paring away the surface. It leaves no monuments to show the magnitude of its results, as does denudation by water. River beds and sandbanks are examples of the excavating and building up through sedimentation by the water.

Water is a base leveler in the sense that it transfers material from higher places to lower; but where it erodes, it always works more rapidly

along the lowest lines and leaves ridges and islands, by which its results can be measured. The water currents have, at any one spot, but a single direction, and the furrows and mouldings of the curved surface are grouped in a single system; but the wind may blow in many directions, and produces series of corresponding complexity.

It is a well known law in dynamical geology that all sedimentary deposits are stratified. This lamination is somewhat different when caused by eolian influence than when resulting from the action of water. The sorting power of water is more distinct than that of wind, because of the greater regularity of water currents.

As a consequence of the rapid variations to which the transporting power of the wind is subjected, eolian deposits are generally straticulate, finer and coarser laminae succeeding each other in indefinite alterations. But there is not the evenness of layer characterizing aqueous deposits, even when made over level surfaces. To make beds without straticulation would require winds without these irregularities,—little varying and long continuing,—such as few regions have, except those that have winds of too moderate velocity to carry any but the finest particles. The gusty winds also tend, by their denuding as well as transporting work, to make wavy rather than plane upper surfaces. Moreover, any barrier, as a projecting rock or a stump, or a tuft of grasses, causes a heaping of the sands around the obstacle, and makes curving surfaces in the heaps, owing to the eddies in the air.

We must here consider the following kinds of lamination:

- 1) horizontal
- 2) oblique
- 3) flow- and plunge
- 4) irregular.

Horizontal strata are developed in water only, especially in non-running water. Each lamination here represents different conditions of the water in which the sediment is deposited, and oblique lamination or cross-bed structure is a result of deposition by rapid shifting currents, carrying material of varying coarseness. While strictly horizontal lamination cannot be formed by winds, obliquely laminated layers occur in eolian deposits, indicating that somewhat regular winds have blown for some time.

This cross-bed structure of the sediments is characterized by a lamination in a plane, oblique to the horizon. It results from the pushing along of the sand by currents, causing at first a little elevation, and

then the deposition of successive layers over the front slope of the elevation. If the currents are transient, alternating with conditions of still water, the obliquely laminated beds will alternate with others horizontally laminated. Such laminations may be due to changes of wind or tide, or to the periodical or occasional fluctuations in the volume of rivers.

The flow- and plunge structure has been caused by plunging waves accompanying the rapid flow of a current, through which action the oblique laminae have been broken up into short, wavelike parts. This lamination bears evidence of being the result of an agent less variable, and moving slower than that which has formed the irregular structure so characteristic of most eolian deposits.

THE DEVELOPMENT OF COASTAL SAND FORMATIONS.

The sand formations, which will come under discussion in connection with our present subject, all have their origin ultimately due to the action of the sea. We can conveniently divide these marine formations into following groups:

1. Submarine sand banks.
2. Sandy islands.
3. Sandy spits.
4. Sandy beaches.

1. The first class of formations or submarine sand banks are formed by the combined action of streams and the waves of the sea, or by the latter alone. Most of these accumulations contain more or less of river detritus, which is brought down to the sea during floods. The ocean's waves and currents meet it as the tide sets in, with a counter action, or one from the sea landward; between the two the waters, as they lose their velocity, drop the detritus over the bottom. Where the river is very large and the tides feeble, the banks and reefs extend far out to sea. Where the tide is strong, sand bars are formed, and the stronger the tide, the closer are the sand bars to the coast. Where the stream is small, the ocean may throw a sand bank quite across its mouth, so that there may be no egress to the river waters except by percolation through the sand; or, if a channel is left open, it may be only a shallow one.

In other cases the material constituting the sand banks is derived

from the land through the erosion and transportation of waves and currents. This material consists usually of coarse or fine sand, but may include some beds of pebbles or stones when the currents are strong. The stratification is comparatively regular and nearly horizontal.

2. When the accumulations just spoken of increase under wave-action in shallow water, until they rise above low tide level, they form sandy islands.

3. Sandy spits are the lengthwise extensions of beaches formed through the waves throwing material on shoals at the turn of the shore. Their composition is similar to that of the above formations.

4. Sandy beaches are made by material thrown up on the shore by waves. This material is coarse where the waves break heavily, because, although trituration is going on at all times, the powerful wave action and the undertow carry off the finer material seaward into the offshore shallow waters, where it settles over the bottom or is distributed by currents. It is fine where the waves are gentle in movement, as in sheltered bays, or estuaries, the trituated material accumulating in such places near where it is made.

As soon as the accumulations of eroded material have increased so far as to rise above the surface of the water, the further growth is similar to that of the beaches, and from these latter other coastal sand formations such as dunes and sand fields are developed by the influence of wind. The development of these two kinds of eolian sand formations will be discussed in detail under separate headings.

It is a well known fact that the salts of seawater hasten the deposition of sediments, and consequently the shape and formation of sand banks and beaches on marine coasts is somewhat different from those of corresponding freshwater deposits. I have not been able to ascertain whether the seawater acts differently on siliceous material than on clay sediments. We usually find that deposits nearer the shore or the source of the material contain more silica than further out in the deep water, but this may depend on the usually large size and the greater weight of the siliceous fragments, which causes them to sink sooner.

In order to determine this, experiments were conducted in the laboratory. I tried ordinary seawater from the Baltic, of a salinity of 0.6% measured with areometer, and artificially prepared solutions of resp. 2.7% and 3% corresponding to the salt content of ocean water. Finely ground clay and beach sand were stirred in the water samples, and allowed to settle in vessels 25 cm., 50 cm., and 100 cm. deep, all being 42 cm. in diameter. The following results were obtained:

Depth of vessel.	No. of vessel.	Salinity of water per cent.	Hours for settling.	
			Silica.	Clay.
25 cm.	{ 1	fresh	29	38
	{ 2	0.6	10	12
	{ 3	2.7	2	2.5
	{ 4	3.0	1.75	2.25
50 cm.	{ 5	fresh	42	50
	{ 6	0.6	14	16
	{ 7	2.7	3	3.75
	{ 8	3.0	2.50	3.25
100 cm.	{ 9	fresh	68	84
	{ 10	0.6	24	30
	{ 11	2.7	5	6.25
	{ 12	3.0	4.25	5.25

As will be seen from this table, silica in all cases both in salt and fresh water settled faster than clay. Whether this fact was merely a result of a greater weight of the siliceous particles, or whether other factors influenced the sedimentation, I was unable to decide. At all events it was evident that the salt produces a considerable flocculation in the water. The primary cause of the growth of the deposit in water is sedimentation, but in many cases the rising of the level of the coast-line has to be taken into consideration as a secondary factor. It is often difficult to determine to what extent the rate of growth of a deposit is due to one of these factors or the other. Especially is this the case on a low coast, where the growth always takes place more rapidly than on a steeper shore. The horizontal growth of the deposit is also much greater on coasts protected by islands than on open coasts with deep water, where the material is more easily carried away.

With regard to the position of the marine sediments it will be noticed that they are apparently horizontal, and the tendency is to level the beds through filling all depressions. The coarser sediments are always nearer the shore in comparatively narrow lines, parallel to the coast, whereas the finer sediments are spread over a larger area further off the shore. Banks and beaches are always sloping gently seawards, and they are, perhaps, somewhat steeper on marine coasts than on fresh water shores, general conditions being equal.

We have here also to consider the peculiar results of the wave-action of both water and wind, which are generally known by the name of ripple marks, a term introduced by *Lyell*.

The phenomena of rippling have in recent times had a careful observer in *Cornish*, and the following statements are principally based on his studies of this problem, although the laws and facts presented by him have been subjected to a detailed investigation in the field by the present writer, and I am able in a few instances to bring forward some evidence in support of *Cornish's* theories.

The same factor which causes the wave formation of water has a similar influence on the sand. The resulting wave-forms or ripples consist of alternate ridges and furrows made by the wash of the waters over a sand flat or beach, or over the bottom within soundings. They may also be made by the action of wind on a surface of sand. When the ripples are formed through the action of water we can distinguish between

1. wave formed ripples,
2. current made ripple marks, and
3. tidal sand ripples.

The parallel formations of wind made sand waves are

4. eolian sand ripples, and
5. dunes.

Comparing waves of water with those of a more solid medium, such as sand, we find that, while in the case of water two kinds of waves, oscillatory and wind driven, can be recognized, wave formation in sand is always connected with onward movement of the particles. In oscillatory waves the water particles on the crest are moving forward, but those in the trough backward with the same velocity and consequently the water body as such does not move in either direction. It is customary to express this motion by saying that the particles move in a circular orbit. When the waves are wind driven the forward velocity is greater than the backward, and a bodily movement of the water in the direction of the acting force is the result. The curve described by the water particles is still closed, having a trochoidal form. In the case of drifting sand the particles from the crest of the wave move in curves, which are open.

Wave-formed sand ripples have an unsymmetrical form, always facing with the waves. Current made ripple marks are similarly unsymmetrical in form, the sheltered side being steeper, and the front facing the cur-

rent. Tidal sand ripples, first described by *Reynolds*¹⁾ and later by *Cornish*²⁾ occur in estuaries and also on some shores where the sand is exposed to waves as well as currents. *Cornish* is of the opinion that they do not require for their formation any cooperation between flood and ebb currents. The size and form of these ripples is constantly changing with the variations in the tide. *Cornish* describes this in the following words:

“At neap tides the sands were nearly smooth, and as the tides increased the tidal sand ripples appeared, short and relatively steep. The amplitude increased steadily, the average wave-length also increased, apparently by elimination of some of the ridges. When the highest spring tide was passed the amplitude rapidly diminished, the wave-length remaining nearly, but not quite constant, and the mean sand level remaining practically unchanged.”

Tidal sand ripples sometimes attain a considerable size, *Cornish* giving the wave length of from 1 to 6.7 m. I have often noticed a finer rippling of the proper tidal ripples, and in two instances, on the eastern coast of Australia, I observed the tidal sand ripples crossed by another set of large ripples. These were formed by a sudden change of the direction of the tide current through the overflow of a neighboring stream. Both these sets of wave formations were then beautifully rippled in the usual way by little current marks, facing almost transversely the second set of larger ripples. *Cornish* attributes the formation of current marks to the pulsation of the fluid rather than to the current itself.

In the formation of eolian sand ripples it is the heterogeneity of the material which is of the greatest importance. The sorting action of wind is remarkable, and it is evident at the first glance on a group of ripples that the heavier grains always constitute the crest, the lighter the trough. A moderate range of sizes of grains seems therefore most favorable to the formation of ripples.

*Darwin*³⁾ remarked the uniformity of pattern in the ripples formed by wind, which uniformity, as a rule, is absent from ripples made in

1) Reports of committee appointed to investigate the action of waves and currents on the beds and foreshores of estuaries by means of working models. — British Association for Advancement of Science, Reports '89, '90, '91.

2) The formation of wave surfaces in sand.—*Scot. Geogr. Mag.* 17: 1—11. 1901.

3) *G. H. Darwin*: On ripple mark. — *Proceedings of Royal Society*, London, vol. 36. 1883.

water. When the wind blows upon the sand, a winnowing process takes place, the finer particles being carried farther away than the coarser material, which then produces the ridges of heavier grains mentioned above. This uniformity of pattern connected with the fact that the wave length increases with the time during which the force of the wind is acting upon the sand led *Cornish*¹⁾ to advance the following law for rippling by wind: *The rippling takes place when the eddy in the lee of the larger grains is of sufficient strength to lift the smaller.*

The systematically corrugated surface of loose sand can only be produced by a wind that is not too strong for the larger grains to remain on the ground. If the breeze is too strong no rippling whatever takes place as all the particles of sand then will be transported. If on the other hand the wind is too weak to make an eddy, the sand moves slowly, but does not form ripples.

The height of the waves and their distances from each other is larger the larger the grains are. The movement of the waves is of different rapidity and depends on the force of wind and the size of the grains. It is naturally more rapid when the wind is stronger and the sand fine. Following results were obtained by the author from a number of measurements of amplitude or height of ridge and wave-length of sand ripples made by wind on the coast of West Australia. All measurements are given in millimeters:

No.	Coarseness of grains.	Amplitude.	Wave length	Number of measurements of which sample is average.
1.	0.7	8.6	36	34
2.	0.6	3.1	29	6
3.	0.4	3.7	34	3
4.	0.3	2.5	47	14
5.	0.8	6.2	40	8
6.	0.6	4.4	39	6
7.	0.7	8.7	51	25
8.	0.8	8.3	68	21
9.	0.6	14.6	82	19

These measurements serve to support the results obtained by *Cornish* and the law advanced by him, that *amplitude and wave-length increase*

1) On the formation of sand dunes.—*Geographical Journal*, vol. IX: 280.

in same proportion. His other conclusion that regular rippling has an amplitude of three grains from trough to crest, seems to me rather hasty. I have, however, not made any regular observations to test this statement, it being of minor importance in connection with my present inquiry.

For the study of wave forms, which as a legitimate subject for investigation has attracted the attention of several scientists since the time of *Newton*, *Cornish* has proposed¹⁾ the term *Kumatology* ($\kappa\upsilon\mu\alpha$ -wave).

Accepting this name for the sake of convenience, the writer has to point out that the digressions here made into the domain of *Kumatology* have been necessary in order to arrive at a better understanding of the factors which control the movements of sand, the interpretation of which is in many respects still contradictory.

SANDY BEACHES.

The beach may be defined as that strip of the shore which is formed by the agency of waves. As a rule, it is situated between the lowest level of the water and the formations produced by other geological agents.

The method of beach formation has already been indicated. It was mentioned that the mechanical action of the sea is evidenced in the phenomena of erosion, transportation and sedimentation. The eroding action of the sea is especially prominent on steep rocky shores, and on places where the difference between low and high tide is great.

The material from the rocks eroded by the waves as well as the sand and silt carried down to the rivers, sinks to the bottom of the sea and is again transported by the waves and currents to the coast, there to be accumulated. Although the transporting power of the waves is immensely great, the distances to which rocks or even sand can be carried is limited. In sediments of a clastic nature a sifting takes place through the action of the waves against the shore, the finer material being carried farther away, while the coarser is left on the shore. On very steep shores, only larger pebbles and gravel are found, on lower fine sand, and on very low coasts, silt.

If we consider the movements of the sand on a low shore, we will

1) *Geographical Journal*, March 1897 and June 1898.

notice that the sand grains follow the movement of the waves, that is roll up and down. The deposit of sand takes place only when the returning current does not carry back all material brought forward by the wave. It follows that the velocity of the forward movement must be greater than that of the returning current which is possible only on very low strands, the sloping angle of which is not greater than five degrees. If the size of the grains is large, the angle naturally also changes. At the limit to which the wave reaches, an instantaneous absorption of the very thin strata of water takes place in the sand, so that the returning current does not begin at this limit, but at a place lower down. It is easy to determine the width of this belt in which the absorption takes place, as the sand surface first is shining by the water and then quickly turns dull. The width is always varying, and is in direct relation to the strength of the waves, and also to the sloping angle of the beach. During a strong gale and on a very low strand, this belt is from 2 m. upwards on the Baltic coast, and on the western coasts of Australia and the Pacific coast of America, where the mighty waves of the ocean strike the shore with all their force, this belt is still much broader. Secondly, deposits take place only on coasts, the sloping angle of which is not more than 5 to 10 degrees. This angle is about 5 degrees with a grain size of 0.5 to 1 mm. in diameter. With finer sand, under 0.5 mm., as is the case on many places on sheltered shores on the Baltic coasts, it sinks to between 1 and 2 degrees, while with larger grains, from 1 to 3 mm., an angle of 7 or even 8.5 degrees is formed. With a steeper slope, deposition does not take place, but a denudation is commenced.

Sandy beaches afford a certain protection of the coast line against the erosive action of waves and surf. During the constant landward urging of the sediments the coarser ingredients of the arenaceous material soon cease to roll, and come to rest, and as the deposits are augmented they will offer sufficient resistance to reduce the energy of the wave, and consequently the erosion is diminished.

That beach sands remain unworn depends to a great extent on the fact that the particles do not touch each other, as each one is surrounded by a film of water. The beating of the waves also compresses the interstitial water, and the solitary grains are thus not tossed about and therefore do not grind and wear.

The presence of a considerable amount of interstitial water in the beach sand washed by the waves is demonstrated when through the pressure of the foot on the sand this whitens because of the expulsion

of water, while as soon as the foot is lifted the original dull color is quickly resumed.

Very fine sand is angular, and the rounding by water is produced only when the strength of the current is not sufficient to keep the grains suspended, but yet capable of moving them. The specific gravity of the volume of sand is always smaller than that of the solitary grains. The latter leave between each other spaces which are filled with air and water; if all the grains were of the same size and exactly spherical, the specific gravity of the volume of sand would be independent of the absolute size of the grains, but as soon as grains of different sizes are mixed, the small grains fill the spaces between the larger and hence increase the specific gravity. This latter is also, the mineral character of the grains being equal, higher the more dissimilar the grains are.

The texture of the sand in each locality depends entirely upon the nature of the rocks from which it was originally derived. Through having a comparatively large mixture of different sizes, and consisting of the most different minerals of different specific gravity, beach sands exhibit considerable differences in texture. On almost every non-rocky coast, however, some kind of accumulation of fine grained quartz sand can be noticed.

By quartz sand we understand a soil consisting mainly of white or yellowish quartz grains, among which only very seldom any organic matter is distributed. Being conspicuously free from foreign constituents, quartz sand is very uniform. It is generally believed that the pure quartz sand on marine shore is a special result of the action of the sea. This is, however, not the case. I have examined many samples of the littoral sediments on different coasts, but never found the clean white quartz sand of the beach occurring on the bottom of the sea. On the contrary, the sandy sediment under water is impure, mixed with organic matter, and highly colored. As soon as the sand is thrown ashore by the wave and current action, and left at the water level, it is picked up by the wind and carried inland. And if we observe the sand of the beach from the edge of the water landward, we will find that it becomes cleaner the further it is from the sea. This fact is mentioned by several authors; for instance, *Serres*,¹⁾ who speaks of it in discussing the French Mediterranean coast. Beach formations are very irregular in stratification in their upper portions, where they are made by the toss

1) *Marcel de Serres*: Der Treib- und Flugsand des Mittelländischen Meeres. —*Peterm. Mitth.* V: 197—198. 1859.

of the waves combined with the drifting of the winds. But the sloping part swept by the waves below high-tide level is very evenly stratified parallel to the surface: This surface dips usually at an angle of 5° to 15° . Generally speaking the coarsest beaches have the steepest slopes. The sand of the beach is increased or decreased according to the weather and the seasons, it being thickest in summer and thinnest in winter, and sometimes the beach is almost stripped of sand after a series of gales. On the beach, there is formed a ridge of sand during offshore winds. The sand is readily raised by the breakers and usually an excavation or trough is found at the back of the ridge. This is similar to the excavation and elevation produced in ripples. When the wind goes down, a succession of low ridges are formed concave on the side toward the sea, but as soon as a wave reaches over the top of the ridge, the concavity is filled and an edge with uniformly sloping sides is formed. The height of this beach ridge is usually not very considerable on the Baltic coasts; seldom more than 1.5 m. over the general level of the beach, or 2.25 over the sea. On the Atlantic and Pacific coasts, the height is not much greater, although the ridge is formed by breakers of considerable strength.

When the breaker line has been stationary for some time, for instance during a high tide, an excavation is dredged out, and at ebb a lagoon is often left here. For our purposes the beach may be divided into the following belts: 1. *The submerged beach*; 2. *The front beach*; 3. *The middle beach*; and 4. *The upper beach*. The first belt includes that portion of the beach that lies below mean low tide, but which may be exposed by neap tides. It is normally covered with water, and is subjected to the constant beating of the waves, which carry the material ashore in their landward advance. Some of the detritus is deposited, while another part is returned seawards with the undertow. Where the carrying power of the surf is great, the beach is often built up by material containing a considerable amount of coarse gravel and pebbles. On such beaches there is always a residue of mud after a storm or an exceptionally high tide, while no such deposits occur on sand alone. The front beach is the belt between mean low tide and mean high tide, being alternately each day exposed to the air and submerged. It mostly passes without any marked break into the submerged belt. Situated on the border between the land and water the front beach offers very unfavorable conditions, not allowing the deposits to remain stable or resting, on account of the repeated washing of the waves and currents.

With the term middle beach we would designate that portion of the

shore which is continuously moistened by the spray from the sea, and it may even occasionally become inundated. The sand of this formation which has been piled up by the waves, is picked up by the wind and carried inland. It is usually of a light color. The upper layers are rapidly drying up, but the ground water keeps at a high level, and moisture is usually found at a very slight depth.

The upper beach is limited on one side by the line of debris that marks the highest water. This debris, cast up by the sea, consists of lumber and other wooden articles, fruits and seeds, fragments of marine plants, and a quantity of animal remains, rapidly decaying. The upper beach is also characterized by a greater rise in elevation and contains more organic matter than any other part of the beach. The development of this formation is modified to a greater extent by the wind than by water, and it is especially on this strip of the shore, where the sands commence to drift, and where they usually form the first ridges of sand parallel to the coast, which we know as dunes.

The windmade embankments on the beach have a remarkable construction, somewhat different from the usual. When the shifting of the sand is very rapid, the littoral dunes do not reach any remarkable height, and their existence is then very precarious.

DUNES.

The etymology of the word dune is somewhat obscure. Generally it is presumed that it is derived from the Celtic word *dun*, hill. In Latin it is called *dunum*, in Greek *δύννον*, and hence the modern languages have acquired the use of the same term in more or less changed dress. According to *Grewingk*, not every ridge of sand parallel to the coast is a dune, as they can in some cases originally be sand-banks formed under water, which later have been lifted above the surface of the water through the elevation of the shore. Dunes are formed especially where the sands are almost purely siliceous, and hence incoherent, and little fit for any kind of vegetation. They reach their greatest height on projecting coasts that receive the winds from different directions.

The source of the dune sand is usually either diluvial sand, which has been laid bare, or sand which has been brought ashore by the sea.

On the Dutch and Danish west coasts almost all the sand which forms the dunes traces its origin from the sea. It is here thrown up on the beach by the waves, and as soon as it has been dried by the sun,

the wind carries it further inland. On the coasts in question, the westerly winds are the prevailing, and therefore the sand wanders in an easterly direction.

Because of their extreme shiftiness of soil, the dunes do not attain any considerable elevation. The sand deposited by the wind on the summit of the hill is always in a state of unstable equilibrium. It has a constant tendency to be precipitated down the other side, and the higher the summit, the greater is this tendency, so that the dune arrives at last to a point when no further accumulation is possible. The dune, however, still continues to grow, extending its base and generally increasing in dimensions, but does not increase in elevation.

The size and the height of the dune depends on the distance from the sea and on the strength of the wind. In some cases it has been observed that during a strong wind a dune has decreased in height 5 cm., while other dunes have increased 25 cm. Every dune has one side placed against the prevailing wind. This front side has a lower grade than that on the lee side, which is always more abrupt. As long as the same wind prevails, and as long as the wind carries only so much sand as it is able to take away from the top of the dune, so long will the dune retain its position and form, just as a whirlpool in a river is constant, so long as the river maintains the same velocity and volume. Because the sand grains cannot be lifted to any greater height in the air, the dunes, when they have reached a certain elevation, would present to the sand grains an almost insurmountable obstacle, but they have very seldom time to cohere. The wind modifies its work incessantly and the height of the dune is very soon reduced by stronger winds.

The transporting power of the air is, as already mentioned, small compared with that of water, because of its lightness and want of cohesion. The size of the particles has, therefore, a great influence not only on the degree to which the sand is liable to drift, but also on the extent in which it may manifest properties relative to the texture of the soil, among others that of retaining moisture, which is so important to vegetation.

The amount of sand transportation is greatest, other things being equal, where there is no cover of vegetation to keep down the sands, and the deposits made are most extensive in the direction of the prevailing currents. The coarser dune sand particles are pushed along the ground, while the finer form clouds of dust in the air, and settle rapidly or slowly near to or remote from the source of supply according to the force of the wind and the size of the particles suspended.

The drifting of sand by wind takes place according to following principles: If the force of the wind is great, the grains do not move on the surface but are lifted by the wind to a certain height. The larger grains make jumps, and touch the ground from time to time, while the smaller grains often are carried forward in form of clouds at a considerable height from the ground. At a velocity of 4.5 m. in the second, grains of 0.25 mm. diameter slide on the ground, but at a velocity of 15 m., grains of 1 mm. diameter are lifted high in the air. As a corollary of this fact it follows that the movement of the grains depends on their volume. The greater part of the sand grains have an irregular flat form, and hence their movement is not rolling but sliding. That of the largest take place spasmodically and only during stronger gusts. According to *Sokoloff*, a wind of a velocity of 10—12 m. in a second cannot carry grains of 100—150 cubic mm. When the wind is not too strong, the grains slide along the surface, but when they are lifted up during the strong gusts, and fall down at a certain angle, they again rebound at the same angle. *Hagen* has proved that coarser sand grains are sometimes lifted up to 2 m. height, and in such a case they are carried up to 12 m. from their original place.

Ridges or rim formed ripples advance almost entirely by the sliding of the larger grains of the top layer of the crest, and *Cornish* estimates the progress of the ridges at one foot per hour. *Helmann* found in Chiwa that the ripples on the lee-side of the dunes move almost with the same rapidity as on the windward side, and he was not able to interpret this phenomenon. It has been ascertained that the movement of the dunes landward goes on at the average rate of 4.30 m. a year, and that the quantity of sand thus transported is about 75 cubic m. to the running m. of the length of the dune.

The winds have a greater power at a higher elevation than near the surface, and consequently more sand is removed from the summit than the wind is able to lift from the ground. This difference in the strength of wind exercises a modifying influence on the development of the dunes. The effect of the wind is to diminish the maximum slope, but as the formation of dunes is mainly regulated by the supply of sand, the varying angle of the windward slope depends upon the varying density of the sand shower pushed forth toward the summit. In cases where the supply of sand has become scarce or exhausted, the front slope of the dune soon will be almost as steep as the lee side, that is, approach the natural limit of the angle of rest.

The leeward slope of the dune varies but slightly, provided a reverse

of the dominant wind does not take place. It is the gravity which here exercises its force and reduces to the angle of rest any steeper slope caused by the air currents or other factors. The development of a dune is similar to that of a ripple, although it takes place on a larger scale. In lee of the dune crest there is an eddy, the upward motion of which lifts the fine sand particles, and in cooperation with the wind sends them flying from the summit. Gravity acts upon these particles, causing the fall across the stream lines of the air. The coarser sand falls more steeply, and this pitch is further increased by the backward motion of the eddy.

There are thus several factors which influence the formation of dunes. Of these operating factors the force and direction of the wind, the sand shower, the eddy in the lee of any obstacle, the gravity, the configuration of the surface, and the moisture are the principal ones. If the dune is formed at a certain constant sum-total of these factors, it retains its form as long as these factors are constant.

THE SCULPTURAL FORM OF DUNES.

The forms of dunes have a greater variety than those of ripples, because a dune is the result of many changing winds. While the dunes do not owe their origin to the action of the sand grains, like the ripples, still rippling plays a part in the shaping of every dune. Reversible winds produce dunes having both front and back slope very steep. The first effect of reverse of winds is to turn the top of the dune.¹⁾ During strong winds the troughs are always deeper.²⁾ On a hard ground, the windward slope can be as steep as the angle of rest, in case the sand supply fails and the wind is strong. If such is the case the dunes are widely separated.³⁾ This form differs from that of dunes produced in deep sand by dominant wind. The angle of the windward slope in this case decreases with the density of the sand shower, and increases with the power of the wind.

The amplitude of the dune does not exceed one third of the wavelength, and this limit is most nearly approached when the wind blows

1) *Sven Hedin*: A journey through the Takla-Makan Desert, Chinese Turkestan.—Geogr. Journ., VIII: 264—278, 356—372. 1896.

2) *G. Grandjean*: Les Landes et les dunes de Gascogne.—Bull. Soc. Géogr. Coml. de Bordeaux, March 1896.

3) *V. Cornish*: On the formation of sand dunes.—Geogr. Journ. IX., p. 286. 1897.

alternately from opposite quarters, but does not hold in one quarter sufficiently long to reverse the work of preceding winds. *Cornish*¹⁾ remarks that in speaking of amplitude instead of height of dunes, one avoids the common confusion which results from the fact that the vertical distance from the bottom of the trough to the summit may increase even by raising of the crest or by deepening of the trough.

A dune sufficiently large is stationary, and it is an established law that as the amplitude increases, the velocity of the dune wave decreases. The velocity of the dune is the rate of advance of the crest which takes place by accumulation of sand upon the lee slope. There is also a group velocity of dunes to be recognized, that is, the rate of travel of the sand. Increase of wind will increase formation of new dunes to leeward rather than the rate of travel of the individual dune, and is usually accompanied by a considerable lowering of the general level, especially in the case of simultaneous diminution in the supply of sand.

The sorting action of wind already mentioned is supported by rain-water which washes the finer particles down into the trough, and consequently we find the summit of dunes to consist of coarser material. But on the other hand the lower part of the eddy is gouging out the trough and the finer material is carried away through the combined action of the eddy and the wind. The sand is therefore finer in the dunes generally than in the hollows between them. On a large sandy surface the particles are finer at the extremity towards which the wind blows.

Through this winnowing process the dust which consists of friable matter, having been reduced to the size of powder by grinding between the sands is carried away from the dune district and deposited beyond its limit. It is especially in desert regions, where aridity excludes vegetation and allows the wind to play with full force upon the finer particles of the soil, that we notice the development of sandy deserts covered with quartz sand, yet surrounded by grassy steppes consisting of clay dust. This remarkable distribution of the products of rock disintegration by wind and its effect on the physiography of Northern Africa has been eminently shown by *Walther*.²⁾ Already *Buway*³⁾ described the transition between the cultivated coast lands and the desert of Africa, which must be called a steppe, and the genetical relation of these formations is now a generally admitted fact.

1) l. c. p. 287.

2) *Die Denudation in der Wüste*.

3) *Zeitschr. für Allgemeine Erkunde*. Berlin, 1857, p. 290.

If we consider the general appearance and composition of the drift sands we find that they consist in a preponderating degree of somewhat rounded grains of quartz sand with only a very small percentage of other materials. The admixture consists primarily of felspar, of mica, and of various other minerals, such as hornblende, augite and granite, and to some extent of lime, mostly in form of fragments of shells.

In a crystalline rock, such as granite, we find that the different constituents, felspar, quartz and mica, are present in isolated crystals. As soon as these elements are separated from each other, they acquire a granulated form and constitute what we call quartz sand. The grains of felspar and mica act, however, in a different way than those of quartz, the latter representing crystallographically only one or a few individuals, while felspar and mica consist of many thin lamellae. Hence, when exposed to the decomposing agencies, disintegration of felspar and mica is much more intensive than that of quartz. The different particles of sand are moved more rapidly by the wind the lesser their gravity in proportion to their surface. Mica is so light that the least gust of wind carries its thin lamellae away, and it is further so brittle that it is easily broken into small fragments against other sand particles. The same can be said of felspar, although, perhaps, in a less degree. Here we also have to consider the chemical facility for decomposition. During the night and in the dewy mornings, the felspar which has been opened through the many capillary spaces is chemically decomposed by the moisture, while the quartz has a greater resistance against this agency. Consequently the older the dune sand is and the longer time and water have exerted their influence, the less felspar will be found in it and the more dominant is the quartz over the other minerals. As a rule, all the sand grains, however, exhibit more or less the rounded appearance due to attrition and weathering.

Besides the sand, the wind carries all kinds of light plant remains, thin shells, dry crabs, dead and living insects, and similar particles. All these temporary constituents of the dune are, however, insignificant in comparison with the sand, and are usually so rapidly decayed that they are seldom found in the deeper parts of the dune. The separate grains are mostly covered with a fine mold, in part due to the decomposition of the above organic remains, on which depends the fertility of the sand. The drift sand, though varied with a sprinkling of somewhat rare grains of darker colored substances, is generally a mass of a light color.

The stratification of dunes is usually very mixed, and in the same

dune strata, cut in all the four directions of the compass, can be seen. Successive layers dip in various directions, and are abruptly cut short, showing that the growing dune hill was partly cut down by storms and was again and again built up by such disasters. The consolidation of sand is best observed in ripples and rarely well shown in dunes, because the latter are the result of changing winds, and the time involved in their formation is too great for observation.

The fundamental forms of sand dunes include the *transverse* and the *longitudinal*. The former, which is the most common on sea coasts, especially where the wind is of moderate strength or the sand strip comparatively narrow, is that placed at right angles to the prevailing wind; the latter, formed where the wind is so strong as to prevent free lateral growth, is that following the direction of the wind; between these two there is an *intermediate form*; when varying winds act upon this latter form, *conical* dunes are produced. They are, as a rule, *stationary*, while the longitudinal form represents the most rapidly *traveling* dune.

The dunes which are placed parallel to the direction of the prevailing winds have originated quite differently from those which are placed at right angles to the wind. As we have seen, the usual mode of development of a dune is that the sand forms a ridge transverse to the direction of the wind. The sand is blown up on the lower slope on the front, and when it reaches the top it falls down along the lee slope; the ridge growing until it has reached considerable height. The parallel longitudinal dunes are, however, formed through the central part of the dune, being blown further and further forward, while the ends are kept back by various forces. The rule is that such a horseshoe-shaped or *parabolic* dune on the seashore *moves with the convex side in the direction of the prevailing wind*.

Apparently diverse, even opposing effect is produced in sandy deserts, if the observations of *Rolland* and many other travellers regarding the dunes called *Barchanes* are correct. In *Traité de Géologie of Lapparent*, 3 Ed., 1893, p. 140, we find the following opinion expressed about these wandering dunes: "Enfin la forme de dunes en marche doit être généralement celle d'un croissant tournant sa convexité vers le vent; par les particules sableuses, ayant moins de hauteur à franchir sur les bords de la dune qu'en son centre, cheminent plus vite à droite et à gauche. La crête doit donc se courber en projectant deux pointes vers l'intérieur. Cette forme *en croissant* a été bien constatée par tous les voyageurs qui ont parcouru le Sahara et les déserts américains."

Now the question arises: How is this phenomenon to be explained? *Cornish*¹⁾ refers to the development of barchanes in the following words: "They form here and there upon the desert floor where the wind will let them. It appears that they neither occur in localities where the sheet of wind has everywhere a complete mastery over the sand, nor where the burden of all the flying sand is everywhere too great for the carrying power of the wind; they dot the desert plain in localities where the sheet of wind has, for the most part, the mastery of the sand, but drops its burden here and there at certain points or more probably along certain strips."

"The *horns* or *cusps* of the barchanes, pointing to leeward, are readily explained, for the lowest parts of the dune travel quickest. A form as of the moon in her first quarter (i. e. that is to say with the cusps pointing in the direction of motion) is the form of front proper to a traveling sand-wave as viewed in plan. In this case gravity does not operate, so that the incoherence of sand does not hinder the formation of the cusp as it does in the profile of dunes."

This explanation seems negatived by the fact that the cusps generally are very insignificant as compared with the body of the dune, and in most cases a difference in size of the cusps can be recognized. Thus *Lessár*²⁾ observed in the Kara-Kum desert in Central Asia that the southwesterly cusp always was longer. This seems to indicate that the cusps are formed in a way similar to that of the low ridges which have often been noticed on the lee side of both stationary and wandering dunes on sea coasts. These lee ridges are usually placed at right angles to the length of the dune and are formed by the combined action of the eddy in the lee and the current sweeping around the side of the dune. If we accept this explanation for the formation of cusps in lee of the barchanes, the original form of which tends to the oval, according to *Sokoloff*³⁾, we will find a satisfactory solution of the action of wind in the development of the barchane without having to theorize about the lower cusps of the dune moving more rapidly than the higher, which cannot be correct, as we know that the force of the wind is considerably greater on the higher parts of the dune hill than on the lower, and that consequently the central and highest part travels quicker. *Steenstrup*⁴⁾ has also shown that a parabolic dune never can move with the

1) On the formation of sand dunes, p. 290.

2) *P. M. Lessár*: Die Wüste Kara-Kum. "Izwestija" Russ. Geogr. Soc. 20: p. 115. 1884.

3) Die Dünen. 1894. p. 164.

4) Om Klitternes vandring. 1894. p. 14.

closed side toward the wind, and I must subscribe to his opinion, as I have not, on any of the dunes visited by me, been able to observe a phenomenon of that kind.

Summing up the foregoing discussion on dune forms, we would say that:

1. Dunes are formed in lines transverse to wind in unobstructed places.
2. Dunes are formed in lines parallel with wind in places where some kind of obstruction is in the path of the wind.
3. Wandering dunes have their convexity in the direction of the prevailing wind.

POLYGENETIC ORIGIN OF A DUNE COMPLEX.

The fundamental principles of dune formation established in the previous section must be recognized at the outset of this discussion in order to facilitate an understanding of the conditions which cause the origin and development of a dune complex. With this term, dune complex or dune tract, as distinguished from a solitary dune or a dune massiv, we signify a collection of secondary dune hills interspersed with deep gullies.

The dune complex is formed behind the chain of primary dunes, when the rate of travel of the sand is locally diminished without a corresponding decrease in the supply of sand. The formation takes place either through older dunes having been broken up into rough hummocks by the wind, or through secondary embryonic dunes being started by the piling up of drifting sand around some obstacle, in most cases a congregation of plants.

One of the most important factors determining the development of a dune complex is the presence of ground moisture. Without this factor we would not be able to explain the apparent irregularity of formation of a group of small dunes, where the quality of sand ought to have called for a regular dune massiv. The action of wind alone is insufficient for this modelling of the surface, but in connection with the greater coherence of the sand particles caused by the ground moisture the phenomenon is easily explicable.

It is the irregularity in action of wind, caused by the breaking up of the regular even surface of a dune or a sand field into small elevations

and depressions, that governs the development of such embryonic sand hills into a dune complex. In almost every case the latter formation has had such origin from a number of nuclei, while a dune massiv is formed from a single embryonic dune.

If the plants should not influence the development of dunes the ridges would, like large waves, roll over the land until they were stopped either by water or by high mountains. In most cases it is the plants which have caused the broken forms of the sea coast dunes. Inland dunes have, as a rule, a more regular shape.

There is no other geological formation of the present time which is the result of such a combination of factors from the organic and inorganic nature. Dunes are developed wherever the winds can play over the loose sands, and as soon as the sand begins to drift, the ordinary vegetation is destroyed and plants which thrive in drifting sand immigrate, and thus begins the co-operation between the drift sand and the dune plants, the result of which is the dune. Although there is a struggle for power between the moving sand and the plants, it is remarkable with this strife that they both thrive best where they are almost of equal strength. If the plants have gained a victory they will soon be replaced by other plants, and then it can happen that the wind again breaks open the soil and the sand starts to drift afresh.

SAND FIELDS NEAR THE COAST.

As long as an obstruction has caused the formation of a dune, one of these will act as a recipient for the sand, and in this way dunes after dunes are formed until finally a whole sea of sand covered with dunes is formed.

The encroachment of dunes is due not only to the travel of the dunes themselves, but also to the formation of new dunes to the leeward from material supplied by the sand shower.

In some cases, however, when the dunes have not been fixed by a vegetation, the sand skims along the surface like snow drifting before a stiff breeze and accumulates rapidly, covering the plains without forming any hills. Further, the fine material which has been lifted to a certain height in the air, is deposited behind the dune region, and is quickly covered with vegetation, as it offers better condition for plant life on account of its greater coherence and capacity of retaining moisture than the coarser dune sand. These sand fields sometimes cover con-

siderable areas, and it seems often almost inexplicable that no rippling or dune formation takes place. The explanation of their non-formation is to be sought in the fact that the sand-sized particles are too small in proportion to the mass of material, and further, the deposition of dust takes place so rapidly that the wind is not able to carry it away, leaving the coarser particles to accumulate.

CONDITIONS FOR PLANT LIFE.

There is a great variation in the conditions for plant life on different sand formations. The climate has something to do with this result as well as the quality of the soil. Sea air and saline constituents of the soil destructive to some plants may be beneficial to others. The mobility of a drifting sand dune on the coast may be a condition of life to one plant, while dry atmosphere and the stability of an inland sand field may be essential to the growth of another. Even *Pinus maritima*, which has produced such wonderful results on the Landes of Gascony, does not grow everywhere even on sand formations in France. It is therefore necessary to study in every case the natural conditions of the locality before the problems of ecological relationship can be solved.

Some of the conditions of sand formations are, however, everywhere the same and these will here be briefly considered. One of the most important points in this connection is the relation to moisture. The rain-water sinks easily into the sand, the better the coarser the grains are. Generally speaking, the power of retention of water is very small and of all soils sand ranges lowest in this respect. The sandy soil has also a very low power of absorption, and is able to condense only a small portion of the atmospheric moisture. This is especially the case with quartz sand.

Further, sandy soil dries easily, and it is therefore heated quickly by the sun; but it also cools very soon at night. The difference between day and night temperature can be as high as 40-50° C. In consequence of this, sand is subjected to a considerable bedewing at night, a factor which is important for its capability of carrying a vegetation cover. The great variation of temperatures of the soil is disadvantageous to the plants in one respect, they being more liable to injury by frost, than if growing on any other soil. Sand floras, on the other hand, are always developed earlier, because of the greater heat capacity of the soil.

The nutritive value of the sand is very different according to the chemical character of the grains. The commonest form, or quartz sand, is the most barren on account of the insolubility of the quartz grains, and also because of their resistance to decomposing agencies, as already mentioned. Sand consisting of mica, felspar, limestone, and other minerals, disintegrate, however, and have by reason of this a higher nutritive value.

Formation of mould takes place only to a small degree in dry sandy soil, because the organic constituents are so easily decomposed through the admittance of air, and the particles are further quickly distributed and carried out of reach of the plants by sinking with the water through the loose soil. The proportion between organic and inorganic constituents in this soil is too great, the quantity of the former being too small to establish a sufficient supply for the demand of a more luxuriant growth of plants.

This scarcity of plant food results in a more or less open vegetation consisting of low growing plants, which do not give each other the mutual assistance against mechanical influence of wind and other factors, that is evident in the arrangement of plants on most other soils. The injurious effect of the intense light, both direct and reflected from the surface of the sand, has to be guarded against. The transpiration of open sand vegetation, especially on the seacoasts, is always considerable because of the constantly changing atmosphere, resulting from the almost continuous winds. The plants have to develop some means of reducing this excessive transpiration.

Summing up, we may say that the competition for food is more intense, the water supply less, the light stronger, the temperature higher, the transpiration greater, the foothold more uncertain and difficult, the conditions for plant life generally more adverse, than on any other soil.

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The Sand Strand Flora of Marine Coasts

by

Pehr Olsson-Seffer, Ph. D.

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The Sand Strand Flora of Marine Coasts

By *Pehr Olsson-Seffer, Ph. D.*

1. REVIEW OF THE LITERATURE ON SAND FLORAS.

The earliest data about plants confined to sand formations, particularly coastal dunes, we find in Smallegange's *Chronijk van Zeeland*, 1696, where it is mentioned (p. 313) that some dunes on the North Sea coast had been planted with Marram-grass or Helm (*Ammophila arenaria*) already in 1307. Maximilian of Austria issued in 1510 a proclamation upon planting the Helm, and in 1567 the government of Holland also prescribed, in an official edict, the planting of this species on the coastal dunes.

The problem of arresting the drifting of sand and of utilizing the dunes has since that time been considered to be of primary importance for Holland, and we find that the Dutch had made great progress by the middle of 1700, when the question was brought into prominence in Denmark and on the coast of Northern Germany.

At Tidsvilde in Sjaelland in Denmark there is still an old monument bearing an inscription in Latin to the effect that the drifting sand at that place had been fixed in 1738 by Roehl, a German by birth, who planted the dunes with Marram-grass. The Danish king resolved in 1779 that every citizen should plant a certain area with this grass, and the document, which is still preserved in the public archives in Copenhagen, gave detailed instructions regarding the mode of planting.

On Wangeroog, one of the North Friesian islands, similar plantations were made at least as early as 1754, from which year there is on record a map by J. D. Tanner.

In 1768 Professor J. D. Titius of Wittenberg wrote a prize essay on fixation of drifting sand on the Baltic coast (Gerhard, p. 286), and his proposals were put into practical tests at Danzig under the direction of a Swede, Abraham Lindström, during 1771. The experiment proved,

however, a failure, and it was not until several years later that Sören Biörn, a Dane, succeeded in establishing a plantation on the dunes.

At the same time Baron de Charlevoix-Villers wrote several treatises on the subject of fixing the dunes of Gascony (Grandjean p. 53), and his views were utilized by N. T. T. Bremontier, who in 1788 started the reclamation of the Landes of France, which has changed certain parts of this inhospitable region into fertile fields.

On the coasts of Holland, Germany, Denmark, and France the fixation of dunes, started by these pioneers, has ever since been continued, and similar work was later taken up in various other countries. It lies not within the scope of this review to describe the different phases of this reclamation work as it came to be more and more a practical application of experience gathered by previous cultivators and by scientific investigations.

One of the first studies of the strand flora from a phytogeographical point of view was that of Boll on the beach flora of the German shores of the Baltic, published in 1848.

The coastal sand flora of Eastern Germany has since been studied by Kalmuss, von Klinggraeff, Klinsmann, Krause, Marsson, Ratzeburg, and Schäfer.

Brick gives in his work on the ecology of strand plants of the Baltic a number of valuable suggestions, and in Ackermann's Physical geography of the Baltic there is a number of pages devoted to the coast flora.

The most comprehensive work of recent date on coastal sands is Gerhard's "Handbuch des deutschen Dünenbaues," in which the dunes of the German sea coasts are treated. The flora has been described in this work by Abromeit.

The continuation of the sand region of Eastern Germany along the Baltic shore of Curland has been carefully studied by Klinge, while the sands of the Gulf of Riga are to some extent described by Doss and Robert. We may have to expect in the future a treatise on the dune flora of that region by Dr. Kupffer.

Studies of the dune sands on the shores of Gulf of Finland have been made by Sokoloff and Thesleff. Other dunes of Russia are described by Rauner, and minor inland dunes in Finland by Granit and Hult. Some dunes of the Finnish coast of the Gulf of Bothnia have been worked over by Rosberg. Professor Vilhelm Ramsay recently studied the sand formations on the coast of the White Sea, but his observations are not published.

The small island Gotska Sandön situated in the Baltic, 40 km. N.

of Gotland, and consisting exclusively of sand, has been visited and studied by Sernander, Andersson, Eisen and Stuxberg, Holtz and Johansson.

The only publications, in which the sand flora of the Baltic coast of Sweden is treated, are by Erikson. In an excellent paper he describes in detail the topographical features of the vegetation and also the structural adaptations of the sand strand plants of Eastern Scania, the southernmost province of Sweden. Schultz has recently studied the geographical distribution of the strand plants of the Baltic countries.

Warming's different papers on the sand flora of the Danish North Sea coast are of the greatest importance, giving a good description of this extensive sand district with its typical formations. The observations are made with the critical acumen so characteristic of this author. The review of sand vegetation generally, which Warming gives in his ecological plant geography, is a most comprehensive one.

Feilberg has written on grass cultivation on Skagen, the sandy Northernmost point of Denmark, and Raunkiaer published in 1889 a good paper on the east and south shore of the adjoining part of the North Sea. Of other authors who have written on the flora and ecology of the Danish dunes, we may mention Andersen, Bang, Børgesen & Jensen, Mentz, Paulsen, and Schmidt.

Buchenau has written considerably on the sand flora of the German North Sea coast, and his studies are characterized by acute observations, and suggestive details.

Fischer-Benzon, Focke, Graebner, Hansen, Hock, Hubbe, Knuth, Lemmermann, Meyer, Noldeke, Reinke, Sandstede, and von Seeman have all written more or less about the flora and vegetation of the same coast, and especially on that of the outlying islands.

Among more recent writers on the dune sand of Holland, and its flora, we may mention Dozy, van Hall, Holkema, Lorie, Retgers, Scholten, Vuyck, Winkler, and de Witt Hamer. Blijdenstein and Brants have briefly referred to the flora of the dunes of this country and Eeden has especially studied the distribution of dune plants, while Giltay paid attention to some of the ecological adaptations.

The vegetation of the sandy coast of Belgium has been investigated by Massart and van der Swaelmen.

Lesage has written on modifications of the leaf of maritime plants when subjected to different environmental conditions.

Various other writers, such as Baraban, Van den Bosch, Chodat, Costantin, Delfortrie, Girardin, Gosselet, Gras, Labats, Masclef, Partiot,

Poisson, Sauvage, de Vasselot, and de Vicq have studied the conditions of the dunes on the northern coast of France.

Among authors on the Landes of Gascony may be mentioned Brown, Chambrelent, Dulignon-Desgranges, Durègne, Engler, Fabre, Géneau-Lamarlière, Goursand, Grandjean, Houtreaux, Laval, and McNaughton.

Flahault and Combres have made valuable observations on the dunes of Southern France. Daveau, and especially Willkomm, have written upon the subject as regards the Iberian peninsula. Börgesen in a brief article discussed the sand strand vegetation in Southern Spain.

The sandy beaches on the coast of Norway are touched upon in the works of Blytt, Holmboe, Norman, and Wille. The coastal sands of the British Isles have been to some extent studied by Bailey, Dowker, Rob. Smith, Thompson, and Whilden as regards the flora, while Cornish has carefully investigated their origin and development.

The sand floras of the interior of the European continent we find referred to in the extensive literature on the steppe formation. Borbas described the sand vegetation of the plains of Hungary, and Adamovic the sand steppes of Servia.

From the Mediterranean shores of Africa there are studies by Parrau and Serres, and from the dunes of Italy by Sprenger and Tommasini.

Volken's important work on the flora of the Arabian desert, although treating of island sands, contains a rich supply of suggestions on the adaptation of psammophile plants.

Other writers on the sand deserts of Northern Africa are Jordan, Kotschy, Riston, Rolland, Schirmer and Walther, the latter having made an especially careful study of the formation of dunes.

During Nordenskiöld's Vega-expedition Kjellman studied the coast flora of Siberia.

In the works of Hedin on his explorations in Central Asia we find much valuable information on the sand desert of Gobi and the dune vegetation of that region, and other travelers have described continental dunes from various other parts of Asia. Helman wrote about the dunes in Chiwa, Nalivkin on those of Ferganah, Radde on the dune vegetation of certain parts of Caucasus.

The extensive sand dunes of India have caused considerable trouble to cultivation, and the sand binding plants of that country have been referred to by Clark, Duthie, and Cleghorn.

Schimper gives in his "Indomalayische Strandflora" a valuable treatise on the vegetation and flora of the coastal sand, and in his

“Pflanzengeographie” the subject is extensively treated with reference to different regions.

Karsten wrote (1891) more especially about the mangrove-vegetation of the Indo-malayan archipelago, and Goebel treated the strand flora of tropical Asia.

In South Africa Thode made a good study of the coast flora, and Werth has described the sand strand vegetation of the Zanzibar Island.

The extensive coastal and interior sand formations of the Australian continent have attracted only little attention by scientific writers so far. We have to note briefer articles by Benbow, Boyd, Maiden, and Walter Smith.

The New Zealand dunes have been studied by Cheeseman, Cockayne, and Kirk. Diels also wrote on certain ecological features of the flora. He had not, however, himself visited these islands, but based his study on collections, and on information by Dr. Cockayne. The latter made valuable observations on the sand flora also on Enderby, and Chatham islands, and he recently published an excellent paper on the dune flora of the eastern coast of the Middle Island of New Zealand.

Kurtz and Reiche have briefly treated the sand flora of Chili. On the sand dunes of the Pacific coast of North America nothing is written except some brief notes by Davy, Lamb, and McKenney.

The extensive dune formations on the Atlantic coast of the United States, and their flora, have been the subject of study of several writers, as Britton, Gifford, Harshberger, Jelliffe, Mohr, Ross, Rothrock, Westgate, and Webber. The ecological study of the strand vegetation of North Carolina by Kearny is an excellent piece of work. Lloyd and Tracy have treated the insular flora of Mississippi and Louisiana.

The flora of the interior sand hills of North America has been worked over especially by Hitchcock, Rydberg, Smith, Pound, and Clements. Lamson-Scribner has treated the value of grasses as sand stays. Cowles made a study of the vegetation on the sand dunes of Lake Michigan, and Hill has written on the sand dunes of northern Indiana and their flora.

MacMillan's admirable study of the strand flora of the Lake of the Woods is without any equal in the phytogeographical literature of the United States.

Börjesen has carefully studied the strand flora of the Danish West Indies.

From the dunes of Southern Brazil we have an excellent description by Lindman, and Schenck also recently wrote of the strand vegetation

of Brazil. Brackebusch has contributed to the knowledge of the sand flora of Argentine. The coast plants of Japan have been treated by Imamura.

Mention may also be made of the general description of dunes which is contained in Richthofen's "Führer der Forschungsreisende," as being a valuable and suggestive treatise.

The present writer has published several papers on sand formations in connection with the inquiry referred to in the following pages.

II. OBSERVATIONS ON CERTAIN SAND FORMATIONS.

BALTIC COASTS.

It has been claimed by certain authors, as *Vogt*, for instance, that maritime dunes are formed only on coasts with tide phenomena. According to him sand particles are thrown up on the shore at high tide, and having been dried during low tide, they are subsequently carried inland by wind. The dunes on the northern coasts of the Baltic where there is no visible tide, as well as the extensive dune formations near many inland seas in America, for instance, show, however, that tides are not necessary for the formation of dunes.

A remarkable coincidence exists between the topographical form of the coast, and the development of dunes. This is nowhere more evident than on the Baltic coasts.

The east coast of Sweden washed by the Gulf of Bothnia, the Åland Sea, and the Baltic, is almost everywhere rocky, and extensive sand formations occur only at a few places. The northernmost location where observations have been made by the writer, was at the mouth of the Dal river, where a visit was made in October 1897. On a very limited area there are sandy beaches, and in one place a few embryonic dunes have been formed on the upper beach. The sand was of a yellowish color, and consisted of medium sized quartz grains, with some admixture of felspar. On the middle beach there were some light accumulations of mould. The sand was slowly drifting back and forth along the beach forming beautiful ripples. The salinity of the sea water was low.

At Saltsjöbaden near Stockholm, at Östanå, and Sandhamn, minor sand formations were visited in 1896, '97 and '99. Only beach forma-

tions occurred on the former places and the dunes in the latter locality are not very extensive. The beaches consist generally of very narrow strips of loose material; the gradient of the shore being comparatively steep, the area of influence of the sea is consequently limited, especially as the force of the waves is never very great within this archipelago.

In the neighborhood of the city of Norrköping there is quite an extensive archipelago, consisting of a few larger and many small islands. In June, 1899, I visited a number of these islands, near Arkösund. Of the great number of beach formations investigated only a few were sandy,



FIG. 1. Beach with *Halianthus* community. Swedish East Coast

shingle beaches being far more common. Where sand occurred it was very coarse, except in some sheltered places. All these islands are exposed to the strong winds of the Baltic, and those being only a couple of kilometers distant from the mainland, had no tree vegetation. The salinity of the seawater was here varying from 0.49-0.66%.¹⁾

On the open coast, facing Kalmar strait, some observations were made in June, 1899. The shores south of the town of Kalmar are very low, more or less muddy. In some places shingle beaches were formed, and these were sometimes covered with fine sand, mixed with clay par-

1) All my measurements of salinity of seawater in the Baltic were made with an areometer (Åderman type) purchased in Stockholm.



FIG. 2. Sand field with *Armeria* community, Swedish South Coast.
PHOTOGRAPH BY ERIKSON.



FIG. 3. Gray dune with pines on Swedish Southeast Coast.
PHOTOGRAPH BY ERIKSON.

ticles. This shore is sheltered by the island Öland from the direct force of easterly winds and waves of the Baltic. The salinity of the sea-water was 0.66%.

In the Blekinge archipelago Torhamn and several islands as well as the shores near Karlskrona were visited June 18th, 1899. The few sandy beaches observed were not extensive, and were formed of a rather fine sand, quite often mixed with clayey residue. On June 19th, 1899, some shores near Karlshamn, especially at Helenebärg and on Boö were investigated. The sandy beaches were formed of coarse material mixed with pebbles. Large boulders were strewn on the narrow beaches. The shores in this neighborhood are usually steep and rocky.

A number of sandy formations were studied at Sölvesborg, June 20, 1899. The shore sloped generally at an angle of 30 degrees. The material was pure yellow quartz sand. The coast is open to the Baltic.

At Åhus there are extensive sand strands, with long stretches of beach formed of pure sand. (See Fig. 1.) Inland there are minor dunes and large sand fields. My observations here were made June 21—22, 1899. The vegetation on these sand formations has previously been studied by *Dr. Erikson*.¹⁾ (Fig. 2.)

The coast near Simrishamn is low and open to the Baltic. Sandy beaches at Horshäll and Brantevik and also north of the town were studied, June 23—24, 1899. The sand is of coarse consistency, and the slope is here generally about 45 degrees.

The whole eastern coast of Sweden is rocky and steep, the hard cliffs are disintegrated only very slowly, and the material is usually washed out to sea except where inlets give a resting place. The only more extensive sand formations on the coast are in the south at the places just mentioned. (See Fig. 3.)

SHORES OF GULF OF FINLAND.

On the steep rocky coasts of Esthonia, on the southern shore of the Gulf, dunes are very rare, and occur only where the calcareous bluff retreats landward, and leaves a narrow sandy strip along the shore. In the eastern part of the Gulf of Finland, from the mouth of Narwa river, the coasts are sandy, and dunes are common. The largest dune district is that between Systerbäck and Björkö, in the innermost part of

1) *J. Erikson: Studier öfver sandfloran i östra Skåne.*—Bih. K. Sv. Vet. Ak. Handl. 22. 3—81. 1896.

the Gulf. The coast is here unsheltered by any islands; and the shore is exposed to the full force of the open sea. The prevailing winds are westerly and southwesterly, that is, those which have a free passage along the whole stretch of the Gulf from the Baltic. They meet no obstacles in their way, and they strike the land with their full intensity. On this coast a series of dunes have been formed following the coast continuously for about 80 km. Although every sign of tides is absent, the sea is very seldom or never quite calm. The constant breakers and the great difference between the high and low water caused by winds have developed the sand formations of this district. Some of the dunes are smaller and some larger; some of them are still drifting before the high winds, constantly changing their form and their position, encroaching more and more on the land. Others again are in ridge form, covered with vegetation, and are stable.

This sand consists of quartz of a yellow-white color, mixed with felspar and mica. The size of the grains is 0.3-1 mm., and they are sometimes larger, up to 3 mm. On this coast, the development of the dunes is promoted by human agency, the natural forests being destroyed and the larger pebbles, which have been left by the wind on the shore, and which retard the advancing sand thrown up by the waves, are collected and transported to St. Petersburg for road-making purposes and thus the sand is given a full opportunity to spread. The form of these dunes is varying. They consist mostly of long hills of very different dimensions, some almost round, others nearing but never completely assuming the horse-shoe form.

These dunes have been studied by *Sokoloff*¹⁾ and *Thesleff*²⁾, and my own observations were made during several visits in May, August and October, 1898.

On the Finnish south coast, which is rocky, there are only a few sand formations. Sandy beaches of the same character as those of the Swedish east coast near Stockholm were studied, near the city of Helsingfors, during 1893—'99 and on the coast of the province of Nyland, 1891—'92, and 1898—'99. On the Hangö peninsula there is a smaller dune district which was made the subject of detailed investigations in June 1895, in July 1896, in August and September 1897, in April, August and September, 1898, and in August, 1899. The sand is here of glacial origin, having been redeposited by waves and wind. The salinity of the sea water was 0.6% at a temperature of +14.0°C.

1) Die Dünen. Berlin, 1894.

2) Dynbildningar i östra Finland.—Med. Geogr. För. Finl. p. 36—77. 1895.

ISLANDS IN THE BALTIC.

The great island archipelago along the southwestern coast of the Finnish mainland, and thence stretching in a westerly direction towards Sweden, consists of small islands with rocky shores. This is especially the case in the outer part of the archipelago, where the influence of the sea is more conspicuous, and the finer material is very seldom able to find rest on account of the steepness of the shore. In the inner archipelago the beach is covered with boulders ranging from 4 dm. to 1 m. in diameter. Between these boulders the soil consists of sand and gravel, more or less mixed with clay. In Åland pure sand beaches are very seldom of common occurrence. This is especially the case in the Kōkar and southern part of the Sottunga archipelagoes. In the Korpo and Nagu archipelagoes sandy beaches are quite common, but sand dunes do not occur. On the shores of the Kimito Island, the flora of which was studied by the writer in 1893,¹⁾ quite a number of sandy beaches are found. Usually it is the innermost part of an inlet, which consists of sand.

The island Runö on the southern side of the Gulf of Finland is low, and sandy beaches are frequent. A number of observations were made in June and July, 1896.

On the island Ösel, visited in 1896 and 1898, sand formations were investigated on the southern coast, facing the Gulf of Riga, and at Rootsiküll, on the western coast. The sandy shore west of the town Arensburg is at Jerwe formed by a very narrow strip of beach, and then rises to a steep sand bank, 12-15 m. high, on which a number of low, circular dunes occur.

The material, of which these are composed, is a comparatively fine sand, the average size of the grains from 16 samples being 0.3 mm. The salinity of the sea water at this place was found to be 0.82 per cent. with a surface temperature at noon of +16.6° C. The shore is open to the waves from south.

On the Swedish side of the Baltic the large island Gotland has sandy shores, especially at its northern end. Their vegetation has been studied especially by *Johansson*.²⁾ The present writer only visited the coast near Visby on the western, and at Ronehamn on the eastern

1) *Bidrag till kännedomen om floran i Kimito skärgård.*—Acta Soc. F. Fl. F. XI. No. 11. 1895.

2) *Hufvuddragen af Gotlands växttopografi och växtgeografi.*—K. Sv. Vet. Ak. Handl. 29: No. 1. 1897.

side, in June, 1899. At the former place the shore was steeper and only small accumulations of sand were formed. The sand was here rather coarse, almost gravelly, and contained much lime. At Ronehamn the coast is low, open to the sea, and exposed to winds. The sand was mixed with large quantities of silt and pebbles.

North of this island there is a small island, Gotska Sandön, composed entirely of sand. It has been visited by several botanists and geologists, and occasional observations of the dunes and their vegetation are found in various works.

Öland, the other large island on the Swedish east coast, was visited in June, 1899. Both the eastern and the western shores are low, and where sand formations occur, they are formed of coarse gravel, and cover only very limited areas.

The island Bornholm, in the southern part of the Baltic, was visited in June, 1899. On the western coast, south of Rönne, there are quite extensive sand formations. At Svaneke, on the eastern side, the coast is rocky, but between the cliffs small deposits of coarse sand were accumulated. The coast is everywhere unprotected and exposed to waves and winds.

WEST COAST OF RUSSIA.

The shores of the Riga gulf are low and sandy, especially in the southern part, and they are also rich in dunes, which in some places reach a considerable height.

Between the Düna river and the watering place Catharinenbad, the belt of dunes varies in width from 0.5 to 2 km. (Fig. 4) and west of the river, especially near the mouth of the Bolderaa river, the sand covers a large area. In many places the sand is drifting. It consists primarily of quartz, but is mixed with felspar and hornblende, and even granates. The average size of the grains is 0.25-0.35 mm. The sand is brought down to the sea in quantities by the rivers and is again thrown up on the shore by wave action. This district was visited in 1898.

The west coast of Curland is bordered by a broad belt of diluvial sand, and it is therefore for its whole length covered with a continuous chain of dunes. At some distance south of Libau the dunes are very high, up to 35 m. The highest dune on this coast, Koope-Kaln, rises 70 m. above the sea. The sand rests in many places, especially near Libau, on a compact stratum of peat, in which trunks of trees often are



FIG. 4. Temporarily stable dune near Bullenhof, Riga, Russia. The moving sand of the lee-slope is in progress of being naturally arrested by grasses, (*Koeleria glauca* and *Festuca ovina*), herbs, (*Artemisia campestris*, *Hieracium umbellatum*, *Pulsatilla pratensis* and others), and by pines (*Pinus sylvestris*.)

PHOTOGRAPH BY KUPFER.

found. The landward side of the dune belt is bordered by extensive swamps.

The dunes near Libau are formed by a somewhat fine sand averaging 0.15 mm. It is a pure white quartz sand, the admixture of other minerals or other colors being inconspicuous. The salinity of the sea water is about 0.8 per cent.

GERMAN NORTH COAST.

In direct continuation of the last mentioned dunes follow those on the German north coast which is sandy along its whole stretch to Swinemünde. On the long narrow spits, known as Kurische and Frische Nehrung, the dunes have reached a remarkable development and the dune district is second in size to none in Europe except that of Gascony.

The detailed description we have of these dunes in the comprehensive work of *Gerhard*¹⁾ makes it unnecessary here to discuss their general appearance. In connection with our treatment of the sand vegetation some comparisons will be made.

SWEDISH SOUTH COAST.

We have yet to mention some minor sand formations on the Baltic coasts visited by the author. At Ystad, in southern Sweden, there is a long sandy beach, which was made subject to study in June and July, 1899. The sand is fine quartz, almost pure, yellowish in color. The sloping angle of the beach is about 35 degrees. The coast is here unprotected, as is also the case at Dybeck and Trelleborg, where sandy and gravelly shores occur. The dune district at Falsterbo was not visited. Along the Swedish coast of Öresund there are sandy shores in numerous places, both in the neighborhood of Malmö and Helsingborg. At Engelholms hamn a series of small dunes occur near the mouth of the river. These were studied in 1900.

1) Handbuch des deutschen Dünenbaues.—Berlin, 1900.

THE NORTH SEA.

The West Coast of Denmark,

from Cap Skagen, the northernmost point of Jutland, is sandy along its whole length, and the sandy shore continues through Schleswig-Holstein to the mouth of Elbe river. (See Fig. 5.) This dune district comprises an area of some 70,000 hectares. The dunes do not run to any considerable height, 32 m. being given as the greatest. A chain of islands follows the southern part of this coast and they are all sandy. On the island of Sylt, the height of the steep coast is 34 m., and on this dunes up to 28 m. in height are developed.

The size of the grains on these dunes along the North Sea coast decreases southwards from Skagen. On Anholt, *Jessen* still found, however, a dune sand in which 91% of the grains had a diameter of over 2 mm. *Jentzsch*, in Gerhard's handbook, mentions that samples of dune sand from Sylt contained grains of the largest size; while the finest sand came from Borkum. On the small island Norderney, outside the German North Sea coast, the sand grains are of very small size, 0.11 mm. in diameter according to *Wessely*.

The Danish and German North Sea dune flora is the best known, many investigators having worked here, principally *Warming* and *Reinke*. The writer's personal knowledge of the dunes on Jutland is confined to a few points, visited in 1900.

SAND DUNES IN HOLLAND.

The belt of sand dunes which, as already mentioned, marks the coast from north of Jutland to Elbe, continues from that river almost without any break along the southern shore of the North Sea to the Straits of Calais, for a distance of about 500 km. In most other countries the dunes are a source of trouble through injury to forests and cultivated fields, but in Friesland, Holland, and Belgium, they are a protection against the invasion of the sea, being natural dykes. Their height is not very remarkable and they very seldom reach over 20 m.

The dunes are especially well developed on the West-Frisian islands and on the mainland between Heider and Hoek van Holland. This dune belt is mostly of a comparatively narrow width, but in some places as in the neighborhood of Haag it covers several kilometers inland from the sea.



FIG. 5. Arresting drift sand with a cover of heath—Denmark.

PHOTOGRAPH BY BANG.

At the last mentioned place the dunes do not show any regular arrangement as is usually the case, but they constitute a large dune-complex in which no order can be recognized. The dunes on this coast are, as a rule, low, but reach sometimes an elevation of 60 m. Westerly winds prevail on all these coasts.

SCOTLAND.

In October, 1899, a passing visit was paid to the dunes at Gullane Point, south of Firth of Forth, not very far from Edinburgh. For a distance of about 10 km. the coast is here sandy, and by far the most extensive dunes of this place are on the eastern shore of Aberlady Bay, where the sandy belt is about 2 km. wide. All stages of development are met with. Sandy shore, embryonic dunes, dune-complexes, and sandy fields. A greater part of these sand formations was fixed by vegetation.

The general conditions did not materially differ from those on other coasts of the North Sea. I have not been able to get reliable information as to the salinity of sea water in the Firth of Forth, but so far out the influence of the river is doubtless comparatively insignificant. The prevailing winds are those from N. N. E.

ATLANTIC COAST OF EUROPE.

Near Plymouth in England

the writer made some observations in October, 1900. Only sandy beaches of small extent were visited. The sand was coarse, mixed with humus, the remains of decomposed seaweeds and marine animals thrown ashore by waves. The beach was exposed to southerly winds, but being in the interior of the harbor it was protected against the currents, and consequently the amount of kelp accumulated was considerable.

On the west coast of France,

from Graves at the mouth of the river Gironde to the bank of l'Adour and even further to the cliffs of Bearn, a series of dunes follow the coast for more than 200 km. This belt having an average width of four to five and in some cases seven to eight km., is in many ways remarkable.

It is the natural border between the Bay of Biscay and the territory known as the "Landes." The sand had for centuries been constantly shifting, making great devastations, until its progress was arrested by plantations. Engineering skill and judicious planting of sandstays and trees has changed this district from desolate, unhealthy marshy moorlands and unproductive sandy tracts to a habitable, and in some places, fertile country.

According to early writers, the dunes advanced in former times constantly inland covering houses, filling the outlets of rivers, making great damages to cultivations and increasing the unhealthiness of the Landes. The advance of the sand was especially rapid in the neighborhood of Saint Pol-de-Léon; there existed before the year 1666 several villages which had to be abandoned, and which were buried under 6 and 7 m. of sand. In 1722, this dune had progressed more than 24 km., which would indicate a yearly advance of more than 500 m. According to *Brémontier*, the dunes advanced at his time, or about 1790, from 20 to 25 m. a year, and they did great damage to the fields in the neighborhood of Bordeaux.

The whole coast from Gironde to the foot of the Pyrenees presents an aspect in regard to its geological constitution, quite uniform with the sandy coast in the north. Capbreton, situated at the ancient estuary at l'Adour, at the present day covered with dunes, was formerly a flourishing harbor, which has since been replaced by Bayonne. The dunes on this coast are often high, in some places averaging 70 m.

The sand is composed of pure quartz, reduced to minute grains, generally rounded by trituration, and moving easily. The width of the upper beach is about 200 m. from highwater mark to the foot of the littoral dune.

The dunes form a series of parallel ridges, the valleys being of varying width. Whenever the dune valleys, locally called "Lettes", reach a width of 1 km. they are covered with a luxuriant vegetation.

The most frequent winds, and the most violent ones on this coast, are those from the west and south west.

AUSTRALIA.

Sand formations on the west coast

are very common on this island-continent. At Geraldton they are quite high and are constantly shifting. North and South of Fremantle there is a dune district of considerable extent, and this was studied in the

fall of 1900 and in September and October, 1902. The coast is open to the Indian ocean and the waves strike the beach with full force. The beach is usually narrow and sloping in an angle of about 30° . (See Fig. 6.) Landwards it is bordered by a series of dunes, often of considerable height. I have measured dunes being 32, 37, 44 m. over the surface of the sea.



FIG. 6. Shrub vegetation on stationary dunes North of Fremantle, Western Australia.

PHOTOGRAPH BY THE AUTHOR.

South of Fremantle the beach is wider and then gradually merges into dunes by the way of low mounds. Here the sand is still drifting rapidly and many of the streets of the outskirts of the town are constantly being filled with sand.

The texture of the sand is coarse. The grains are angular, of a white or in some places reddish color.

On the southern coast of Western Australia there are quite extensive sand formations, but they were not visited by the writer.

Dunes in South Australia.

The greater part of the coast of this state is more or less sandy. At Vincent's Gulf the dunes are especially well developed. The sand grains are of medium size, yellowish in color, and rounded through constant trituration. Sandy beaches and dunes are common also on the Victorian coast. At Port Phillips Head there are some formations which were visited.

Sandy beaches near Sydney.

At Botany Bay, near Kensington, on Cronulla and Bondi Beach sand formations occur. Those at the last mentioned place are the most extensive and have caused some trouble through drifting. The quartz sand is very pure, and of a light color, where dust from the surrounding country has not been blown over the sand. The reclamation which was commenced several years ago, has now considerably changed the original topography of the sand, and in many places the loose material has completely blown away, while in others it is fixed by vegetation.

The drifting at Botany Bay was caused by the rejuvenation of a sand dune, which previously had been covered with vegetation. The sand advanced inland and destroyed a part of the park at this place.

The salinity of the sea water outside this coast was found to be 2.9 per cent. Several visits on various occasions during 1901—02 were made to these sandy beaches.

Drift sands in Queensland.

The beach from Tweed River northwards to Southport consists entirely of sand. The sand forms an elevated bank or floor, on top of which regular dunes are formed. (See Fig. 6.) They advance steadily inland, covering everything and have already done considerable damage to property in the town of Southport.

Further north at Cleveland and Manly there is a long stretch of sandy shore with a few dunes, but there is almost no vegetation on the ground, because everything is destroyed by the thousands of holiday excursionists from Brisbane. Stradbroke Island in Moreton Bay is entirely built up of sand, and is considered by some writers as a single

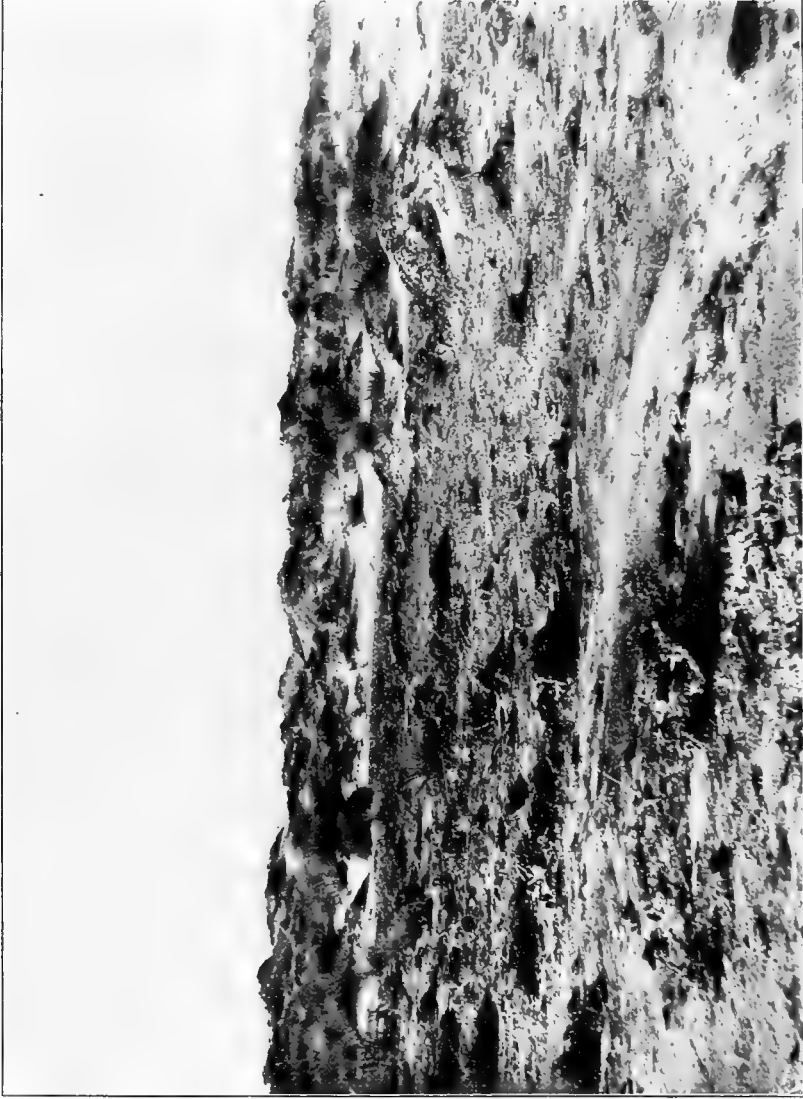


FIG. 7. Shows how an exceptionally high tide has swept into the dune complex, leveling the lower portions and destroying the non-halophytic vegetation. In front drift debris of wood, *Zostera* and "kelp" (*Macrocystis*, *Durvillaea* and others.) Small *Solidanella* dune 84 cm. high, can be seen on the right, and an embryonic dune covered with one simple plant of *Coprosma acerosa* in the center. On the level floor tussocks of *Festuca littoralis* and in background *Scirpus frondosus* dunes.

PHOTOGRAPH BY COCKayne.

dune¹⁾ about 60 km. long and 5 km. wide. Its maximum height is 270 m. At Sandgate, north of Brisbane, there is a narrow sand beach, and still farther north, at Coloundra, dunes are found. Fraser's Island in Wide Bay has some very interesting sand formations, and on the opposite mainland, at Pialba, there is a narrow beach between the high, steep bank and the high tide mark. On all these places, visited by the writer at intervals in 1900—1902, the sand is coarse, sometimes even gravelly.

Southeasterly winds are the most effective on this coast. The salinity of the surface water in the ocean is 2.7 per cent.

Along the northern coast of Queensland, at Mackay, and north of Townsville, extensive dunes were observed, but the writer had not the opportunity of examining these.

NEW ZELAND.

Beaches on the North Island at Doubtless Bay were visited in the late fall, 1902. The dune flora of the district is described by *Cheeseman*²⁾ and I am not able to add materially to his observations. The sandy beach merges gradually into low sand hills, and behind these there are extensive swamp lands. (Fig. 7.)

HAWAII.

Various sand dunes on the islands of Oahu and Hawaii were visited and studied in detail in 1903, in December, and again in 1906, during the months of August and September.

PACIFIC COAST OF NORTH AMERICA

South of Golden Gate

in California there is a district of sand formations covering an area of about 72 sq. km. From the ocean the sand stretches eastward to near San Francisco Bay, embracing almost the whole end of the peninsula. The greater part of these sand formations is now reclaimed and used for cultivation or as building lots in the city. On the Pueblo lands of

1) *Boyd*: Forestry in connection with the sand dunes of Queensland.—Queensl. Agr. Jour. 1902: 123.

2) On the Flora of the North Cape District.—Trans. N. Z. Inst. XXIX: 333—385. 1897.

San Francisco is situated the beautiful Golden Gate Park, a result of successful reclamation operations, but south of the park there is still an extensive area, where the drift sand is blown about by the winds.

The shore is open to the Pacific and the waves break furiously on the sand. After a strip of gently sloping beach, about 25 m. wide, follows a well developed littoral dune, and inside of this there is a depression, the bottom of which is sometimes level and dry, in other places occupied by small pools of stagnant water. Further inland, small mounds of sand, kept together by vegetation, still persist. A



FIG. 8. Established dune at San Francisco.
PHOTOGRAPH BY THE AUTHOR.

series of small dunes follow and then we find the dunes assuming greater and greater proportions. (Fig. 8.) The vegetation is scanty and the sand drifts in all directions. The main advance goes, however, eastward. Underlying these extensive sand deposits, is a kind of argillaceous sandstone, considered to be of Cretaceous age.

All stages can here be observed, and the even sand surfaces on the slopes of the great dunes offer good opportunities for observations of the ripple phenomenon.

The sand is coarse, mainly consisting of quartz, but is of a dark color, and contains in some places an abundant admixture of organic matter. After rain the surface is often almost gray. I found the

cause of this to be minute coal particles, brought down from the atmosphere by the rain. The origin of this coal dust is, no doubt, the smoke from the factories of the city, which settles all over the neighborhood, but is nowhere so easily perceptible to the eye as on the white sand surface.

The salinity of the sea water is according to chemical analysis¹⁾ of sample secured in the spring of 1904, 1.649 per cent. The surface temperature of the water at noon was $+12^{\circ}\text{C}$. with an atmospheric temperature of $+16^{\circ}\text{C}$. (III, 10, 04.)



FIG. 9. Pine forest on sand field in lee of the dune chain at Point Pinos, Pacific Grove, Cal. The advancing dune can be seen in background.

PHOTOGRAPH BY THE AUTHOR.

Between Pescadero and Santa Cruz on the San Francisco Peninsula sandy shores and small dune accumulations occur in various places. During the summer 1904 a visit was made to this district. The character of the dune sand corresponds to that of the San Francisco district.

1) Made by *Mr. R. W. Dodd* in the chemical laboratory of Stanford University through courtesy of *Dr. J. M. Stillman*.

MONTEREY BAY.

in its inner part, is lined with a chain of high dunes, which sometimes extend for 1 km. or more. The beach is similar to that south of Golden Gate, but no distinct littoral dune is formed, the dune-complex commencing immediately after the upper beach. Inside of the dune belt usually follow sand fields.

The Hopkins Laboratory is situated on a rocky point at Pacific Grove, and only small patches of narrow sand beach occur between the



FIG. 10. Dunes covered with a *Lupinus* community, at Seventeen Mile Drive, Pacific Grove, Cal.

PHOTOGRAPH BY THE AUTHOR.

bluffs and the ocean in the immediate neighborhood. One kilometer south of the laboratory, at Point Pinos (Fig. 9), sand formations of greater extent again commence. The beach is gravelly or even consisting of shingle for a distance until Moss Beach, where it is sandy.

The recent drift sand has accumulated into small dunes some distance from the shore (Fig. 10), leaving a belt of older consolidated sand bare or covered with a dense carpet of various plants. Further inland the dunes grow in size and finally, about 0.5 km. from the ocean, they reach quite a considerable height. One of these dunes is about 90 m. in height, sloping abruptly on its leeward side to the plain behind.

With a few interruptions by rocky points the sand dune belt continues to Carmel Bay. Here it is, however, quite narrow.

An analysis of the sand at Point Pinos gave the following result:

Quartz	61.2%
Felspar	37.6%
Hornblende	1.2%
	100%

This constitutes a fair sample of the sand in the district. The average size of the grains of 16 samples was 0.35 mm., half of the samples having been secured from the middle of the windward and the other half from the leeward side of dunes.

The prevailing winds at Point Pinos are those from W. and consequently the dunes wander in an easterly direction. It holds true that wherever winds blow in many different directions, as is the case at this place, the arrangement of the dunes is very irregular. Near the lighthouse, situated at the point, the dunes do not have any regular position, but turn in all directions. Only one kilometer further south, where the coast line is straight, the sand ridges are almost parallel to the shore. In cases where the wind has been able to break through these ridges, the central part of the dune has traveled forward more rapidly than the sides, thus leaving ridges transverse to the dunes parallel to the coast. I was here able to observe that similar results to these mentioned were obtained by the wind working through an opening between two advancing dunes, thus pushing the sand forward in the depression, and forming low ridges or cusps to leeward of the dunes. When this work has gone on for some time, the result will be exactly the same as when the wind is cutting through the central part of the dune by pushing the concavity forward until an opening is effected, that is, longitudinal ridges are formed. Fig. 11 illustrates both these modes of work of the wind. We thus find that in some cases the dune apparently travels with its convex side turned towards the wind, and I am inclined to the opinion that the formation of "barkhanes" in Sahara and other deserts, as described by several authors, takes place in this way rather than in that suggested by *Cornish*.

SOUTHERN CALIFORNIA.

At Santa Barbara in Southern California sandy beaches are common. They are, however, rather narrow, and have a steep slope. The sand is coarse, of a light yellow color. Quite extensive sand deposits are found



Fig. 11. Dunes planted with *Ammophila*. West coast of Jutland, Denmark.
PHOTOGRAPH BY BANG.

at Santa Monica. Sand dunes and sandy fields stretch inland from the beach. The sand is fine and is easily carried by the wind.

The dunes at Surf, San Diego and some other places in Southern California, as well as those at Point Reyes and Humboldt Bay, Northern California, and the extensive sand formations in Oregon and Washington are as yet unfamiliar to the writer.

MEXICO AND CENTRAL AMERICA.

Mexican Pacific Coast.

At Mazatlan the sandy beaches occurring near the town were studied. They are very small in extension, but interesting on account of the peculiar red color of the sand. Through erosion from some red cliffs extending into the ocean a sand was formed which was then thrown ashore in quantities. It was very coarse, and was not carried by the wind.

The sand at San Blas was also very coarse and of a dark hue, caused by a quantity of organic matter being constantly brought down with the river and deposited at the mouth, whence waves and wind carried it up on the beach and over the sands.

West Coast of Chiapas.

From Salina Cruz southward there is a long sand bank extending as far as the border of Guatemala, at a distance of a few hundred meters to three or four thousand from the coast. This sandbank is in places quite broad, and high dunes are formed. Inside of the bank a long lagoon is formed called the "Estero." Its shores are fringed with mangrove forests. The outer side of the bank is a continuous sandy beach, with a slope of about 35°. The sand is always tossed about by the mighty breakers of the Pacific, and the hot tropical sun assisted by the strong winds causes a rapid disintegration of the sand grains, which are carried over the bank and deposited on the estero side, gradually filling the lagoon. The sands of this bank are of a fluvio-marine origin. It is carried down by the numerous rivers that intersect the lowlands on the southern slope of Sierra Madre, then taken in hand by the waves and currents of the ocean which distribute the material evenly along the coast.

Pacific Coast of Central America.

The writer's experience of this coast is limited to the sandy beaches at Champerico in Guatemala. The slope of the beach is nearly 50°. This unusual steepness is accounted for by the heavy breakers which here strike the coast with full force, and the strong undertow which erodes the submerged beach. The sand was coarse and very little drifting occurred.

Sand Formations at Vera Cruz, Mexico.

These are very extensive and all phases of development can be observed. Sand was drifting at the time of my visit and the formation of ripples was perhaps more clear in all its details than at any other place I have seen. The dunes moved rapidly, unchecked by any vegetation. The sand contained a considerable amount of lime which added to the light color.

III. PRINCIPAL COMPONENTS OF THE SAND STRAND FLORA.

In presenting a list of the principal representatives of the flora on sandy sea shores, I do not intend to discuss the systematic relation or the specific characters of these plants. For ecological purposes this is of minor importance, at least in the present state of ecological knowledge, and in the study of this flora I have often found it to be of greater significance to consider many of the collective species, which have been divided by recent systematists, as "geographical species," whose distribution represents a distinct whole, rather than as systematic units.

As a taxonomic account I give a list of the principal plants occurring on coastal sand formations, with a short description of the vegetative parts of these "species," showing adaptations to the physical conditions of environment. This list does not pretend to be exhaustive, and contains principally those plants only which have come under the writer's personal observation.

TAXONOMIC ACCOUNT.

LIST OF SAND STRAND PLANTS.

RANUNCULACEAE.

Ranunculus acaulis Banks et Solander.

Perennial, glabrous herb, with creeping stolons; leaves slightly fleshy, 3-foliate, with sheathing petioles; creeping scions almost filiform and often subterranean.

Confined to sandy beaches of New Zealand and Chili.

A submersed plant, *R. marinus* L., occurs on the submerged beaches of the Baltic, and on the dunes of California *R. californicus* Benth. is found, but this species is not confined to the coastal sands.

Thalictrum minus Dum. var. *dunense* Buchenau.

Annual herb, with creeping rootstock; stem erect, much branched; leaves tomentose below.

On dunes of East- and West-Friesian islands, North Sea.

DILLENIACEAE.

Candollea glaberrima Steud.

Procumbent shrub, much branched, glaucous; glabrous; leaves flat, linear, obtuse, 1—5 cm. long, sheathing at base, leaving a ring round stem when falling off.

Sand formations near Perth, West Australia.

C. Huegelii Endl.

Shrub with stiff, glabrous, shining branches; leaves rigid, narrow-linear margins revolute, appearing almost terete, acute, often broken at ends, thus appearing truncate, 2—7 cm. long.

Sand formations near Fremantle, West Australia.

C. pedunculata R. Br.

Branching shrub, erect from a thick rhizome, 30—40 cm. high, glabrous; leaves linear, truncate, 1—3 cm. long, margins recurved; narrowed below, with a stemsheathing base, leaving a ring round the stem in falling off.

With preceding species.

Hibbertia grossulariaefolia Salisb.

Shrub, with weak, prostrate stem; leaves small, alternate, with a prominent midrib underneath, flat, petiolate, ovate, mostly coarsely toothed, 2—4 cm. long, glabrous above, pubescent underneath; flowers pale yellow.

Occurs together with several other species of the same genus on sands near the mouth of Swan River, West Australia.

CRUCIFERAE.

Cakile americana Nutt.

Annual herb, with deep root, decumbent stems up to 1 m. long, fleshy leaves, obovate, obtuse, crenate or sinuate toothed; flowers small, purplish. Pod fleshy, dry and corky when ripe.

Sandy shores of east and west coast of North America. Also along the Great Lakes.

C. maritima Scop.

Annual herb, with often meter deep root; stem much-branching, hard at base, erect-decumbent; leaves few, fleshy, with oblong lobes; flowers purplish or white.

On all seacoasts of Europe and Western Asia, North Africa, North and South America, extratropical Australia.

Crambe maritima L.

Perennial herb, glabrous, glaucous, with branched stems, 0, 5 m. high; leaves petiolate, large, thick, oblong, undulate, and coarsely toothed, upper leaves small; flowers white; pod globular, indehiscent, with one seed.

Sandy and gravelly seashores of Baltic, Western Europe, and Black Sea.

Erysimum capitatum (Dougl.) Greene.

Perennial herb, stout, erect, 15—45 cm. high, leafy, finely pubescent; leaves narrow, entire; flowers cream-colored.

Seashores of California.

Malcolmia litorea R. Br.

Suffrutescent; leaves obovate-oblong, obtuse, coarsely toothed, covered with a dense grayish tomentum.

On maritime sand dunes of Western Mediterranean. Several other species of the same genus occur on the dunes of that region.

VIOLACEAE.

Viola arenaria DC.

Perennial rootstock; stems tufted, spreading, 5—15 cm. long, finely puberulent; leaves ovate, crenulate, obtuse, somewhat thick; petioles long; stipules incised; flowers violet.

Sandy shores of Europe and Eastern America, but goes also inland.

V. tricolor L.

Annual herb, distributed over Europe and Northern Asia, and is introduced to America. Often found on coastal sand formations, although an inland plant.

PITTOSPOREAE.

Bursaria spinosa Cav.

Shrub, very bushy, somewhat thorny, glabrous; leaves clustered, obovate, obtuse, 1—3 cm. long; narrowed at base, petiolate, green on both sides.

On the coasts of Tasmania and Australia, from Queensland to South Australia (St. Vincent's Gulf), but also found in the interior. A variety *incana* Lindl. is hoary in its young stages, and the under side of leaves are always tomentose. This form is found in West Australia and in the tropical parts of that continent.

Pittosporum crassifolium A. Cunn. and *P. umbellatum* Banks et Sol. are two littoral shrubs occurring on North Island of New Zealand, but are not confined to sand formations.

FRANKENIACEAE.

Frankenia grandiflora C. et S.

Perennial herb, erect or diffuse, slightly suffrutescent, 20—35 cm. high, smooth or somewhat pubescent; leaves entire, obovate, 1—2 cm. long, with revolute margins, sessile or short-petiolate, fascicled in the axils, the opposite pair mostly united by a somewhat membranaceous sheathing base.

Common especially on the marshes of the California sea shore, but spreads into Nevada, Arizona, and New Mexico, preferring saline soil.

A shrubby *F. pauciflora* DC. is common on the sandy shores of Tasmania, West Australia, South Australia, and Victoria, but occurs also in the interior deserts.

F. hirsuta L.

Perennial herb, prostrate, seldom erect; leaves linear or oblong-linear, margins revolute.

A true halophyte, occurring in Southern Europe, North Africa, and Siberia.

F. pulverulenta L.

Annual herb, prostrate; leaves obovate, thickly pulverulent on lower side.

On seashores of the whole Mediterranean, but not confined to sand formations.

CARYOPHYLLACEAE.

Ammodenia peploides (L.) Rupr.

Perennial herb, with long, brown rootstocks, fleshy, glabrous; stems tufted, stout, simple or branched, erect or diffuse, 7—25 cm. high; leaves sessile, clasping, ovate, acute; flowers small.

On sandy beaches and littoral dunes in Northern Europe and Asia, and on the Atlantic coast of North America from New Jersey to the Arctic.

Arenaria serpyllifolia L.

Annual tufted herb, slender, slightly pubescent, much-branched, diffuse, 5—20 cm. high; leaves ovate; flowers white.

Occurs often on dunes of Europe, Northern Asia and is introduced into North America. Not confined to coast.

Cerastium semidecandrum L.

also not unfrequently occurs on dunes of Europe, but is not a sea coast plant. It often varies when growing near the sea.

Sagina crassicaulis Wats.

Perennial herb, smooth, stem stoutish and succulent, branching, 3—12 cm. long, decumbent; leaves linear, thickish, 4—10 mm. long, the basal forming a rosette, the cauline connate by broad scarious membranes.

Beaches of California from Monterey to Tomales Bay.

S. procumbens L.

Annual, 3—5 cm. high, branching and decumbent at base, forming tufts, glabrous; leaves subulate, forming at base a short sheath; flowers small.

It is especially a maritime form, *S. maritima* Don., with thicker leaves, which occurs on the coast. Europe, Central Asia, North America, Australia.

Silene gallica L.

Annual herb, hairy, viscid, 15—35 cm. high, erect; lower leaves small, obovate, the upper ones narrow and pointed, flowers small, white.

Common on sand, gravel and waste places in almost every part of the world, and seems to prefer the coast. Abundant on dunes at Fremantle, West Australia, and in Central California.

S. nicaeensis All.

Perennial herb, covered with long viscid hairs; leaves green, linear-oblong, obtuse, acute.

Coastal sands of Mediterranean countries.

Of this genus several species as *S. viscosa* Pers., *S. maritima* With., and *S. inflata* Sm. var. *litoralis* are distinctly maritime near the Baltic, but usually do not occur on sand.

Tissa Clevelandi Greene.

Perennial, viscid, glandular; stems prostrate, forming deep-green mats, 10—30 cm. broad; leaves filiform, conspicuously fascicled in the axils, all longer than the internodes.

On the dunes near San Francisco, Presidio near that city being the type locality.

T. macrotheca (Hornem.) Britt.

Perennial herb, succulent with fusiform fleshy roots, stout stems, 18—30 cm. high, erect or ascending from the short, often branched, woody crown of the thick taproot; herbage deep green, viscid-pubescent above, glabrous below; leaves narrow-linear, 2—4 cm. long; stipules large, ovate.

Common on sands near San Francisco and Pacific Grove, California.

Var. *scariosa* Britton, with paler herbage, glandular-pubescent, or almost glabrous, and short internodes, is frequently met with on dunes at San Francisco and Monterey, although it prefers the bluffs near sea.

T. marina (L.) Britton.

Annual, biennial, or mostly perennial herb, glabrous or with short viscid pubescence; numerous stems branching from base, forming prostrate tufts, 6—12 cm. long; leaves fleshy, on coast, linear, with small, scarious stipules at base; flowers pink or white.

Common on sea shores in many temperate and subtropical countries. Europe, temperate Asia, Australia, New Zealand, North America, and some parts of South America.

PORTULACACEAE.

Portulaca oleracea L.

Fleshy, prostrate annual, seldom exceeding 15 cm., with succulent, alternate leaves, glabrous, cuneate or obovate, obtuse; flowers sessile, yellow, open only in sunshine; seeds many, capsule.

One of the most common sandy sea shore plants in the tropics and in most subtropical countries. Does not occur on California dunes.

Claytonia

is often represented on coastal sands by different species, *C.* (or *Montia*) *perfoliata* Donn., for instance, at San Francisco, and *C. australasica* Hook. f. on sandhills near Dunedin, New Zealand (Kirk.).

TILIACEAE.

Triumfetta procumbens Forst.

Prostrate perennial; stems 6—12 dm. long, rooting at joints; branches ascending, tomentose; leaves petiolate, ovate, obtuse, 2—5 cm. long, entire, or divided into 3 or 5 lobes, glabrous above, tomentose underneath; flowers yellow; fruit globular, 15 mm. in diameter, covered with prickles.

Occurs on sandy sea shores of Queensland, most of the Pacific islands, and in the Malayan Archipelago.

LINACEAE.

Linum monogynum Forst.

Perennial, glabrous herb, woody at the base, branched or simple, erect, 15—50 cm. high; leaves numerous, narrow, lanceolate, 1—3 cm. long; flowers large, white.

Restricted to New Zealand, where chiefly littoral.

ZYGOPHYLLACEAE.

Zygophyllum Billardieri DC.

Prostrate herb, much-branched; leaves fleshy, opposite, with two distinct leaflets; these oblong or linear, 1—3 cm. long; stipules small; flowers white.

Endemic in Australia, where it occurs on drifting sands in Victoria, South Australia, and West Australia.

RUTACEAE.

Correa alba Andr.

Much-branched compact shrub, 3—12 cm. high, branches covered with a hoary, brown-reddish tomentum; leaves ovate-obovate, obtuse, 1—3 cm. long, coriaceous, somewhat tomentose above, in age glabrous, densely tomentose beneath; flowers pink.

Common on sandy shores of Victoria and South Australia.

RHAMNACEAE.

Ceanothus thyrsiflorus Eson.

Shrub, 1—2 m. high, much-branched; leaves green, oblong-obovate, serrate, 2—6 cm. long; flowers blue.

Coastal sands of California, but not confined to these situations.

Discaria Toumatou Raoul.

Varying from a small thorny shrub to a 6 m. high tree; leaves small, usually glabrous, absent in old plants; branchlets reduced to opposite woody spines, nearly 5 cm. long.

Restricted to New Zealand.

ANACARDIACEAE.

Corynocarpus laevigatus Forst.

Evergreen, glabrous tree, with alternate, oblong leaves narrowed into short, stout petioles.

Very abundant on the coasts of New Zealand, but also found inland.

LEGUMINOSAE.

Acacia retinoides Schlecht, and *A. salicina* Lindl.

are often among the species of this large genus, which occur on the coastal sand formations of Australia, the former being common on dunes in Victoria, the latter the most abundant form on the sandhills round St. Vincent's Gulf in South Australia. *A. pycnantha* Benth. is recommended as suitable for planting on drift sands.

Astragalus arenarius L. Pall.

Low perennial with creeping rootstock, prostrate stems, branching at base, 5—15 cm. long, hairy; leaves pinnate; leaflets linear-lanceolate, flowers bluish-purple.

Has a wide range on coastal sands of Europe, Asia, and North America, but does not extend to the Arctic or to the tropics. Sometimes also on inland sand formations in Europe.

A. Menziesii Gray.

Perennial, stout, erect, 6—12 dm. high; young herbage whitish pubescent, soon green, but hirsute-pubescent; leaflets many, commonly crowded on the rachis, broadly oblong, usually retuse at apex, 10—15 mm. long, stipules broad, not pointed; corolla yellowish-white, with purple-tipped keel; pod 2—4 cm. long, thin-walled, much inflated, ovoid.

Coastal sands of California.

Canavalia obtusifolia DC.

Perennial herb, with trailing stems, glabrous; leaflets broadly obovate, obtuse, 5—7 cm. long, thick; flowers pink.

Common on coastal sands in the tropics of South America, Africa, Asia, and Australia. At Moreton Bay in Queensland.

Crotalaria Cunninghamii R. Br.

Shrub, 6—10 dm. high, terete, tomentose branches; leaves ovate, broad, obtuse, 3—18 cm. long, densely tomentose on both sides, petiole 1—2 cm. long, geniculate above middle; stipules and bracts subulate; flowers large, yellow-green, streaked with dark lines.

Sandy shores of North, South, and West Australia.

Gastrolobium spinosum Benth.

Shrub, 6—8 dm. high, mostly glabrous, but sometimes the young shoots are clothed with evanescent wool; leaves opposite, ovate-cordate, ending in a pungent point, and bordered with prickly teeth, 2—4 cm. long and just as broad, rigidly coriaceous, usually glaucous.

Together with several other species of the same genus common on dunes near Fremantle, West Australia.

Genista monosperma Lam.

Common shrub in the Mediterranean countries on sand, but is not confined to sea coasts. Is often planted on dunes as an effective sand stay.



FIG. 12. *Scaevola frutescens* community on dunes, at New Brighton, Canterbury, New Zealand. In front drift from exceptionally high tide.

PHOTOGRAPH BY COCHRANE.

Lathyrus litoralis (Nutt.) Endl.

A maritime species occurring on sea shore of Marin Co. and northward in California (Jepson: Flora of Western Middle California, 1901, p. 298).

L. maritimus Bigelow.

Perennial herb, with creeping rootstock, stout, 30 cm. high or more, glabrous, stems sharply angular, spreading; leaves with many pairs of leaflets, these ovate or elliptical; leafstalk ending in a long tendril; flowers large, purple; pod hairy when young, 3—5 cm. long.

Sandy and gravelly coasts of Northern Europe, not going further south than Picardy; Arctic Europe, Asia, and America, where it extends down the eastern coast. A form called *L. californicus* Dougl. is found on sea shores of Washington, and a variety *aleuticus* White, is found in the arctic parts of America.

Lotus corniculatus L. var. *crassifolius* Pers.

Perennial stock, with a long taproot; stems decumbent or prostrate, 1—5 dm. long; leaves pinnate, somewhat fleshy; leaflets ovate, pointed, flowers yellow.

This variety represents a race characteristic to the sea shores of Europe, but is not related to *L. crassifolius* Greene, which is a different plant of Western America, where it does not follow the coast.

Distributed over Europe, Northern and Central Asia, the mountainous districts of East Indian Peninsula, and Australia.

Lupinus arboreus Sims.

Arborescent or suffrutescent, silky pubescent on young stems and lower surface of leaves; petioles short; leaflets narrowly lanceolate, 3—6 cm. long, 9—11 on first leaves, 6—8 on later leaves from the axils, these smaller; corolla sulphur-yellow, keel purple tipped; cotyledon of the seedling petioled.

Sand strands and in the neighborhood of coasts, California.

L. Chamissonis Esch.

Perennial, stems woody below, 3—12 dm. high, densely tomentose; leaflets 7—9, silky-pubescent, oblong-oblancoelate, 1—3 cm. long, petioles short; flowers blue, the banner with a yellow spot.

Sandy soil along the whole Californian coast and Oregon coast.

L. litoralis Dougl.

is a sea shore plant of California, from Point Reyes northward to Vancouver Island. (Jepson l. c.)

L. trifidus Torr.

Annual herb, branched from base, 15—30 cm. high, densely pilose pubescent, the younger parts canescent; leaflets 6—8, linear; corolla blue, with a white spot on the banner.

Coastal sands at San Francisco and Pacific Grove.

Medicago litoralis Rohde.

Annual herb, with obovate leaflets, toothed at apex, hairy.
On sandy sea shores of the Mediterranean.

M. marina L.

Perennial herb, with obovate leaflets, toothed at apex, tomentose; flowers yellow, large.

Sandy shores of the Mediterranean region.

Oxylobium callistachys Benth.

Tall shrub, young branches angular, clothed with appressed silky hairs; leaves lanceolate, 5—10 cm. long, obtuse, coriaceous, glabrous and reticulate above, silky-pubescent beneath, especially when young; flowers yellow.

Restricted to Western Australia.

O. reticulatum Meissn.

Shrub, 6—10 dm. high, rigid branches, silky-pubescent; leaves opposite, obovate, obtuse, 2 cm. long, coriaceous, reticulate and glabrous in age.

Sea shore sands of West Australia. Occurs also on inland sand formations of that country. With several other species of *Oxylobium* common in the neighborhood of Perth.

Swainsonia

is a genus represented by several species on the sand formations of Australia, especially Victoria, but these plants are not restricted to the coast.

Trifolium fragiferum L.

Perennial stock, creeping stems, rooting at the nodes; leaflets

obovate, toothed; leafstalks long, slightly hairy; flowers sessile, white, the head very compact.

Europe, Central Asia, preferring the coast, especially on the Baltic.

T. repens. L.

Perennial plant, glabrous or sometimes slightly hairy; stems creeping, rooting at the nodes; leafstalks long, flowers white, sometimes pinkish.

Europe and Northern Asia, whence spread to many countries. Not confined to coasts or sandy soil, but often occurring on such localities.

Vicia cracca L.

Perennial rootstock; the annual stems climbing, with branched tendrils, 6—12 dm. long, hairy; leaflets numerous, oblong, 20—25 mm. long.

Common in Europe and Northern Asia, whence introduced to North America. Not confined to coast.

Ulex europaeus L.

Shrub, 6—20 dm. high, much branched, hairy; the small branches all end in a thorn; lower leaves lanceolate, upper ones reduced to thorns.

Sandy, dry soil in Western and Southern Europe, but not confined to maritime situations.

Vigna lutea A. Gray.

Prostrate or trailing herb, almost glabrous; leaves pinnately trifoliate, stipulate; leaflets entire, obovate, obtuse, 3—8 cm. long; stipules short and broad; flowers yellow.

Common on sandy shores in tropical Asia, South Africa, Australia, and Pacific Islands, rare in West Indies. On several islands along the Queensland coast, on shores of Moreton Bay and in New South Wales at Newcastle and Botany Bay on coastal sands.

A nearly related form *V. luteola* Benth. occurs on sandy sea shores in different countries, but has not been observed by the writer.

ROSACEAE.

Adenostoma fasciculatum H. et A.

Evergreen shrub, 6—25 dm. high, with virgate branches clothed with leaf-fascicles; leaves linear, rigid, entire, numerous, and mostly fascicled. 8—12 mm. long; flowers small, white.

Although not a sea coast plant, this species is included here, because

it is a conspicuous feature of the older dunes of the Californian coast, especially at Monterey Bay. It is one of the characteristic plants of the chaparral formation in certain parts of California.

Argentina anserina (L.) Rydb.

Perennial, stemless herb, silvery with white tomentum especially beneath, rootstock sending out numerous, long, slender, jointed runners from the nodes; leaves 8—15 cm. long, in tufts, unequally pinnate; leaflets in 5—20 pairs, oblong or rounded, with very small ones intermixed, deeply toothed, white-silky, tomentose beneath or on both sides; flower large, yellow.

In temperate countries in both hemispheres, extending to the Arctic. Seems to follow the coast in California, and is never absent from suitable localities on the sea shores of the Baltic.

Fragaria chilensis Duchesne.

Perennial acaulescent herb, with stout runners; upper surface of leaves glabrous; rest of herbage densely pubescent with long weak hairs, especially beneath; leaves of firm texture, dark green, leaflets 1—3 cm. long; flowers 2 cm. in diameter, white.

Coastal sands from San Francisco northward to Alaska. Also in Chili.

Potentilla reptans L.

Perennial herb, with slender, prostrate stems, rooting at the nodes; leaves petiolate; leaflets 5, obovate, coarsely toothed; flowers large, yellow.

Dispersed over Europe, Northern and Western Asia. Also naturalized in New Zealand.

Rosa pimpinellifolia L.

Erect shrub, with widely creeping subterranean stem, much-branched, 2—4 dm. high; leaflets small, glabrous; flowers pinkish.

Europe and temperate Asia, but not in Arctic. Occurs generally not far from the sea, and is a characteristic plant on the dunes of the Friesian Islands (Buchenau).

CRASSULACEAE.

Sedum acre L.

Perennial tufts, procumbent, consisting of numerous short, barren

stems, and erect flowering branches, 3—7 cm. high, glabrous, somewhat yellowish; leaves small, thick, ovoid; flowers yellow.

Common in Europe and temperate Asia. Not confined to coastal sands, but frequently occurring there.

Tillaea minima Miers

Low succulent annual, simple or with many ascending branches, 2—7 cm. high; herbage of adult plant reddish; leaves ovate or oblong, obtuse, 2 mm. long.

There is a *Tillaea* common on sandy shores in Australia, f. i. at Moreton Bay, Sydney, Port Phillip, Vincent's Gulf and Perth, and the same form is said to occur in New Zealand and extratropical South America. It is recognized as *T. verticillata* DC. by Bentham, but the difference, if any at all, is inconspicuous between this form and *T. minima* Miers., which is widely distributed in temperate South America and California. When occurring on the coast this species is always more succulent than in inland situations.

T. moschata DC.

Annual herb, with red creeping stems, 8—20 cm. long, succulent, rooting from the axils; leaves 1 cm. long, entire, obovate, obtuse; flowers comparatively large.

Occurs in New Zealand and on adjoining islands, in Southern Chili and Fuegia, as well as on several oceanic islands, as Falkland's and Kerguelen's Land.

T. muscosa L.

Annual herb, 2—4 cm. high, much-branched, reddish, succulent; leaves linear.

In Western and Southern Europe from Mediterranean northwards to Holland.

HALORAGEAE.

Gunnera arenaria Cheeseman.

Fleshy glabrous herb, with slender rhizomes, tufted; leaves 3—5 cm. long, ovate, petioles sheathing at base, with short flattened hairs on upper part. This species shows a remarkable dimorphism in the form of flowers, drupes and even nuts.

Coastal sands of New Zealand.



FIG. 13. Moist hollow between fairly stable dunes occupied by a *Soklanella* community in which *Gunnera arenaria* Cheesm. is dominating. Upper surface of most *Gunnera* leaves is covered with sand.

PHOTOGRAPH BY COCKAYNE.

Hippuris vulgaris L. f. *maritima*.

Perennial rootstock, with annual stems, 3—6 dm. high, stout; leaves entire, linear, acute, 10—15 mm. long; flowers inconspicuous.

Occurs on coasts of Baltic. The typical form is dispersed over Europe and northern North America, and is not a coast plant.

RHIZOPHOREAE.

Rhizophora mangle L.

The common mangrove of all tropical coasts does not, as a rule, occur on sandy shores, but occasional specimens can be found on sandy beaches or fringing sandy islands.

MYRTACEAE.

Calythrix aurea Lindl.

Erect shrub, rigid, not much branched, minutely pubescent; leaves erect, ovate, thick, concave, obtuse, ciliate on margins and midrib; flowers yellow in leafy heads.

Together with other species of the same genus on sands at Swan River, West Australia.

Kunzea pomifera F. Muell.

Rigid, prostrate shrub, glabrous, or young shoots somewhat pubescent; leaves ovate, narrow at base, rigid, spreading, obtuse, 6—12 mm. long; flowers white.

Sandy shores of Victoria and South Australia (St. Vincent's Gulf). Also in interior deserts of Australia.

Leptospermum laevigatum F. Muell.

Tall shrub, glabrous, somewhat glaucous, young shoots often silky; leaves oblong, 1—4 cm. long, 3-nerved, alternate, rigid, entire; flowers white.

Coastal sand formations in Australia (Sydney, Port Phillip, South Australia, and Tasmania). Does not extend to West Australia.

L. scoparium Forst.

Rigid shrub to 7 m. high tree, much-branched; leaves small, ovate, alternate, erect, concave; young shoots covered with silky hairs, adult foliage mostly glabrous.

Australia and New Zealand on the beach. In the latter country it extends to an altitude of 1000 m.

On sand at Moreton Bay and Port Jackson *L. myrtifolium* Sieb. is quite common.

Melaleuca.

Several species of this typical Australian genus occur on coastal sands, f. i. *M. parviflora* Reich. on sand dunes of Victoria. Not restricted to the coast, however. *M. ericifolia* Smith thrives in very salty situations, growing almost like a mangrove on muddy ocean shores. It is especially well adapted for fixing sand along salt lagoons and in wet places between dunes.

Metrosideros tomentosa A. Rich.

Large shrub or tree with massive spreading arms and stout, tomentose branchlets; leaves 3—10 cm. long, with short petioles, oblong, usually narrowed towards apex, rounded at base, margins flat or recurved, clothed with white tomentum beneath.

New Zealand (North Island only) coasts. Abundant on North Cape.

ONAGRACEAE.

Fuchsia procumbens R. Cunn.

Much-branched; stems prostrate, slender, 15—45 cm. long; leaves alternate, ovate, 1—2 cm. long, shorter than petioles; berry large, glaucous.

Sandy places near highwater mark on Northern coast of North Island, New Zealand.

Oenothera cheiranthifolia Hornem.

Annual caulescent herb, prostrate and radiating from a central radical rosette, crowning the taproot, 45—75 cm. long, rigid and tough; leaves thick, canescently pubescent, obovate-oblong, obtuse, shortly petiolate, 1—3 cm. long; flowers yellow; seeds many.

Coastal sand dunes, California.

O. micrantha Hornem.

Annual; branches procumbent from a short primary axis, not rigid or tough, pubescence hirsutulous; leaves radical, in rosette, oblong-lanceolate, 4 cm. long, slightly undulate, denticulate.

Does not differ materially from foregoing species.

Californian coast from San Francisco southward. According to

Abrams¹⁾ not confined to coast, but also found on sand in the interior valleys of California.

Mesembryanthemum aequilaterale Haworth.

Perennial plant often forming extensive mats; robust, prostrate stems, woody at base, with short ascending flowering branches; leaves opposite, stem-clasping, 4—8 cm. long, glabrous, succulent, linear, triangular, sometimes compressed laterally, acute; flowers rose-colored; seeds minute, numerous.

This species scarcely differs from the South African *M. acinaciforme* L. except in smaller flowers and less succulent leaves.

Follows the coast in California, Chili, and Australia. In the latter country it sometimes ascends the rivers as far as the water is brackish, and it occurs on the salt plains of the interior in a few places. Grows generally on the littoral dune, where that formation is developed.

M. australe Sol.

Perennial; stems prostrate, rooting at base, 3—15 dm. long; leaves opposite; connate at base, triangular, flat above, keeled or convex beneath, acute, fleshy, 2—4 cm. long, often crowded in short auxiliary shoots; some plants have red, others green leaves; flowers rose-colored.

Appears not to be very distinct from *M. crassifolium* L. of South Africa.

Coasts of Australia, New Zealand, South Pacific Islands and California, at San Francisco, where most likely introduced.

M. capitatum Haw.

Perennial, often suffruticose caudex, simple or branched; leaves crowded, very long, triquetrous, glaucescent.

A South African species sometimes cultivated on sand dunes in Australia. The nearly related *M. pugioniforme* L. from South Africa is also a good sand stay.

M. crystallinum L.

Prostrate annual or biennial, much-branched, stems thick, about 3 dm. long, covered with transparent vesicles; leaves undulate, succulent, obovate, obtuse, narrowed into a stemclasping petiole; flowers white or pink.

1) L. R. Abrams: Flora of Los Angeles and vicinity, p. 271, 1904.

Common on sea coasts of South Africa. Also on the coasts of Southern Europe, Canary Islands, California and Australia (South and West Australia).

M. edule L.

Stems stout, spreading, prostrate, angular. Leaves opposite, fleshy, 7 cm. long, shortly connate at base, linear, triquetrous, concave above; keel serrulate.

Coast of South Africa, whence introduced into many countries as a sandstay and then naturalized, f. i. on North Island of New Zealand.

Tetragonia expansa Murray

Succulent perennial, branched, erect or prostrate, 3—6 dm. high, glabrous, papillose; leaves alternate, plane, rhomboid-ovate, 4—5 nerved beneath, 2—8 cm. long, abruptly narrowed into a broad petiole, entire, acute or obtuse; flowers small, yellow; fruit angular with 2—4 spines.

On coast of Australia, New Zealand, and adjoining islands, Japan, Polynesia, temperate South America and California (Pacific Grove and shores of San Francisco Bay).

T. trigyna Banks & Sol.

Stems suffruticose, 2—15 dm. long, almost trailing and climbing; leaves alternate, broadly ovate, abruptly narrowed into the petiole, papillose.

Australia, Tasmania, New Zealand and adjoining islands.

A number of species of this genus occur on the sandy sea shores of South Africa.

UMBELLIFERAE.

Angelica litoralis Fries.

Perennial, 1—2 m. high, 2—3 ternately divided; leaflets ovate, acute, serrate; petioles thick, the upper ones much inflated; flowers greenish-yellow.

Occurs on gravelly and stony shores of the Baltic.

A. rosaefolia Hook.

Suffruticose plant, chiefly littoral in New Zealand (Kirk: Student's Flora of New Zealand).

Apium prostratum Labill.

Root stout; stems prostrate, 15—60 cm. long, stout, grooved; leaves 2—3 pinnate; leaflets sessile; obovate, narrow-linear, membranous.

Sea shores of Australia, Tasmania, New Zealand, South Pacific Island, South America, South Africa, and several oceanic islands.

Crantzia lineata Nutt.

Small, creeping, glabrous perennial, with solitary or tufted, erect, cylindrical leaves, springing from the nodes; rhizomes slender, rooting at the nodes; leaves 1—12 cm. long, linear-fistular, obtuse, sometimes compressed, especially when growing in elevated situations.

North America on the Atlantic and certain parts of the Pacific Coast; New Zealand and Chatham Island. Is a saltmarsh plant, but occurs often in moist hollows between dunes.

Daucus maritimus Lam.

Biennial, with leaves in rosette, densely covered with a short tomentum.

Mediterranean countries, where often found on sand dunes.

Eryngium maritimum L.

Perennial root herb with deep root; about 8 dm. high, stiff, erect, much-branched, glabrous, glaucous; leaves stiff, broad, sinuate, divided into 3 broad, short lobes, veined, bordered by coarse teeth, radical leaves petiolate, others clasping.

Common on maritime sands of Europe, North Africa and Western Asia, mostly growing on the upper beach or the littoral dune.

E. vesiculosum Labill.

Perennial, with stout root; stems 5—15 cm. long, prostrate, but never rooting at the nodes; radical leaves rosulate, lanceolate-oblong, narrowed into a flat petiole, 3—9 cm. long, deeply toothed; teeth spinescent.

Sandy beaches of New Zealand and Australia.

Hydrocotyle Novae Zealandiae DC.

occurs sometimes on sandy beaches of North Island, New Zealand, in a form, described by Kirk (in his Student's Flora, p. 189) as *H. robusta*.

ARALIACEAE.

Pseudopanax Lessonii C. Koch.

Much branched shrub or small tree; branches stout; leaves 2—5 foliate; leaflets sessile, 2—10 cm. long, obovate, obtuse, thick and

coriaceous, glossy, entire or sinuate-serrate; veins indistinct; petioles 5—15 cm. long.

Sea coast of North Island, New Zealand.

RUBIACEAE.

Coprosma acerosa A. Cunn. f. *arenaria* Kirk.

Low shrub, seldom more than 1.5 m. high; branches often interlaced; leaves narrow, close-set; bark yellowish-brown.

On drifting sands of New Zealand, rarely inland.

C. Baueri Endl.

Shrub or small tree, glabrous except the young shoots, which are sometimes minutely pubescent; branchlets stout, terete; leaves somewhat fleshy, broadly ovate, narrowed into a short slender petiole, rounded at the tip; margins often recurved, glossy; stipules broad, acute, minutely toothed; peduncles axillary.

Coast of New Zealand.

Galium verum L.

Perennial from woody rootstock, glabrous; stems much-branched at base, decumbent, 15—30 cm. long; flowers yellow.

Europe and temperate Asia. Not confined to the coast, but occurs often on upper beach and littoral dune, not infrequently together with *G. mollugo*.

VALERIANACEAE.

Valeriana officinalis L.

Perennial stock; creeping runners; erect flowering stems, 15—20 cm. high; leaves pinnate with many lanceolate segments, 2—6 cm. long, coarsely toothed, somewhat hairy underneath; flowers white or pinkish.

Common in Europe and temperate Asia. Not confined to coast, but frequently occurring on upper beach near brackish water.

Valerianella olitoria Poll.

Annual herb, glabrous, 6—15 cm. high, erect or ascending, branching from base, radical leaves caespitose, oblong, 3—5 cm. long, rounded at top, entire, narrowing at base; stemleaves narrower, clasping, coarsely toothed.

Common in Europe, especially in the south.

CAMPANULACEAE.

Campanula rotundifolia L.

Perennial, with slender, creeping rootstock; radical leaves ovate, others narrow-lanceolate, entire; flowers blue.

Common on dry places throughout Europe, but not confined to coast, although it frequently occurs on established dunes.

Jasione montana L.

Biennial, with tufted leaves, linear or lanceolate, somewhat hairy; flowers blue.

Widely spread in Europe.

It is especially the form *litoralis* Fries, prostrate and tufty, which occurs on the dunes of the Baltic.

COMPOSITAE.

Achillea millefolium L.

Perennial herb, common in Europe and North America, but not confined to the coast, although it frequently occurs on dunes.

Anaphalis margaritacea (L.) B. & H.

Is abundant on dunes at San Francisco and Pacific Grove, but is not restricted to coastal sands.

Angianthus eriocephalus Benth.

Low, slender annual, 2—5 cm. high, leaves narrow-linear, opposite, entire, woolly-white.

On coast sand formations in Victoria and Western Australia. Occurs also in Tasmania.

Artemisia absinthium L.

Shrubby, with short stem, much-branched and leafy, annual flowering stems hard, 3—6 dm. high, white-gray tomentose; leaves small, divided into oblong, linear, obtuse lobes.

Near the sea in Europe and temperate Asia, whence introduced to North America and New Zealand.

A. campestris L.

Perennial stock, sometimes shrubby, low, branched; annual branches spreading, 3—4 dm. long, glabrous, somewhat reddish; leaves small, once or twice pinnate, with few narrow-linear segments, green on upper surface.

Frequently on shores, although not restricted to coast. Europe and temperate Asia. Several forms of this plant occur on the coastal dunes of Germany, as *sericea* Fr. and *stramentisia* G. Beck.

A. maritima L.

Suffrutescent, much-branched, decumbent, covered with white tomentum; leaves twice pinnate, with narrow-linear segments.

Maritime sands of Western Europe, Mediterranean, Black Sea, and Caspian Sea.

A. pycnocephala DC.

Perennial herb, with stout stem, 4—8 dm. high, somewhat woody at base, crowded with leaves, once or twice pinnately divided into linear entire segments; herbage densely silky-villous; flowers yellow.

Coastal sand dunes of California, from Monterey northwards,

A. Stelleriana Bess.

Perennial, densely white-tomentose; stem-branched, 3—7 dm. high, bushy; branches ascending; leaves obovate, 2—8 cm. long, pinnatifid into oblong, obtuse, usually entire lobes; densely tomentose beneath, but green and glabrous above in age.

Sandy sea beaches, Kamtschatka, Southern Sweden, Denmark, England, Ireland, Atlantic coast of North America.

A. vulgaris L.

Perennial, thick and woody stock, erect flowering stems, 5—10 dm. high, glabrous; leaves pinnatifid, with lanceolate, pointed lobes, coarsely toothed, dark green and glabrous above, white tomentose underneath.

Common in Europe, Asia, and North America. Not confined to coast.

Aster (Olearia) axillaris F. Muell.

Erect shrub, much-branched, 1—3 m. high, white-tomentose; leaves obovate, or linear, 1—2 cm. long, obtuse, entire, with revolute margins, glabrous and shining above, white-woolly beneath.

On coastal sand dunes in Victoria, South Australia (St. Vincent's Gulf), and Western Australia (Perth). Also in Tasmania.

A. (Olearia) glutinosus Benth.

Much-branched shrub, 1—1.6 m. high, glabrous, glutinous; leaves narrow-linear, acute, 1—4 cm. long, flat, margins somewhat recurved.

Sandy coasts of Tasmania, Victoria and South Australia.

A. (Olearia) ramulosus Benth.

Shrub, 1—2 m. high, much-branched, pubescent, sometimes glutinous; leaves small, spreading, obovate, petiolate, obtuse, with revolute margins, glabrous above, woolly beneath.

Together with other species of this genus on dunes in Victoria, but not confined to coast. In Tasmania, New South Wales, and South Australia.

A. (Olearia) Solandri Hook. f.

Much-branched shrub, 1—4 m. high, branchlets stout, puberulous; white-yellowish tomentose beneath; margins recurved.

Usually on coast; New Zealand, especially on North Island.

A. Tripolium L.

Perennial herb, glabrous, 2—3 dm. high, erect or decumbent; leaves linear, entire, somewhat succulent; rayflowers purplish.

Maritime coasts of Europe, and temperate Asia.

Baccharis pilularis DC.

Evergreen shrub, prostrate on sand, 2—15 dm. high; branchlets angular; leaves sessile, obovate, 1—3 cm. long, sinuately toothed.

The more erect form is widely spread inland in California, while the prostrate form is confined to the coast. Rare south of Point Conception according to Abrams.

Bidens bipinnata L.

Glabrous annual, 0.5—1 m. high; branches angular; leaves thin, pinnately divided; leafsegments again divided into small, deeply toothed lobes; flowers yellow.

On sandy shores of Queensland, as Moreton Bay. Is common in various situations in the eastern part of North America and in the tropics of that continent.

Calocephalus Brownii F. Muell.

Low, rigid, much-branched shrub, 3 dm. high, covered with a white, woolly tomentum; leaves alternate, linear, obtuse, 2 mm. long.

On sea coasts of Tasmania, Victoria, South Australia and Western Australia.

Cassinia fulvida Hook. f.

Erect shrub, about 1 m. high, much-branched; branches covered with a yellowish, subviscid tomentum; leaves narrow, linear, spreading, margins slightly curved, clothed with fulvous tomentum; glutinous above. Midrib obvious below.

Restricted to New Zealand, where it goes up to 1200 m. from sea level.

C. retorta A. Cunn.

Shrub, 1—3 m. high, with slender branches, covered with gray tomentum; small, erect, narrow-linear leaves, with recurved margins, underneath covered with whitish appressed tomentum.

On North Cape, New Zealand.

Cirsium occidentale Nutt.

Biennial herb, stout, 4—10 dm. high, white with thick coating of cottony wool; leaves pinnatifid, not very prickly, glabrate above, canescent beneath; flowers purple.

Common on established dunes near San Francisco, and follows the coast southward in California, extending inland among hills of coast ranges.

Corethrogyne obovata Benth.

Perennial with decumbent stems, 3—6 dm. long; leaves 2—3 cm. long, obovate, obtuse, toothed above middle, densely white-woolly; disk flowers yellow, ray flowers violet blue.

On sand dunes of California, from Pacific Grove northward.

C. virgata Gray.

Suffrutescent, erect, 2—10 dm. high, branched; herbage woolly; leaves oblanceolate, serrate; disk flowers yellow, ray flowers violet blue.

Coast of California.

C. viscidula Greene.

Perennial, tall, slender; stem and flowers at flowering time purplish, glandular-scabrous; leaves narrowly-oblanceolate, acute, serrate, viscid-glandular; disk flowers yellowish-brown; ray flowers violet blue.

On sand dunes at Monterey Bay, California.

Cotula coronopifolia L.

Small perennial glabrous herb, with succulent, clustered, creeping stems, rooting at the nodes; branches ascending, 10—20 cm. high;

leaves alternate, often distant, sheathing at the base, lanceolate, nearly linear, entire or pinnatifid, 25 cm. long; flowers yellow.

Widely dispersed. West coast of Europe, from Spain (Cadiz) to Denmark, and Norway (Sognefjord), South Africa, Australia (New South Wales to Western Australia), Tasmania, New Zealand, Chatham Islands, California (supposed by Behr to be introduced), Chili and Brazil. Occurs in wet places among the dunes.

C. perpusilla Hook. f. and *C. Traillii* Kirk

are two other species occurring occasionally on blown sand in New Zealand (Kirk).

Diotis maritima Cass.

Perennial rootstock, creeping; stems branching at base, hard, 20—30 cm. high, covered with a dense, white tomentum; leaves alternate, oblong, entire, 1 cm. long; flowers yellow.

A plant nearly related to *Achillea*. Occurs on maritime sands of Europe, from the Mediterranean to the British Islands.

Ericameria ericoides (Less.) Nutt.

Low evergreen shrub, with decumbent or ascending main stems and numerous erect branchlets; foliage punctate, resinous; leaves linear-terete, 2—5 mm. long, fasciated; flowers yellow.

Common on sand dunes of California.

Erigeron acris L.

Common on established dunes in Europe, but not confined to coast.

E. glaucus Ker.

Perennial herb, with mostly entire leaves, stem very leafy at base, the cauline leaves much reduced, flowering stems erect, 10—25 cm. high, commonly one-headed, arising from a radical tuft of leaves crowning the fleshy caudex and often from rosulate offsets terminating prostrate woody branches; stems pilose pubescent; leaves finely pubescent, spatulate, obovate, entire, rarely with a small tooth on either side below the apex, 2—8 cm. long, upper cauline small and scattered.

Coast of California. Abundant on dunes at San Francisco.

Eriophyllum staechadifolium Lag.

Suffruticose plant, 6—10 dm. high; leaves alternate, pinnately parted into 5—7 lobes, the margins revolute, and the under surface white with

a dense feltlike tomentum; upper surface green, and tomentum of stems deciduous; flowers yellow.

Coastal sands and sea cliffs in California.

Franseria bipinnatifida Nutt.

Perennial branching herb, with procumbent stems, 6—10 dm. long, somewhat hirsute; leaves twice or thrice pinnately parted into oblong lobes, canescent.

Common on sandy shores in California.



FIG. 14. Dune covered with *Franseria* community, at San Francisco.
PHOTOGRAPH BY THE AUTHOR.

F. Chamissonis Less.

Perennial branching herb, woody at base, stems procumbent, 6—10 dm. long, hirsute; leaves narrow-ovate, with cuneate base, serrate or the lower laciniate.

Coastal sands of California; not so common as foregoing species.

Gnaphalium chilense Spreng.

Annual or biennial, with several stems, erect from a decumbent base, stout, 15—75 cm. high, densely clothed with leaves, narrowly spatulate, the short decurrent bases broad; herbage woolly.

On dunes at San Francisco and Pacific Grove, but not confined to the coast.

Grindelia robusta Nutt. var. *maritima*.

Perennial herb, with ascending or erect stems, 3—4 dm. high, herbage lightly pubescent; leaves oblong, obtuse, serrulate; heads filled with white gummy exudation; rays yellow.

Sometimes on drift sand, but prefers hard ground near coast, California.

Helichrysum arenarium (L.) DC.

Perennial herb with single stems, densely white-tomentose; leaves sessile, obtuse, the lower oblong-obovate, the upper linear-lanceolate; flowers yellow.

On dunes of Northern Germany, but also inland in certain parts of Europe.

H. cinereum F. Muell.

Erect, much-branched shrub, 1—1.5 m. high; branchlets tomentose; leaves linear, obtuse, 1—2 cm. long, with revolute margins, glabrous above, tomentose beneath, sometimes succulent.

Common on sand dunes in Victoria. Also said to occur in New South Wales and Tasmania.

Hieracium pilosella L. and *H. umbellatum* L.

are commonly found on established dunes along the Baltic, but are adventive from inland.

Jaumea carnosa (Less.) Gray.

Perennial glabrous herb, with many slender stems, from the fleshy crown of the taproot, mostly simple, 10—15 cm. long, decumbent at base and rooting at the nodes; leaves linear, entire, fleshy, opposite, 20—25 mm. long; flowers yellow.

Sandy beaches, California.

Lessingia Germanorum Cham.

Annual herb, low, diffusely branched, 10—20 cm. high; herbage with appressed white tomentum, wholly glabrate in age, at least on branches; lowest leaves pinnatifid, those of the branchlets scattered, linear and usually entire, not gland-bearing; flowers yellow.

Common on sand dunes of California from San Francisco southwards, but not confined to the coast.

Matricaria inodora L. var. *maritima* L.

Perennial herb, erect or spreading, much-branched, 3—5 dm. high, leaves succulent; disk flowers yellow, ray flowers white.

Common on the Baltic shores.

Senecio Colensoi Hook. f.

Stem erect, simple or much-branched, woody at the base, flexuose, grooved, the whole plant covered with white tomentum. Some are white on both surfaces, others only beneath. On the shore they are fleshy and glabrous. Leaves polymorphic, entire, obovate to lanceolate, narrowed into short petioles with broad wings. The leaves vary, however, greatly in form.

North Island, New Zealand.

S. lautus Sol.

Prostrate, decumbent or erect, glabrous or pubescent, annual or biennial, 8—60 cm. high; stem and branches stout or slender, grooved; leaves succulent, 2—5 cm. long, lanceolate, narrowed into a petiole, pinnatifid.

A very variable species occurring on coasts of New Zealand, comparatively seldom inland.

S. spathulatus A. Rich.

Much-branched perennial; leaves obovate, toothed irregularly, the lower petiolate, the upper stem-clasping, all fleshy; 2—4 cm. long.

Sandy shores in New South Wales (Bondi), Victoria and Tasmania.

S. silvaticus L. and *S. viscosus* L.

are not uncommon on sand formations of the Baltic coasts, but are not confined to such situations.

Solidago spathulata DC.

Perennial herb, with glabrous, slightly glutinous herbage; stems 35—45 cm. high, branched at base, decumbent, thickly clothed with broad leaf bases; leaves basal, spatulate, rounded at apex, narrowed to a long marginal petiole, serrate above the middle; flowers yellow.

On sand dunes at San Francisco and Monterey, California.

Sonchus arvensis L. *maritimus* G. F. Meyer.

Perennial; creeping rootstock; stems 6—10 dm. high; leaves long, pinnatifid, lobes lanceolate, curved downwards, bordered by large prickly teeth; the lower petiolate, the upper stem-clasping; flowers yellow.

S. asper Hill. var. *litoralis* Kirk.

Perennial herb, with stout roots; stems 30—45 cm. high, robust; radical leaves rosulate, closely appressed to the ground, somewhat fleshy, ovateoblong, obtuse, often waved, toothed, cauline leaves few, acute, amplexicaule.

Coast of New Zealand.

Tanacetum cam phoratum Less.

Perennial herb, strong scented, villous-tomentose when young, the wool more or less deciduous in age; stems robust, decumbent or ascending, 3—10 dm. long; primary and secondary divisions of the leaves much crowded, the latter oblong, the margin more or less revolute; flowers yellow.

On sand dunes of California from San Francisco to Puget Sound, along Upper Great Lakes and from Hudson Bay to Maine on the Atlantic coast of North America.

T. vulgare L.

Occurs usually on the coast near the Baltic, but in New Zealand, where it also is found, it is not observed to favor maritime situations.

Taraxacum officinale Web.

is often found on seashores of the Baltic, especially in a prostrate, glaucous form *corniculatum* Kit.

Troximon apargioides Less.

Perennial herb, with deep taproot, low and tufted, stem erect or ascending from a woody caudex, 18—40 cm. high; leaves narrow, pinnatifid.

On sand dunes at San Francisco.

GOODENOVIEAE.

Scaevola suaveolens R. Br.

Prostrate perennial, covered with appressed silky hairs; leaves alternate, obovate, petiolate, thick, entire; flowers blue.

Common on coasts of Australia. In Queensland at Wide Bay and Moreton Bay, in New South Wales (Manly Beach, Botany Bay), Victoria (Porth Phillip) and South Australia.

EPACRIDAEAE.

Cyathodes acerosa R. Br.

Tall shrub with spreading branches; leaves scattered, spreading, linear, rigid, with a pungent point, recurved margins, about 1 cm. long; flowers white; large pulpy drupe.

Sand dunes of Victoria. Also in Tasmania and New Zealand.

Leucopogon margarodes R. Br.

Low shrub, branches pubescent; leaves oblong-lanceolate, obtuse, margins recurved, 5—15 mm. long.

Coastal sands in Queensland (Moreton Bay) and New South Wales (Newcastle).

L. Richei R. Br.

Tall shrub, glabrous; leaves oblong-lanceolate, obtuse, recurved margins 1—3 cm. long.

Common on sea shores of Australia. Queensland (Moreton Bay), New South Wales (Porth Jackson), Victoria (Porth Phillip), Western Australia (Perth). Also on Chatham Islands.

PLUMBAGINACEAE.

Armeria vulgaris Willd.

Acaulescent perennial, with a close tuft of linear, flat or revolute-channeled leaves; flowers rose color.

On coasts in temperate countries in Northern and Southern Hemisphere, but not in the tropics.

Statice auriculifolia Vahl.

Perennial, tufted, branched, leaves 2—3 cm. high; resembles *S. limonium* L.

Coasts of Western Europe and the Mediterranean, usually on rocks, rarely on sand.

S. limonium L.

Stemless perennial, with tufts of radical leaves 5—15 cm. long, obovate, glabrous, fleshy, petiolate, flowers rose colored.

On coastal sands and salt marshes in Western Europe, Mediterranean, Western Asia, California, South America.

S. reticulata L.

is a form still smaller than *S. auriculifolia*, and occurs on coastal sands of Mediterranean and Western Asia, and is said to go on the west coast of France.

PRIMULACEAE.

Anagallis arvensis L.

Annual, glabrous herb, with 15—30 cm. long, procumbent or ascending stem; leaves opposite, entire, broadly ovate, acute, sessile, 12 mm. long; flowers bright red.

Usually near the coast, but also inland on cultivated soil. Europe, temperate Asia, Africa, and on Atlantic and Pacific coast of North America, where introduced, as in Australia.

Glaux maritima L.

Succulent perennial, with creeping rootstock; stem glabrous, branching, 8—15 cm. high; leaves small, opposite, sessile, ovate or almost linear, entire; flowers purplish or white.

Widely dispersed in Europe, temperate Asia, and North America. On the eastern coast it ranges from New England north, while on the Pacific it occurs from San Francisco to Alaska. Also in the interior in limited areas on subsaline soil.

Primula sibirica Jacq.

Perennial herb, with fibrous roots; glabrous, green; leaves ovate or obovate, entire, petiolate; flowers lilac.

In arctic America, Greenland, Northern Europe, and Asia to Kamtschatka.

Samolus repens Pers.

is a saline marshplant, sometimes found on moist sand in Australia, New Zealand, and New Caledonia.

S. Valerandi L.

occurs on similar localities as the former species, being dispersed in some form over almost all temperate and warmer regions of the globe.

MYRSINEAE.

Aegiceras majus Gaertn.

One of the commonest mangroves, ranging from Ceylon and the Indian Peninsula to the Eastern Archipelago and the South Pacific Islands. Also in Australia on the Queensland coast and at a few places in New South Wales.

APOCYNÆÆ.

Alyxia buxifolia R. Br.

Low shrub, spreading, glabrous; leaves opposite, shortly petiolate, obovate, obtuse, thick, margins recurved.

Abundant on coastal sand dunes in Victoria and South Australia. Also in Western Australia (Perth) and Tasmania.

LOGANIACEÆÆ.

Mitreola paradoxa R. Br.

Erect, branching annual, slender, 7—12 cm. high, glabrous; leaves linear-lanceolate, connate, sheathing at the base, 6—10 mm. long; flowers small, white.

On coastal sand in Tasmania and Australia. Victoria (Port Phillip), South Australia, Western Australia (Fremantle).

GENTIANACEÆÆ.

Erythraea australis R. Br.

Erect glabrous annual, 15—45 cm. high, with few branches; leaves sessile, lanceolate, obtuse, the lower stem-clasping, 1—3 cm. long; flowers pink.

Common on all Australian coasts, and also in a few inland places. New Caledonia.

Differs very little from *E. spicata* Pers., the common form in the Mediterranean countries.

E. litoralis Bab.

Annual, much branched, 5—25 cm high, leaves narrow, forming a spreading radical tuft, the upper in pairs, narrow-linear; flowers red.

Common in Europe and Central Asia.

E. Muchlenbergii Gris.

Annual, simple, or branched from base; 5—15 cm. high; leaves oblong, obtuse, 1—2 cm. long; flowers rose colored.

Coast of California from Monterey to San Francisco.

E. pulchella Sw.

Low annual, with single much-branched stem; leaves thin, ovate, the radical opposite; flowers small, red.

Coasts of Baltic.

HYDROPHYLLACEAE.

Phacelia Douglasii (Benth.) Torr.

Annual herb, branched from the base, with ascending or decumbent stems, 10—20 cm. long, herbage puberulent and hirsute with spreading hairs; leaves linear, pinnatifid; corolla light blue.

Coastal sands of California from San Francisco southward.

BORRAGINACEAE.

Amsinckia lycopsoides Lehm.

Annual, with erect stems, branching; the branches sometimes decumbent, 3—6 dm. long, herbage light yellowish-green, hairy, the hairs often conspicuously hardened; leaves ovate-lanceolate, usually with entire margins.

Coastal sands near San Francisco.

Cryptanthe leiocarpa (F. & M.) Greene.

Annual, with strong taproot, branched from base with many erect or ascending branches, 12—30 cm. long; stems in sand short, sometimes caespitose.

Coastal sands of California.

Heliotropium curassavicum L.

Prostrate, much-branched perennial, fleshy, glabrous, glaucous; stems 15—90 cm long, spreading; leaves oblong, obtuse, narrowed into a short petiole, 1—3 cm. long; flowers sessile, small, white with a yellow eye.

Widely spread on sandy sea coasts of North and South America, West Indies, South Africa, Australia (Western Australia to New South Wales), Pacific Islands. Sometimes on alkaline lands in the interior (Australia, California).

CONVOLVULACEAE.

Convolvulus Soldanella L.

Prostrate, trailing perennial, up to 5 dm. long, with creeping rootstock; stem succulent, glabrous; leaves deep green, thick, 3—5 cm. in diameter, reniform, entire, on long stout petioles; corolla funnelform, up to 5 cm. broad, pink or purplish and white.

Common on sandy sea shores in extratropical countries. Extends in Europe from Mediterranean as far as the East-Friesian Islands (Buchenau).

Seems not to vary much in appearance on the coasts of California.

Europe, and Australia, as far as the writer has seen, but Cockayne¹⁾ remarks a considerable variation in forms from New Zealand and Chatham Island: "The trailing stems of *C. Soldanella*, furnished with a few fleshy leaves, are very short, being rarely more than 4 cm. in length; the rest of the plant is subterranean, with the exception of the flowers. These latter are large, lilac and white in color, semiprostrate, with their peduncles buried beneath the sand right to the base of the calyx. This small development of *C.* contrasts greatly with the same species, when growing on the sand dunes at some distance from the sea in many parts of New Zealand. There it forms great masses trailing over the sand, or, when growing in sheltered positions amongst other plants, it actually assumes a climbing habit of growth."

This species does not differ much in habit from the sea coast form of *C. sepium* L. and it has also been reduced to this by F. v. Mueller²⁾ although it exhibits characters, which certainly justify its being considered a different species.

Cressa cretica L.

Small, erect, much-branched perennial, 7—15 cm. high, silky-pubescent; leaves sessile, linear or ovate-lanceolate, entire, 5 mm. long.

On sandy coasts of the warmer parts of Europe, Asia, Africa, Australia, and America. In California and Australia it also occurs in the interior on saline soil.

Evolvulus alsinoides L.

Perennial, much-branched, prostrate; 15—30 cm. long stems, silky-hairy; leaves lanceolate, entire, sessile, 1—2 cm. long, obtuse or acute; flowers small, white or bluish.

Abundant on Queensland coast, and also found in New South Wales (Clarence River), South and West Australia. Reported from many places of the interior.

Ipomaea carnosae R. Br.

Prostrate or creeping glabrous perennial; leaves petiolate, ovate, obtuse, cordate at base, succulent, 1—3 cm. long; flowers large, white; seeds woolly and hairy.

On sea coasts of warm countries in America, Africa, and Asia. Also occurs on the Mediterranean coasts, and on the shores of Gulf of Carpentaria in Australia.

1) A short account of the plant covering of Chatham Island.—Trans. N. Z. Inst. XXXIV. p. 257.

2) Fragmenta Phytographiae Australiae, VI. p. 100.

Is nearly related to *I. pes caprae* Roth, and differs mainly by having a more succulent, narrower leaf, less prominently veined.

I. palmata Forst.

Glabrous, twining; leaves digitately divided into 5—7 ovate-lanceolate, obtuse, 3—5 cm. long lobes; corolla purple or white; seeds pubescent, with long silky hairs.

On tropical coasts in Asia, Africa, and America. In Australia quite abundant at Moreton Bay, and near Tweed River and Port Jackson in New South Wales. Also on North coast of North Island, New Zealand.

I. paniculata R. Br.

Perennial; stems trailing, glabrous, leaves palmately divided to below middle into 5—7 ovate-lanceolate, obtuse lobes; the whole leaf 12—20 cm. long and broad; flowers large.

Tropical coasts of Asia, Africa, Australia, and America. Also in West Indies.

I. pes caprae Roth.

Glabrous perennial, with up to 40 m. long, prostrate, trailing stems; leaves orbicular, obtusely 2-lobed, somewhat fleshy, 5—8 cm. long, on long petioles; flowers large, pink; seeds hairy.

On sandy shores of the tropics. Abundant on East Australian coast southward to Richmond River. Used in India (Madras) as a sand stay.

SOLANACEAE.

Nicotiana glauca Graham.

from Argentine and Uruguay is grown in a few places on coastal sands of Australia, and is considered by some authors as a very good sand stay.

Solanum nigrum L.

in various forms is often found on dunes in Northern Europe and California, and *S. sodomaicum* L. on those of Australia, New Zealand, and the Iberian Peninsula, but both species are inland plants.

SCROPHULARIACEAE.

Castilleja latifolia H. & A.

Root-parasitic perennial herb, (sometimes suffrutescent), 15—45 cm. high; herbage viscid-pubescent, leaves thick, alternate, ovate or obovate, mostly less than 3 cm. long, sessile; flowers dull-yellowish, the bracts and calyx lobes more showy than corolla.

Coastal cliffs and sands of California.

Collinsia bartsiaefolia Benth.

Annual herb, finely puberulent; leaves somewhat fleshy, ovate, 3 cm. long.

On sand formations from San Francisco southward along Californian coast.

Linaria supina Desf.

Perennial; stem short, much-branched, 10—15 cm. long, high, decumbent, glabrous; leaves linear; flowers yellow.

On sandy soil especially near the sea in Western Europe; very common in Spain and Southern France.

L. vulgaris Moench.

Perennial; rootstock creeping; stems erect, 3—10 dm. high, glaucous, green, glabrous; leaves linear or narrow-lanceolate; flowers yellow.

Common in Europe and temperate Asia. Often on dunes, but not confined to coast.

Mimulus Langsdorffii Donn. var. *grandis* Greene.

Perennial, with stolons at base, stems simple or branching, 6—10 dm. high; leaves elliptical, serrate, lower petiolate, upper sessile; flowers large, yellow.

Moist sand on California coast.

M. repens R. Br.

Perennial, prostrate, glabrous, rooting at nodes; leaves sessile, sometimes stem-clasping, oblong, obtuse, fleshy, 5—10 mm. long; flowers blue, with yellow center.

Marine coasts of Australia, Tasmania, and New Zealand. Collected by the author near Sydney and Melbourne. Occurs also in the interior on saline soil.

Odontites simplex Hrtm.

Annual, with few branches; leaves fleshy, ovate-lanceolate, serrate; flowers purple.

Coasts of Baltic, mostly on gravelly soil.

Scrophularia californica Cham.

Perennial, very like *S. nodosa* L.

Common in California and Nevada, but not confined to coastal sands, although often found there.



FIG. 15. Vegetation on sand dunes near Ajaccio on Corsica, consisting of *Ammophila arenaria* and *Scrophularia ramosissima*.
PHOTOGRAPH BY BORGESSEN, NOV. 1897.

S. nodosa L.

Coarse, erect perennial found on moist places in Europe, temperate Asia, and parts of North America, often on the coast.

Veronica macroura Hook. f.

On coast of New Zealand, but not confined to sand formations.

V. longifolia L. var. *maritima* L.

is a perennial common on coasts of the Baltic, but occurs rarely on sand.

VERBENACEAE.

Avicennia officinalis L.

Erect shrub of considerable height; branches, lower side of leaf and inflorescence white with a close tomentum; upper surface of leaves usually glabrous in age, black and shining when dry; leaves opposite, coriaceous, entire, ovate-lanceolate, 5—7 cm. long, acute, petiolate.

Common in tropical Asia, Africa, Australia, and America, growing in marshes and inundated sandy places.

Vitex trifolia L.

Low shrub, the branches, lower surface of leaves and inflorescence white, undivided or of 3—5 leaflets, often white on both surfaces, usually glabrous on upper side in age; flowers bluish.

Common on tropical coasts of Asia, and Australia southward to Moreton Bay.

The variety *obovata* has a peculiar habit of growth on the beaches along Gulf of Carpentaria. The black rope-like stems run over the surface of the sands to a length of 10 m. or more, sending up shoots 3 dm. high at short intervals. (J. F. Bailey in letter.)

MYOPORINEAE.

Myoporum viscosum R. Br.

Shrub, erect, 1—2 m. high, glabrous; leaves alternate, lanceolate or ovate, tuberculate-glandular, obtuse, entire; flowers white.

On coastal dunes of South Australia (St. Vincent's Gulf) together with *M. serratum* R. Br. from which it does not differ much. The latter is found in Tasmania, Victoria, South and West Australia. *M. laetum* Forst. is common on some New Zealand coasts, and can easily be grown on the middle beach.

LABIATAE.

Galiopsis tetrahit L.

Annual, 15—30 cm. high, with stiff hairs, stems swollen under the nodes; leaves petiolate, ovate, pointed, coarsely toothed; flowers small, purplish white.

Common through Europe and temperate Asia. Not confined to coast, but often occurring on marine beaches and dunes.

Prunella vulgaris L.

In damp places in Europe, Northern Asia, Northern America, and Australia (except Western Australia). In tropical Asia and South America it is found in the high mountains.

Scutellaria hastaefolia L.

Perennial herb, with erect stems, simple or little branched; leaves petiolate, truncate at base, ovate or ovate-lanceolate; flowers bluish.

On the coasts of the Baltic, but also found in Central France and in Northern Italy.

Stachys ajugoides Benth.

Annual, stems creeping in sand, simple, 2—5 dm. long; herbage densely villous or silky pubescent; leaves oblong, 2—6 cm. long, acute or obtuse, petiolate, upper sessile; flowers whitish.

On sand dunes of California, but not confined to coast.

Westringia rosmariniformis Sm.

Tall, bushy shrub, branches, underside of leaves and inflorescence silvery white with densely appressed hairs; leaves in fours, linear or lanceolate, obtuse or acute, 1—3 cm. long, coriaceous, glabrous and shining on upper surface, margins revolute.

On sand dunes in New South Wales (Port Jackson).

PLANTAGINACEAE.

Plantago arenaria W. K. ver. *divaricata*.

Annual herb, with erect sometimes branched stem; leaves narrow linear or filiform, margins revolute, pubescent.

On sandy sea shores of the Mediterranean countries.

P. coronopus L.

Perennial, hirsute; leaves radical, in a dense tuft, linear, acute, entire or sometimes pinnately divided into linear lobes, hairy.

Marine sands of temperate Europe, Western Asia, and North Africa. Introduced to Australia, where also found on roadsides in Victoria, South Australia, and Tasmania.

P. hirtella H. B. K.

Acaulescent perennial, with thick root, pubescent herbage; leaves oblong-lanceolate, 7—30 cm. long, 2—3 cm. wide.

Coast of California, mostly on clay-bluffs, or in moist alkaline soil away from coast.

P. lanceolata L.

Perennial; rootstock short, woody; leaves erect, spreading, lanceolate, 5—10 cm. long, somewhat hairy, tapering into a petiole at base.

Common in Europe and temperate Asia, whence introduced to many parts of the globe. Not confined to sea coasts, but occurs frequently on marine sands.

P. maritima L.

Low perennial herb, with fleshy linear leaves, pointed, entire or slightly toothed.

Marine coasts of Europe, Asia, South Africa, Patagonia, North America (along the Atlantic and Pacific Oceans). Occasionally inland in Europe in high mountains.

P. psyllium L.

Annual herb, with erect branched stem; leaves narrow linear-lanceolate, pubescent.

Common in the Mediterranean countries. Occurs often on the sea shore sands, but is not confined to these.

NYCTAGINACEAE.

Abronia latifolia Esch.

Perennial, succulent herb with stout stems, 3—6 dm. long, prostrate, only leaves and flowering peduncles ascending and erect; leaves broadly ovate to suborbicular, broader than long, truncate at base, 1—4 cm. long; petioles longer than leaves; calyx yellow.

Sand dunes on coast of California from Monterey northward.

A. maritima Nutt.

Stout, prostrate, pubescent, viscid; leaves thick, broadly ovate, rounded at base, 3 cm. long, petioles short, flowers red.

Coast of California from Santa Barbara to San Diego.

Greatly resembles previous form in habit.

A. umbellata Lam.

Perennial, with slender, prostrate stems, 2—10 dm. long, viscid; leaves almost glabrous, roundish ovate, the margin often sinuate, 2—4 cm. long, narrowed at base to a slender petiole; calyx rose-purple.

Sand dunes along coast of California from Columbia River to Lower California.

PROTEACEAE.

Banksia marginata Cav.

Common on coastal sand dunes at St. Vincent's Gulf in South Australia (Tepper), but not confined to coast.

Several other species of this genus occur on the dunes of Victoria and Western Australia, as well as on those on the Queensland coast.

ILLICEBRACEAE.

Corrigiola litoralis L.

Annual, with numerous stems, procumbent or ascending, slender, glabrous; leaves linear, obtuse, tapering at base.

On sandy sea shores of western and southern Europe, and on the Mediterranean coasts. Sometimes in the interior of Europe.

Pentacaena ramosissima H. & A.

Perennial herb, tufted; prostrate stems forming dense mats, 12—45 cm. broad, pubescent; subulate pungent leaves crowded on the stems, 1 cm. long; silvery-hyaline stipules, $\frac{1}{2}$ or nearly as long.

Coast of California. Abundant on dunes at San Francisco and Pacific Grove.

CHENOPODIACEAE.

Atriplex Billardieri Hook. f.

Much-branched herb, prostrate, succulent, spreading, covered with papillas like *Mesembryanthemum*; leaves shortly petiolate, ovate, obtuse, entire, 5—15 mm. long.

Sandy beaches near highwatermark. Coasts of Victoria, Tasmania, and New Zealand.

A. californica Moquin.

Perennial herb; prostrate stems, wiry, slender, mostly herbaceous, often much branched and forming a thick mat; root cylindrical, large, 1—3 cm. thick, fleshy; herbage greenish, finely white-mealy or somewhat glabrate in age; leaves thinnish, ovate-lanceolate, 5—17 mm. long, sessile or narrowed at base into a short petiole.

Sandy beaches of California, from San Francisco to San Diego.

A. cinerea Poir.

Branching shrub, whitish with a scaly tomentum; leaves lanceolate or oblong, obtuse, entire, petiolate, 1—5 cm. long.

Coast of Tasmania and Australia. Observed by the writer at Moreton Bay, Queensland; Botany Bay, New South Wales; Port Phillip, Victoria; Port Adelaide, South Australia; Fremantle, West Australia.

A. hastata L.

Annual, slender, with 3—7 dm. long, ascending branches; herbage mealy, scarcely succulent; leaves triangular-hastate, entire or sinuate-dentate, 2—5 cm. long, often as broad or broader, petioles 8—12 mm. long.

Coasts of Europe and Northern Asia.

A. leucophylla Dietr.

Perennial herb, with prostrate stems, densely light brown-scurfy, 3—12 dm. long, somewhat woody at base, many short ascending branches; leaves thick, orbicular to elliptic, 10—25 mm. long, sessile, 3-nerved.

Sand formations on the coast of California, from San Francisco southward to San Diego.

A. patula L.

Annual, stout, succulent, erect or prostrate, 25—50 cm. high, with few ascending branches; herbage green, only the growing parts somewhat mealy; leaves petiolate, the lowest often opposite, lanceolate-hastate, coarsely toothed, 4 cm. long, the upper lanceolate, entire.

Widely dispersed in Europe, Asia, and Africa northward to the Arctic. Introduced to Tasmania and Australia, where found in neighborhood of cities. Also near San Francisco.

Several other species and forms of *Chenopodium* occur on various coasts, but the author has not studied this genus sufficiently to be able to discuss the geographical distribution of these greatly varying forms.

Beta maritima L.

Perennial, with erect or spreading branched stems, 3—6 dm. high; leaves large, broad, fleshy, green, the upper small, narrow; flowers green.

Coastal sands of Europe, Western Asia, and North Africa, especially in localities where the sand is mixed with silt.

Chenopodium californicum Wats.

Perennial, stout, erect or decumbent at base, 4—7 dm. high from a large simple or branched root; herbage green, very little mealy; leaves broadly triangular, truncate or cordate at base, unequally sinuate-dentate, 3—i cm. long, petioles 2—10 cm. long.

Sand dunes of California from Pacific Grove southwards, but is not confined to the coast.

Ch. glaucum L.

Much-branched, diffuse annual, prostrate at base, stems ascending 3—6 dm., glabrous, striate, furrowed; leaves petiolate, the lower lanceolate, coarsely sinuate-toothed, 1—4 cm. long, the upper gradually smaller, narrower, almost entire, all green above and whitish underneath.

On middle beach of sea coasts in Europe, temperate Asia, Australia, Tasmania, New Zealand.

Other species of this genus are often found on coastal sands, but are not confined to these locations.

Kochia hirsuta Nolte.

Annual, with erect, ascendent or procumbent stems; leaves terete, filiform.

Sea shores and saline places in France, Belgium, Denmark, Northern Italy, and some places along the Baltic. Also in Western Asia.

Several related species are found in Australia, both on coastal and inland saline sands. At Port Adelaide, South Australia, Fremantle and Albany, West Australia, the author found specimens belonging to this genus, but was not able to identify them.

Rhagodia Billardieri R. Br.

Diffuse shrub, foliage fleshy, covered with mealy tomentum; leaves alternate, linear or lanceolate, obtuse, petiolate, 1—3 cm. long, green above and white underneath, margins recurved.

Abundant on many places of the American coast, as in West Australia, at St. Vincent's Gulf, S. A., in Victoria (Port Phillip). Also found in New South Wales and Tasmania.

Salicornia ambigua Michx.

Perennial succulent herb, with leafless, 12—30 cm. long jointed stems, from woody rootstocks, erect or decumbent and rooting at the joints; herbage greenish; branches opposite; spikes slender, terminal, not thicker than the sterile portions of the stem.

Coasts of North America, from New England to Florida, and from Oregon to San Francisco. Like all other species of this genus it usually grows in salt marshes, but is also found in lagoons and moist places between the dunes.

S. arbuscula R. Br.

Erect, bushy shrub, 15—90 cm. high, with numerous short and slender branches, internodes dilated at top.

Sea coast of Australia and Tasmania, but also in some places in the interior in saline soil.

S. australis Sol.

Procumbent stems, woody at base, with erect branches, 5—12 cm. high, internodes not dilated at end, usually terete or sometimes 2-lobed.

On sea coasts of Australia, Tasmania, and New Zealand, avoiding dry sandy places. Collected by the writer in Victoria and Western Australia.

S. herbacea L.

Annual, glabrous, bright green or reddish, succulent, erect, 10—15 cm. high, with a few erect branches, shooting from nodes.

Coasts of Europe, temperate Asia (also in the interior), and Eastern North America.

Salsola kali L.

Annual, procumbent, glabrous or seldom somewhat pubescent, 15—45 cm. high; leaves alternate, sessile, hard and rigid, the lower terete or dilate at base, 2—6 cm. long, the upper shorter, thicker, flattened above.

Sea coasts of temperate and sometimes tropical countries. In Australia also in the interior.

Suaeda maritima Dumortier.

Much-branched annual or biennial, erect, 15—45 cm. high or spreading, glabrous, succulent, with a hard and sometimes woody base; leaves alternate, sessile, linear, of green reddish color.

Sea coasts of Europe, temperate Asia, and America. Also in New Zealand, Tasmania, and Australia, where the plant is more suffrutescent.

BATIDAE.

Batis maritima L.

Low shrub, approaching *Chenopodium* in general appearance, occurring on the sea coasts in West Indies, Florida, and Hawaiian Islands, principally on muddy shores, but also at times on sand.

POLYGONACEAE.

Chorizanthe pungens Benth.

Annual, with prostrate branches, 5—30 cm. long; leaves spatulate, 1—3 cm. long, opposite, petioles of cauline leaves 10 mm. long, those of the radical 25 mm.

Sand hills on Californian coast, from San Francisco to Monterey Bay.

Eriogonum latifolium Smith.

Perennial herb, stout, tomentose, the indurated caudex with short leafy branches; leaves 2—5 cm. long, oblong to ovate, obtuse or acute at apex, rounded or cordate at base, margin often undulate, upper surface glabrate, densely woolly beneath; petioles often margined.

Sand formations along California coast, occasionally together with other species of the genus.

Muehlenbeckia adpressa Meissn.

Stem woody at base, prostrate or climbing; leaves petiolate, lanceolate or hastate, obtuse, 2—7 cm. long, margins crisped, glabrous; flowers small, green.

On the sea coast of Tasmania, Victoria, South Australia, and West Australia (Fremantle).

M. complexa Meissn. is a species occasionally occurring on sea beaches of North Cape, New Zealand.

Polygonum aviculare L.

Annual herb, prostrate, with branches leafy to the end, glabrous and green, stems wiry, minutely striate, sometimes meterlong; leaves oblong, acute, 1—2 cm. long, shortly petiolate.

Almost everywhere on the globe, especially in temperate climates.

Very variable, especially on sea shores, where a number of forms occur, as yet insufficiently known.

P. maritimum L.

Perennial, somewhat woody; branches short, thick; leaves glaucous, thick, larger than in *P. aviculare*, which it resembles, especially when young.

P. Rayi Bab.

is a nearly related form, differing only in the fruits.

The distribution of these forms is not well known, but they are found in a number of widely separated localities.

P. paronychia Cham. & Schlecht.

Suffrutescent perennial, with prostrate or ascending stems, 3—10 dm. long, branches leafy above, clothed below with old sheaths; these large, 1—2 cm. long, brown and 5-nerved, margin lacerate above, persistent, the segments becoming hairlike in age; leaves linear-lanceolate, 15—30 mm. long, acute, the margin revolute.

Coastal sand dunes of California, from Pacific Grove to Puget Sound.

Rumex acetosella L.

Perennial herb, with tufted stems, often running red, about 25 cm. high, creeping rhizome; radical and lower leaves hastate or sagittate, the upper reduced or branches leafless, and ending in the reddish (pistillate) or yellowish (staminate) panicle.

Common in most temperate and subtropical countries, often occurring on coastal sands, but not confined to these.

R. conglomeratus Murr.

Perennial herb, with slender, mostly clustered stems, 10—12 dm. high; leaves oblong or ovate, slightly undulate, 10 cm. long, reduced above, petiolate, rounded at base.

Dispersed in Europe, temperate Asia, Australia, and California, apparently introduced into the two last mentioned countries. Sometimes on coastal sands, f. i. at Pacific Grove, California, where it has a characteristic prostrate form.

R. crispus L.

Perennial, with thick rhizome, stems furrowed, stoutish, 6—10 dm. high; leaves bluish green, the radical narrow-elliptical to oblong-lanceolate, strongly undulated with crisp margins, the base often decurrent upon the petiole, up to 20 cm. long, the upper smaller, passing gradually into bracts.

Common in Europe and temperate Asia, especially on roadsides and waste places, but also on sea shores. Also in North America and Australia, where supposed to be introduced.

R. maritimus L.

Annual or sometimes biennial, with stem 3—4 dm. high, much branched, minutely pubescent, erect or procumbent; leaves linear-lanceolate.

Beaches and marshes, especially near the sea, but also inland. Europe, temperate Asia, Atlantic coast, and interior valleys of North America.

THYMELAEACEAE.

Pimelea arenaria A. Cunn.

This plant, characteristic for the driftsands of New Zealand and Chatham Island, is described by Cockayne¹⁾ in the following words:

“The long cord-like underground stems put forth adventitious roots near their extremities, which latter, bending upwards, raise themselves above the encroaching sand. The leaves are all most densely silky on the under surface, a most efficient protection against excessive transpiration. Owing to the leafy extremities of the stems being erect, the semi-rosettes of leaves can receive the incident light to the best advantage.

“It is probable that the oldest portions of the plant—*i. e.*, the most deeply buried portions—die, while the plant continues to increase by the rooting of its terminal shoots.”

P. prostrata Willd. is another species also found on North Cape of New Zealand.

P. serpyllifolia R. Br.

Low shrub, rigid, densely branched, glabrous; leaves opposite, ovate or oblong, coriaceous, somewhat concave; flowers small, yellow.

Common on coastal sands of Victoria, South and West Australia, but mostly in the interior. Also in Tasmania.

ELAEAGNACEAE.

Hippophaë rhamnoides L.

Shrub, 3—12 dm. high, with a scaly scurf, silvery on under surface of the leaves, thin on upper side—rusty on young shoots; axillary shoots ending in a prickle; leaves alternate, linear, entire.

Common in Europe, Central and North Asia.

EUPHORBIACEAE.

Adriana tomentosa Gaudich.

Shrub, 6—12 dm. high, covered with a stellate tomentum; leaves alternate, usually glabrous on upper side, petiolate, deeply 3-lobed, with narrow, obtuse lobes.

Sand dunes of South Australia (according to Tepper), coast of North and Northwest Australia.

Beyeria opaca F. Muell.

Erect shrub, 3—6 dm. high; leaves oblong or linear, obtuse, with revolute margins, white underneath.

1) A short account of the plant covering of Chatham Island, p. 260.

Sea coasts of Victoria, South Australia, and Tasmania.
Closely related to following species.

B. viscosa Miq.

Tall shrub, flowering branches viscid; leaves oblong-lanceolate, obtuse, petiolate, margins recurved, glabrous above, white-tomentose underneath, 2—5 cm. long.

Coastal sands of Moreton Bay, Queensland, Victoria, and Western Australia (Perth). Also in Tasmania and the interior of New South Wales.

Croton californicus Muell.

Perennial herb, suffrutescent at base, with branching stem, erect or diffuse; 4—12 dm. high; herbage hoary, upper side of leaves green, finely stellate-pubescent; leaves oblong, 2—4 cm. long; petioles 1—3 cm. long, staminate plant more slender and shorter branched.

Coastal sand dunes of California, from San Francisco to Los Angeles.

Euphorbia atoto Forst.

Diffuse, glabrous perennial, 30—45 cm. high, branches slender; leaves opposite, shortly petiolate, oblong, obtuse, more or less cordate, thick, 2—3 cm. long.

Sea coasts of East India, Malayan Archipelago, Islands of Pacific, North Australia, and Queensland southward to Moreton Bay.

E. glauca Forst.

is a specimen common on dunes in New Zealand.

E. Paralias L.

Perennial, with short, hard, almost woody stock and erect stems, 15—25 cm. high; leaves short, concave, leathery, pale green.

On coastal sands from Belgium southward in Europe, and extending into Mediterranean. Also on the southern coasts of British Islands.

E. terracina L. var. *retusa*.

Perennial, with long stolons; leaves linear-lanceolate to oblong-linear; very glaucous.

Coastal sands of the Mediterranean countries, Canary Islands, Azores, and Medeira. Very common on the dunes of Spain.

Ricinocarpus cyanescens Muell.

occurs on coastal sands in Western Australia together with several other

species, not sufficiently studied by the author. At Moreton Bay *R. pinifolius* Desf. was found, and near Port Fairy, Victoria, a plant, probably the same species. This genus is not confined to the coast.

URTICACEAE.

Urtica dioica L. and *U. urens* L.

are not infrequently found on coast formations of the Baltic, but are immigrants from inland.

MYRICACEAE.

Myrica californica Cham.

Densely branched evergreen shrub, with fragrant alternate, simple, almost entire or serrate leaves, thick, glabrous, oblong, tapering above to an acute apex, narrowing below to a petiole, 7—12 cm. long; fruit globose, purplish-brown, covered with a coat of whitish wax, 6 mm. in diameter.

Sand dunes on coast of California, and ravines of outer coast ranges.

CASUARINEAE.

Casuarina quadrivalvis Labill.

and several other species occur on the dunes of Australia, especially in Victoria, South and West Australia, but their range is principally inland.

CUPULIFERAE.

Quercus agrifolia Née

in a low, prostrate form is found on coastal dunes of California, f. i. at Seaside, Monterey.

SALICACEAE.

Salix caprea L.

Tall shrub, with large, ovate leaves, grayish green, tomentose underneath, entire.

European and North Asian species, often planted on dunes of Germany.

S. daphnoides Vill.

Low tree or tall shrub, with oblong-lanceolate leaves, serrate, glabrous above, glaucous underneath.

Often on dunes along the Baltic coasts. Extends also in to Central Russia and Siberia.

S. lasiolepis Benth.

Tree or large shrub, with oblong leaves, somewhat serrulate, dull green above, gray-pubescent beneath.

On dunes of California, especially near San Francisco. Extends also inland.

Salix repens L.

Low, straggling shrub, with stems creeping underground, rooting at base, ascending to 3—6 dm.; foliage silky-white; leaves oblong-lanceolate, 2 cm. long, entire, silky on both sides.

On sand formations of Europe and Northern Asia.

Several varieties, especially *argentea* Sm., are met with on dunes of Northern Europe.

S. viminalis L.

Shrub, with long branches, 7—15 cm. long leaves, silvery white underneath.

In wet places in Europe and Northern Asia.

Several other species, such as *S. nigricans* Sm., *S. cinerea* L., *S. aurita* L., *S. purpurea* L., *S. pentandra* L., *S. dasyclados* Wimm., *S. fragilis* L., *S. alba* L., and *S. amygdalina* L., are found occasionally on the dunes of the Baltic.

CONIFERAE.

Callitris robusta R. Br.

often occurs on the dunes of Australia, but is not confined to the coast.

Juniperus communis L.

is common on the sand formations of the Northern Baltic, and sometimes occurs in a low prostrate form, similar in habit to the variety *nana*, which does not, however, grow on sand in the Finnish Archipelago, where it occurs.

Pinus maritima Lam.

Large tree, with branches in whorls; leaves in twos, dark green, 15—20 cm. long, rigid, stout; cones from 10—15 cm. long, about 6 cm. broad, growing in clusters of from 4—8 or more.

Common on sand dunes of the Mediterranean countries, and is extensively planted on the dunes of Western France; its occurrence in India, Australia, New Zealand, Japan, and China is usually attributed to artificial planting.

P. radiata Don.

is found only on the established dunes and immediately inland from these at Pacific Grove, and within a limited area in two other similar localities, one in San Luis Obispo county, one in Santa Cruz county, California.

HYDROCHARIDACEAE.

Halophila ovalis Hook. f.

Submerged marine plant, common on the shores of Moreton Bay, Queensland, and Port Phillip, Victoria. Also in Tasmania, New South Wales, and South Australia, preferring muddy shores, but also on sand.

IRIDACEAE.

Sisyrinchium bellum Wats.

A somewhat prostrate, low form is found on the dunes at Point Pinos, Monterey, California, but it is not a different species, as it will under cultivation in moist, rich soil exhibit exactly the same characters as the inland form. This was tested by the author at Stanford University in the summer of 1904.

AMARYLLIDEAE.

Pancratium maritimum B.

Perennial herb, with large bulb; leaves erect, long, broadly linear, glaucous.

Sandy sea shores of Western France, Iberian Peninsula, and Mediterranean countries.

LILIACEAE.

Allium arenarium L.

Stem 25—35 cm. high, single; leaves cylindrical, hollow, furrowed above, with long sheaths; flowers red.

Sand in a few places on the Baltic coasts.

A. schoenoprasum L.

Stems 2—3 dm. high, usually many together; leaves narrow, cylindrical, hollow, one sheathing the stem at base.

In Northern Europe and Asia, and in mountains in Southern Europe. Britton & Brown (Flora of Northern United States and Canada) say regarding its distribution in America:

“In moist or wet soil, New Brunswick to Alaska, south to Maine, northern New York, Michigan, Wyoming, and Washington.”

Asparagus officinalis L.

Perennial, with creeping rootstock, and annual branching stems, erect, 3—6 dm. high; leaves short, subulate; flowers small, greenish white.

On marine sands of Western Asia, Mediterranean, and Western Europe northward to English Channel; escapes to similar localities in E. America, according to Professor Dudley.

JUNCACEAE.

Juncus acutus L.

A form closely approaching *J. maritimus* Lam. and found on marine sands on the Atlantic and Mediterranean coasts of Europe, and on the Caspian Sea, but not on the Baltic or North Sea, nor in the Southern hemisphere.

J. anceps Laharpe var. *atricapillus* Buch.

Rootstock creeping; stems erect, compressed, leafy.

Observed only between the dunes on the E. Friesian Islands off the German shore of the North Sea.

J. balticus Willd.

Rootstock creeping; stems hard, 3—6 dm. high, cylindrical, leafless, sheathed at base by brown scales.

In high northern latitudes in Europe, Asia, and America, found as far south in the United States as California. Not confined to coastal sands.

J. bufonius L.

Small annual, pale-colored; stems numerous, tufted, 3—20 cm. high, branching; leaves short, slender.

Occurs almost everywhere, and is common in moist places between the dunes.

J. capitatus Weig.

Annual, slender, tufted, 5—8 cm. high; stems numerous; leaves short, slender.

Marine sands of Southern Sweden, Northern Germany, Holland, Western and Southern Europe.

J. compressus Jacq. var. *Gerardi* Bab.

Perennial, with creeping rootstock; stems 30—45 cm. high, erect, slender, compressed at base, with a few radical leaves, narrow, grooved.

Common in Europe, from Mediterranean to the Arctic, and in Northern Asia.

J. falcatus Mey.

Perennial, with slender, creeping rootstock; stems 15—25 cm. high, leafy, terete, in compressed tufts.

Driftsand at Pacific Grove, San Francisco and other places on Californian coast.

J. maritimus Lam.

Perennial, with densely tufted stems, horizontal rhizome, rigid, 6—10 dm. high, with sheathing scales at base, of which one or two inner ones terminate in a rigid, terete, pungent stem-like leaf, shorter than the real stems; flowers in little clusters.

In maritime marshes and moist sands on shores of Atlantic North America, Europe from Mediterranean to the Baltic, where rare, Caspian Sea, and in New Zealand, Tasmania, and Australia from Queensland to Western Australia. Also in the interior of Australia.

NAJADACEAE.

Najas marina L.

Slender, branching, submerged plant, with stout stems, often armed with prickles twice as long as their breadth; leaves linear, with 6—10 spine-pointed teeth on each margin; the broad sheathing base entire or with few teeth on each side.

Widely distributed in Europe, temperate and tropical Asia, Algeria, North America, West Indies, Brazil, Australia, and Hawaiian Islands.

Phyllospadix Scouleri Hook.

Submerged maritime herb, with elongated, narrow-linear, radical leaves, 1.5—5 mm. wide, from much-branched, creeping, brittle rootstock.

Together with another species, *R. Torreyi* Wats., from which it does not differ essentially in habit, growing on sand covered stones and rocks on the submerged beach of the Pacific coast of North America.

Potamogeton marinus L.

Perennial marine plant, with filiform, branched stem; very leafy: leaves narrow-linear, 5—15 cm. long, 1 mm. broad.

In salt water in Europe and North America. Often confused with the following species.

P. pectinatus L.

Perennial marine plant, with threadlike stem, very narrow leaves, 5—8 cm. long, sheathing at base.

On submerged beaches of Europe and North America. In some cases in inland waters of the latter continent.

Ruppia maritima L.

Submerged aquatic herb, with 6—10 dm. long, filiform forking stems; leaves 5—8 cm. long, almost capillary, with a broad sheathing base.

In salt and brackish water over nearly the whole globe, excepting South America. Also in the interior of North America.

Very variable and divided into several species.

Triglochin maritimum L.

Perennial, with short rootstock, the terminal portion of which is covered with the sheaths of old leaves; stem 15—45 cm. high; leaves about 5 mm. wide, fleshy with membranous sheaths.

Coasts of Europe, Asia, and North America. Also in interior of latter continent in saline situations. On Pacific coast from San Francisco northward to Arctic Ocean.

T. striatum Ruiz. & Pavon.

Rootstock small, stoloniferous; leaves narrow-linear, shorter than the scape; fruits nearly orbicular.

Brackish water in North America, extratropical South America, New Zealand, Tasmania, and Australia from Moreton Bay along south coast to Fremantle.

Zanichellia palustris L.

Inconspicuous submerged aquatic, with capillary stems and leaves; these alternate or mostly opposite, 1—3 cm. long.

Widely spread over the whole globe. Often in ponds between dunes.

Zostera marina L.

Submerged maritime perennial, with elongated and very narrow grass-like leaves, with sheathing bases, 3—7-nerved, 3—10 dm. long, 5—12 mm. broad, obtuse.

In shallow water on submerged beach, especially on mud, on coasts of Europe, North Eastern Asia, Arctic and North Atlantic coast of North America, and on the Pacific coast at least as far south as San Pedro, California (Dudley).

Z. nana Roth.

Submerged marine plant, with creeping rhizome, emitting short stems; leaves narrow-linear, grass-like, 3—6 dm. long, notched at the end, base narrow and sheathing.

Coasts of Europe, South Africa, Japan, New Zealand, Tasmania, and on the southern coasts of Australia.

RESTIACEAE.

Leptocarpus simplex A. Rich.

In swamps and swampy saline stations, and also frequently on dunes, in New Zealand.

CYPERACEAE.

Carex arenaria L.

Perennial, with creeping rootstock, emitting small tufts, 7—40 cm. high, leafy at base; culms erect, slender, slightly scabrous above; leaves very long, pointed.

Marine sands of Europe, Western Asia, and Virginia, where adventive from Europe (Britton & Brown).

C. distans L.

Stems 25—40 cm. high, tufted, obtusely angled, smooth; leaves short, narrow, rigid; margins scabrous.

Common on sea coasts of Europe and Western Asia, occurring from Mediterranean to Scandinavia.

C. extensa Gooden.

Perennial, tufted, slender, 3—6 dm. high; leaves narrow, stiff, erect, often convolute.

On marine coasts of Europe from Mediterranean to the Baltic.

C. halophila F. Nyl.

Stems obtusely angled, slender, 3—5 dm. high; leaves broad, of yellowish-green color.

Sea shores of northern part of Gulf of Bothnia.

C. Hookeriana Dewey.

Perennial, with creeping rootstock, clothed with imbricated, nerved, purplish scales; stems 10—30 cm. high, sharply angled, scabrous; leaves shorter than stem.

Sand dunes on coast of California. Also in interior of North America and Europe.

C. maritima Muell.

Stems obtusely angled, smooth, clothed at base with sheaths breaking up into threadlike fibers; leaves broad, pale.

Sea shores of the Baltic.

C. pumila Thunberg.

Rhizomes creeping, stems 10—20 cm. high; leaves longer, rigid with subulate points.

On sandy shores of extratropical South America, New Zealand, Chatham Island, Tasmania, and Australia, from Moreton Bay to South Australia.

C. salina Wahl.

Perennial, with creeping rootstock, stem 6—12 cm. high, obtusely angled, smooth; leaves pale, 2—3 mm. broad.

Sea shores of Northern Europe and America, from the Arctic to New England on the east coast, and to Northern California on the Pacific coast.

Eleocharis uniglumis Link.

Perennial by horizontal creeping rootstocks; culms stout, terete or somewhat compressed, caespitose, striate, 15—30 cm. high, higher when in water; leafless, with one or two sheaths at the base.

Widely distributed in Europe, Asia, North America, from Canada to California.

Lepidosperma gladiata Labill.

Perennial rhizome; rigid stems, 1—12 dm. high, flattened, but convex on both sides about center, with acute smooth margins; leaves equitant, usually about 1 cm. broad, length of stem.

Common on coastal sand dunes in Tasmania and Australia, especially in Victoria, South and West Australia. On the western coast of Australia also other species of this genus are met with.

Remirea maritima Aubl.

Low, branching perennial; stems from creeping and rooting base, ascending, 7—10 cm. high; leaves rigid, 2—7 cm. long, linear, with short, imbricate sheathing bases, pungent point.

Sandy sea coasts of most tropical countries. Africa, East India, Malayan Archipelago, Queensland, tropical America.

Scirpus americanus Pers.

Perennial; stem 3—6 dm. high, slender, triangular, continued as an entire pungent involucre 4—10 cm. beyond the inflorescence.

In moist places and brackish lagoons between dunes on Californian coast. Also in interior of North America.

S. frondosus Banks & Sol.

Cockayne says¹⁾ of this species: "The most characteristic plant of the whole New Zealand area. It can form settlements and hold its own positions where no other New Zealand flowering-plant can exist, and only the most constant and furious winds can destroy a dune where it is properly established. Indeed, for sandbinding power it is probably not equalled either by *Ammophila arenaria* or by *Elymus arenarius*."

S. maritimus L.

Perennial, with creeping rhizome, often thickened into hard tubers; stem 3—10 dm. high, triangular, smooth; leaves often longer than stems.

Common in tropical and temperate countries. In Australia from Queensland to Western Australia, especially frequent on coastal sands.

S. nodosus Rottb.

Creeping rhizome; stems rigid, rush-like, terete or slightly flattened, 3—10 dm. high, leafless, except the sheathing scales at the base.

In South Africa, extratropical South America, several Oceanic Islands, New Zealand, and Australia, from east to west along the coast.

S. rufus (Huds.) Schrad.

Perennial, with slender rootstock; culms tufted, smooth, slender, erect, compressed, 7—30 cm. high; leaves terete, smooth, channeled, the lowest sheathing.

In Northern Europe and Canada, seldom, however, on sand.

S. pungens Vahl.

Perennial, with creeping rhizome; stem slender, 3—9 dm. high, acutely triangular; leaves few, 1 or 2 sheathing.

Western part of Mediterranean, extratropical North and South America, New Zealand, and Australia.

GRAMINEAE.

Agropyron arenicolum Davy

is a maritime dune grass found at Point Reyes in California.

1) l. c. p. 261.

A. junceum Beauv.

Perennial grass, with pungent leaves, rigid; roots extensively creeping. Sea coasts of Europe and Northern Africa on drifting sands.

A. repens L. var. *litoreum* Schum.

Perennial, with creeping jointed rootstock; stiff, ascending stems; sheaths shorter than internodes.

Common on coastal sands of Europe, Asia, and North America; also in the interior of the latter continent.

A. scabrum Beauv.

Common on dunes in New Zealand and Australia, but also inland.

Agrostis alba L. var. *maritima* G. Meyer.

Perennial, stoloniferous; stems decumbent at base, 3—9 dm. high: leaves rigid, glaucous, scabrous, 7—15 cm. long.

Grows especially in moist places between the dunes. Baltic south coast.

Ammophila arenaria (L.) Link.

Tall perennial grass, with long rigid leaves; creeping rootstock; stems 6—12 dm. high, sheaths long; blades convolute and polished without, scabrous and glaucous within.

Coastal sands of Europe, North Africa, and North America. Introduced to many other countries as an effective sandstay.

A. baltica Link.

Is by most authors considered to be a hybrid of the former species, which it resembles in habit, and *Calamagrostis epigea*. This is, however, not yet proved by experiments. Occurs on coastal sand dunes of Northern Germany and Southern Sweden.

Andropogon provincialis Lam.

Perennial grass, with erect culms, smooth and glabrous. 10—15 dm. high: leaves smooth, acuminate.

Southern Europe, where often planted on dunes. *A. furcatus* Muhl. is a North American form with a wide range along the eastern sea board. By some authors, as Hackel, it is considered to be identical with *A. provincialis*.

Aristida plumosa L.

Perennial caespitose grass, with ascendent culms; leaves acute filiform.

Northern Africa, both on the coast and inland. *A. pungens* Desf. is another grass from Northern Africa, which not infrequently is planted on sand dunes on the coasts of Mediterranean.

Arundo conspicua Forst.

Abundant on sand dunes of New Zealand, but also distributed inland.

Avena praecox P. B.

Slender annual, densely tufted, 7—15 cm. high; leaves short. Coastal and inland sands, Central and Southern Europe.

Calamagrostis epigea Roth.

Perennial, with creeping rootstock; stems 10—13 dm. high, erect, firm; leaves long, narrow, somewhat glaucous.

Widely dispersed over Europe and Western Asia. Not confined to coastal sands.

Corynephorus canescens Bernh.

Small tufted perennial, 10—15 cm high; leaves fine, convolute.

Sand formations of Southern and Central Europe, eastward to Caucasus and northward to Southern Sweden. In Norfolk and Suffolk, England, on sea shores.

Cynodon dactylon (L.) Pers.

Perennial grass, with prostrate, creeping and rooting stems, sometimes very long, covered with undeveloped, striate sheaths; roots and tufts of leaves produced at the nodes; blades 2—5 cm. long, stiff, glaucous green.

In all hot and some temperate countries, such as Southern Europe, whence it ranges to Northern France, and Australia. Not confined to coastal sands, but often a roadside weed, as in California, where it is introduced.

Dactylis litoralis Willd.

Perennial grass, with long creeping stolons; leaves rigid, glaucous.

Coasts of Mediterranean, but also on the salt steppes of Eastern Europe and Western Asia.

Distichlis maritima Raf.

Perennial grass, with stout, creeping, scaly rootstock; stems stout, rigid, erect, 10—45 cm. high, often branched below, leafy: leaves pale green, narrow, rigid, very acute, strictly 2-ranked; sheaths glabrous, slightly bearded at the base; ligule reduced to a mere ring, blade 5—15 cm. long, spreading, rigid; margins minutely ciliate.

Varies somewhat, being shorter and more rigid in some places with shorter, stiffer, and more distinctly distichous leaves.

Common near salt and brackish water in America, Tasmania, and Australia. Characteristic on coastal dunes of Victoria and South Australia.

Elymus arenarius L.

Glaucous perennial grass, with stout, widely creeping stoloniferous rootstock; stems tall, rigid, stout, erect, 1—2 m. high; sheaths smooth, channeled; ligule a narrow truncate ring; blades 30—45 cm. long, 10—15 mm. wide, flat or with more or less convolute margins below.

Coastal sands of northern hemisphere. In North America from Greenland and Labrador to Alaska, southward to Maine, Lake Superior and California (San Francisco). Occasionally inland also in Europe.

Festuca litoralis Lab.

Stems 3—10 dm. high, forming dense tufts of pale yellow color; leaves almost cylindrical, erect, rigid, pungent-pointed, glabrous, length of the stem.

Common on coastal sand dunes of New Zealand and adjacent islands, Tasmania and Australia, from Wide Bay, Queensland, to Western Australia.

F. ovina L.

Perennial, densely tufted, 15—50 cm. high; leaves radical, narrow, almost cylindrical.

Common on established dunes, but not confined to coast.

F. rubra L. var. *arenaria* Osbeck.

Perennial, with creeping rootstock, shooting stout, reddish stolons; stems ascending, rigid, hairy; leaves stiff, on upper side grayish green, darker beneath. Resembles much *Agropyrum junceum*.

Common on the coasts of Baltic.

F. uniglumis Sol.

Annual, tufted, 10—15 cm. high; leaves narrow, convolute.

On sandy shores of Mediterranean and on coast of Western Europe northward to England.

Glyceria maritima Reich.

Perennial, with creeping rootstock; stems decumbent or erect, 2—6 dm. high; leaves smooth, glabrous, short, narrow, convolute; sheaths exceeding internodes.

Coastal sands of Europe, Western Asia, Mediterranean, and North America, from Nova Scotia to Rhode Island on the Eastern coast, and on the Pacific to San Francisco.

G. stricta Hook. f.

Tufted, glabrous, erect annual, 3—5 dm. high; leaves narrow, erect, with broad sheaths.

On sea shores of New Zealand, Tasmania, and Australia, from Victoria to Western Australia.

Hordeum maritimum With.

Annual, coarse, tufted, stems decumbent at base, 3—6 dm long; glaucous.

Marine coasts of Western Europe, and of the Mediterranean.

Imperata arundinacea Cyrillo.

Perennial grass, with long roots and 3—10 dm. high erect culms; leaves erect, narrow, often longer than the stem.

Widely distributed in the Mediterranean countries, Southern and Western Asia, Cape Colony, Australia, and Polynesia. Often planted as a sandstay especially in wet localities.

Ischaemum muticum L.

On tropical coasts of Asia, Polynesia, and Queensland, southward to Rockingham Bay.

Koeleria cristata (L.) Pers.

Tufted, pale green, pubescent or silky perennial; stoloniferous rootstock; stem 3—9 dm. high, slender; sheaths striate, ligule very short; blades narrow, obliquely auriculate at the base.

A very variable plant, common on coastal sand dunes, but not confined to these, in Europe, Central Asia, America, New Zealand, and in a few places in Australia (probably introduced).

Lagurus ovatus L.

Annual, erect, 10—30 cm. high, leaves hoary, sheaths swollen.

Common on coastal sands of Western Europe, from Mediterranean to the English Channel.

Lepturus incurvatus Trin.

Annual, decumbent, much branched at base; 10—30 cm. high, with short, fine leaves.

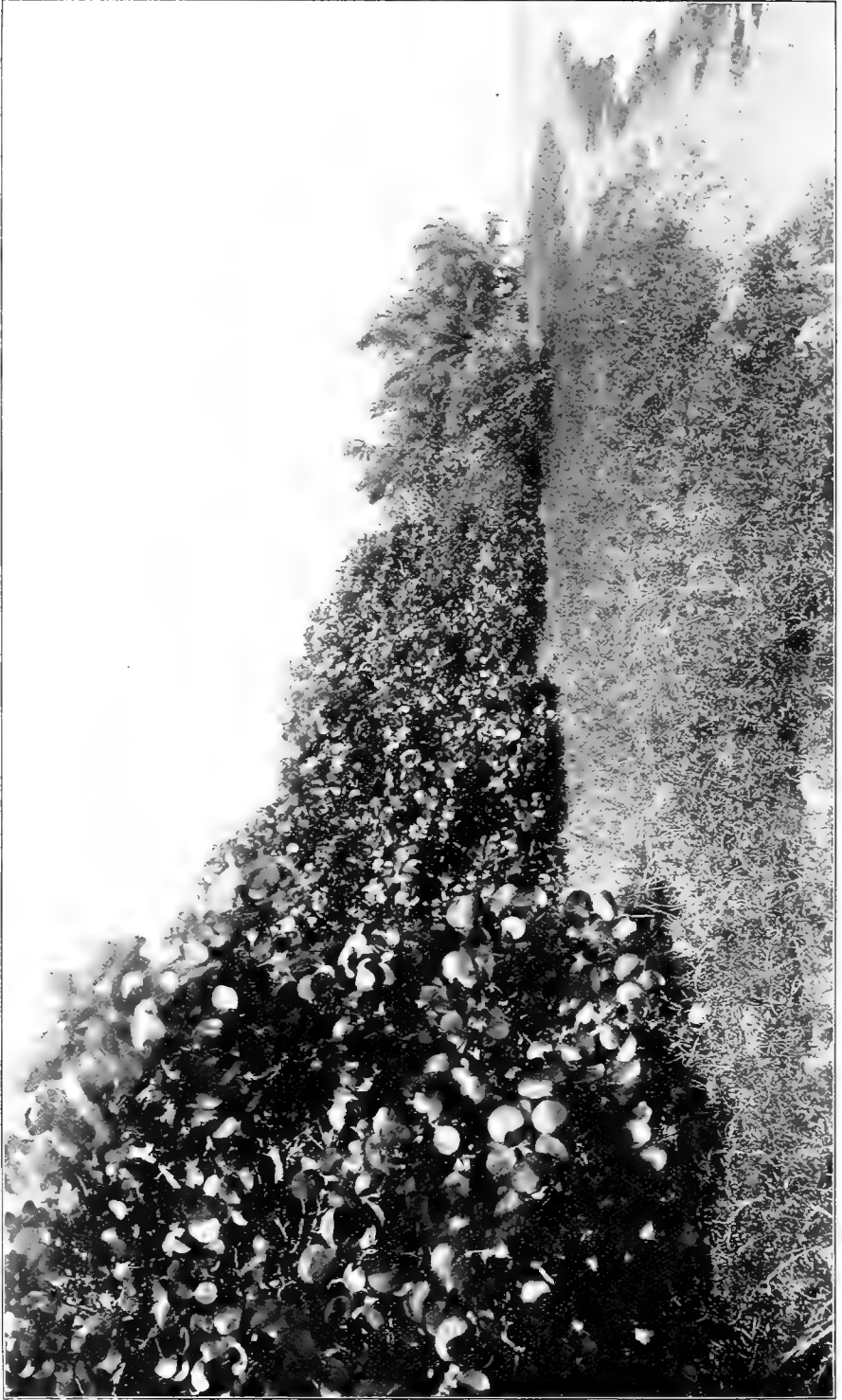


FIG. 16. Sandy shore on St. Croix, Danish West Indies, with *Coccoloba* community.
PHOTOGRAPH BY BORGESSEN.

On marine coasts of Europe, from English Channel along west coast to Mediterranean and Caspian Sea.

L. repens R. Br.

Perennial, creeping grass, with branching stems; leaves spreading, glaucous, glabrous.

Drifting sand on some islands of the tropical coast of Queensland and in Southern Pacific.

Paspalum distichum L.

Stems creeping and rooting, ascending to 4 dm., covered with leaf-sheaths; leaves linear-lanceolate, flat, glabrous.

Widely dispersed in tropical countries, usually on heavy soil, but occasionally on coastal sands. Also in Australia, from Queensland along the southern coast to West Australia, in New Zealand, and in North America from Southern California to Florida.

Phleum arenarium L.

Annual, erect, 5—20 cm. high; leaves short.

Coastal sands of Europe, from Mediterranean to the Baltic.

Poa compressa L.

Perennial, with creeping rootstock; stems erect, 10—30 cm. high, flattened at base; leaves short, with flattened sheaths.

Widely dispersed in Europe, Northern Asia, and North America except the arctic region. Frequently on coastal sands, but not confined to these.

P. Douglasii Nees.

Perennial grass, with slender, widely creeping rootstock; stems tufted, 20 cm. high.

Peculiar to the coastal driftsands of California.

Polypogon litoralis Smith.

Perennial, procumbent, tufted, 3—6 dm. high, leaves short, narrow, scabrous on both sides.

Salt marshes and dune lagoons on sea coasts of Western Europe, Mediterranean, North and South America.

P. monspeliensis Desf.

Annual, procumbent and geniculate at base, 3—5 dm. high; leaves flat, broad, somewhat scabrous; sheaths smooth.

Often on coastal sands, but not confined to these. Widely dispersed in Central Europe, from Holland and France to far into Central Asia, and in North America, from Atlantic coast to California, where it is chiefly found in the mountains. Also in Africa.

Schoenus nitens Hook. f.

Perennial, slender stem from creeping rhizome, 15—30 cm. high; leaves few at base, short, terete, but furrowed along inner side, sheaths not bearded.

Marine coasts of Australia, from Moreton Bay to Western Australia, usually in clayey soil, but also frequently in sand. Also in Tasmania, New Zealand, and extratropical South America.

Spartina stricta Sm. var. *glabra* Muhl.

Perennial grass, with creeping, scaly rootstock, stems erect, stout, 4—12 dm. high, leaf-blades long, flat, smooth, tapering from about 1 cm. wide near the middle to long, slender points; edges rolled inward when dry.

Sea coasts of Europe, from North Sea to Mediterranean, North America, along the Atlantic coast and in a few places on the Pacific.

Spinifex hirsutus Lab.

Stout stems; creeping, forming large tufts; leaves often over 3 dm. long, margins involute, woolly; the male plant has sessile spikes in a terminal head, each spike about 5 cm. long, spikelets sessile in the spike, 15—20 mm. long; the female plant has numerous spikelets in large globular head, the spikelet 20—25 mm. long, acute.

On sandy shores of New Zealand, New Caledonia, Tasmania, and Australia, from Queensland to West Australia.

A slightly differing form, occurring near Fremantle in Western Australia, has been referred to as *S. longifolius* R. Br., but its right as a distinct species is doubtful.

S. squarrosus L.

Resembles foregoing species in habit. The heads are large, radiating, and when the seeds are matured, the heads become detached, and are easily carried by the wind along the sand, thus dispersing their seeds.

On sandy shores of India.

Stipa tenacissima L.

Perennial grass, with long, slender leaves. Resembles in habit

Ammophila arenaria, for which it is a substitute on the dunes of the Iberian Peninsula.

It occurs on sandy tracts everywhere in the western parts of the Mediterranean. A closely allied species, *S. arenaria* Brot., is found on similar localities in Spain and Portugal.

S. teretifolia Steud.

Perennial; stems in dense tufts, 45—75 cm. high; leaves long, slender, terete.

On middle beach and in salt marshes on coasts of Australia (Western Australia to Victoria), Tasmania, and New Zealand.

Thuarea sarmentosa Pers.

Creeping and rooting perennial, forming short tufts; leaves flat, lanceolate, 3—5 cm. long, densely silky-pubescent on both sides.

On sandy beaches in the tropics from Madagascar to Samoa.

Zoysia pungens Willd.

Rhizome creeping; stems erect, 5—15 cm. high; leaves flat or convolute, with rigid, pungent points, glabrous; spike terminal.

Coastal sands of tropical and Eastern Asia, New Zealand, Tasmania, and Australia, from Moreton Bay to Victoria.

OPHIOGLOSSACEAE.

Ophioglossum arenarium E. G. Britton.

Rootstock slightly thickened, with 1 or 2 stalks, stem rigid, erect, 5—17 cm. high, bearing the sessile lanceolate fleshy leaf below the middle; blade 2—5 cm. long, acute or apiculate.

Gregarious in a colony of many plants in sandy ground under trees at Holly Beach, New Jersey. (Bull. Torr. Bot. Cl. 24: 555. 1897.)

O. vulgatum L.

Perennial rootstock; stem single, 8—15 cm. high, with one oblong, entire leaf, 5—8 cm. long, narrowed into a sheathing footstalk.

Although not confined to the coast this plant is often found on inundated sands in the Finnish Archipelago, and on the Swedish east coast.

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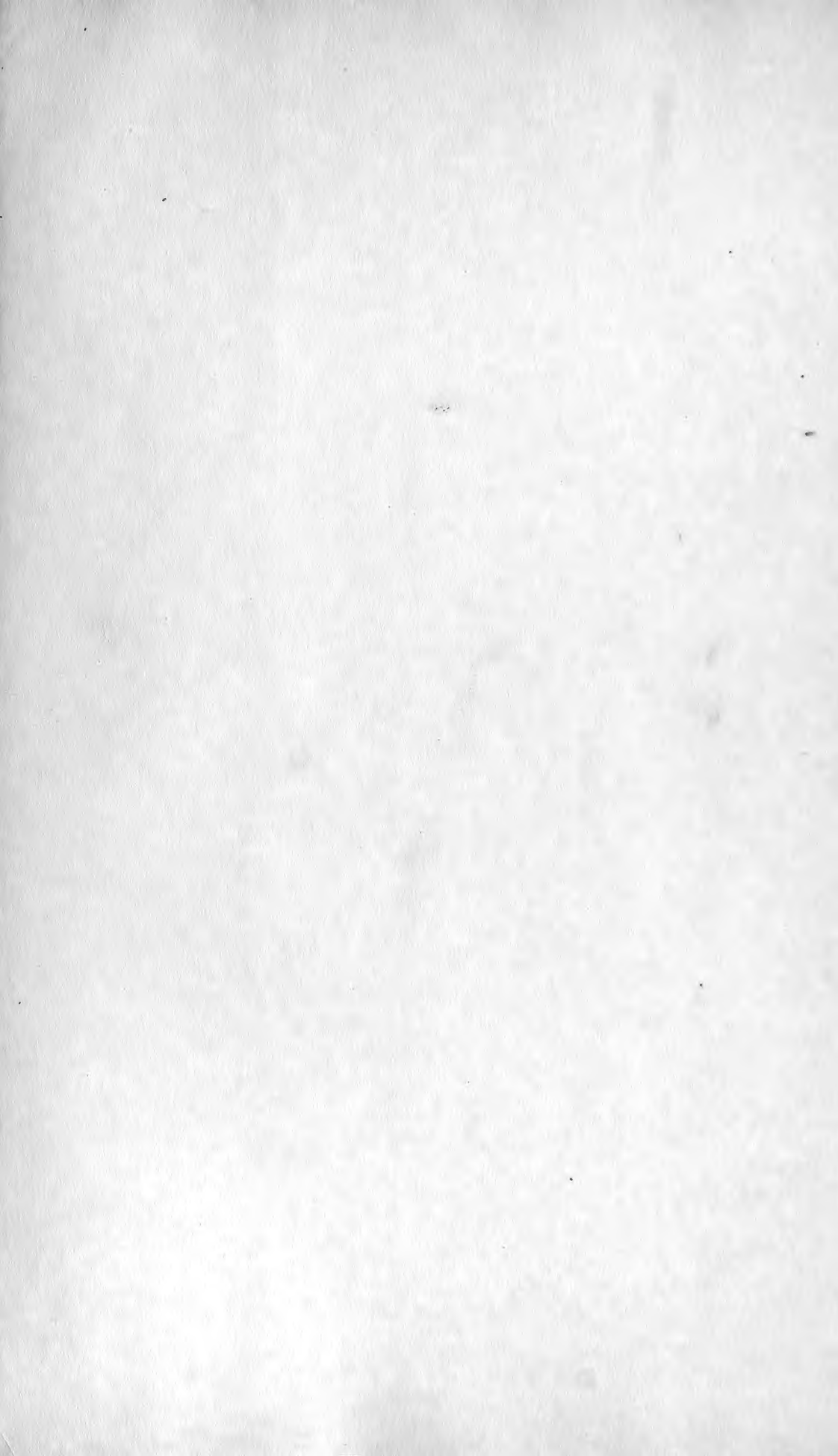
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