Art. XIX.—*Diatomaceous Dust on the Bering Sea Ice Floes*;* by E. M. Kindle.

In ordinary seasons the winter's accumulation of ice in Bering Sea disappears to a sufficient extent by the end of the first week in June to offer no serious obstacle to navigation. The ice conditions during the spring and early summer of 1908 in Bering Sea were very unusual, however, and all of the steamers sailing for Nome in June were imprisoned for brief periods in the Bering Sea ice packs. Most of the vessels occupied from 8 to 10 days in working through the 300 miles of ice floes which lay between the Seward Peninsula and the open water in the southern part of Bering Sea. The steamer Umatilla, on which the writer was a passenger, first encountered the ice pack off the southwest coast of Nunivak Island, June 11, in scattering cakes. During the succeeding eight days, which the vessel spent among the ice floes, the opportunities were favorable for observing the character of the materials appearing upon the surface of the ice and for collecting samples of the dirt on the floes.

At the time of the writer's observations the long-continued attrition of the ice cakes comprising the floes had broken them into pieces generally not exceeding 200 feet in diameter. A few cakes much larger than this still remained, however, and one was observed with a length of not less than 350 yards.

A very large percentage of the ice cakes were more or less discolored by dirt or dust. Probably 80 per cent of the ice bore small amounts of fine dust or dirt in sufficient quantity to give it a slight gray or blackish color in spots. No pebbles or rocks of any kind were observed on the floes. The very fine texture of the dirt together with its dissemination through the snow on the ice suggest that most of it reached the surface of the ice through transportation by the wind. This fine material was observed to show a strong tendency to segregate itself into little pellets as the melting of the snow and ice containing the dirt proceeds. These ranged in size from bird shot up to the size of peas. They were nearly or quite spherical and in the case of the larger ones sufficiently firm and compact to probably reach the bottom without dissolution on the complete melting of the ice in shallow water like that of the northern half of Bering Sea.

The color of the dust seen on the ice was generally gray, dark brownish or black. A sample of the black dust which was examined by Mr. A. Knopf at the writer's request is stated by Mr. Knopf to be unquestionably of volcanic origin. It may represent a fall of volcanic dust which occurred Novem-

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ber 2, 1907, and covered an extensive area in northwestern Alaska, including the greater part of the Seward Peninsula. Samples of the gray dust show very fine-textured earthy material of about the same degree of coarseness as is seen ordinarily in the loess.

An interesting feature of these samples of ice-borne dust is the presence in most of them of considerable numbers of marine diatoms. These organisms are quite as abundant in the dust sample which is chiefly of volcanic origin as in the gray non-volcanic dust. Through the kindness of Dr. Albert Mann, the writer is able to present a list of the species which were found in the samples collected. These were obtained from the ice floes about 30 miles northwest of Cape Romanzof.

The list which follows gives the species which were recognized by Dr. Mann:

List of Diatoms from Ice Floes; by Albert Mann.

"I find the dust collected on ice-floes in Bering Sea to be fairly rich in diatoms. Below are the species found therein:

Coscinodiscus radiatus Ehrenb.
Coscinodiscus subtitis Ehrenb.
Coscinodiscus curvatulus Grun.
Coscinodiscus excentricus Ehrenb.
Coscinodiscus lineatus Ehrenb.
Coscinodiscus robustus Grev.
Coscinodiscus spec?
Coscinodiscus pustulatus Mann.
Biddulphia aurita (Lung.) Breb. & God.
Melosira sulcata (Ehrwnb.) Kutz.
Actinoptychus undulatus
Navicula brasiliensis Grun.
Navicula fontinalis Grun.
Coscinodiscus apiculatus Ehrenb.
Gyrosigma thuringicum (K.) Rab. See Wm. Smith's Synop. Brit. Diatoms; Vol. I; Pl. 21; Fig. 205; p. 65. Mann, Diat. Albatross Voyages: p. 366.

"This last species should retain its well known name *Pleurosigma angulatum* W. Sm.

"The first named species, *C. Radiatus*, is by far the most common. It may be of interest to note that the above species were found by me in the dredgings of the S. S. Albatross, made in the southern part of Bering Sea, mostly at considerable depths. The new species, *C. Pustulatus*, Mann, was found at a depth of over 1800 fathoms.

"*Coscinodiscus* spec? is an unnamed species. I found this also in the Bering Sea dredgings and mentioned it in my

report as *C. Heteroporus*, Ehrenb. The specimen I marked as doubtful. I find several examples of it in these samples and am able to recognize it as identical with the imperfect valve I found in the Albatross material."

Diatoms have not been observed before on the Bering Sea ice and the recorded occurrences of these organisms on floating ice elsewhere are not numerous. The careful observations of Nansen* have shown, however, that the presence of diatoms

FIG. 1.

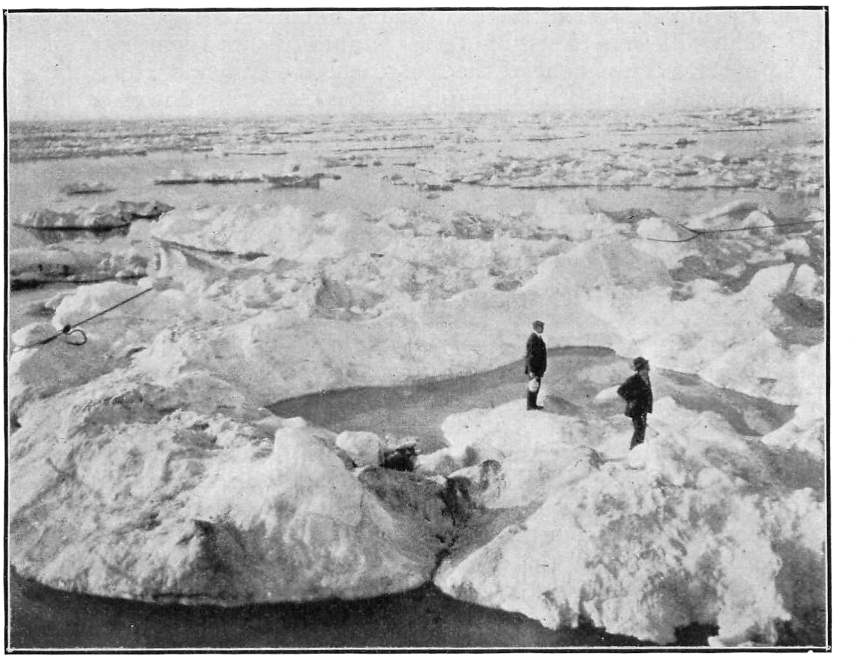

FIG. 1. View of an ice cake showing discoloration of front and left sides by diatomaceous dirt, with pool of fresh water in the center.

on the circumpolar ice packs is not an unusual or accidental circumstance, as was formerly supposed. Many species of diatoms were found by Nansen, during the drift of the Fram, to be living in the shallow pools of water on the surface of the floating ice cakes. Vanhoffen † found on the west Greenland

* Fridtjof Nansen, the Norwegian North Polar Expedition, 1893-1896, Scientific Results, Protozoa on the ice floes of the North Polar sea, vol. v, pp. 5–6, 1906.

† The Norwegian North Polar Expedition, 1893–1896, Scientific Results, vol. iv, 1904, p. 8.

coast that diatoms resort to the under surface of the ice in abundance and are able to live there.

The abundance of diatoms in all of the samples of dirt collected from the Bering Sea ice suggests that the normal habitat of some of the species obtained for part of the year is the shallow ponds of fresh or brackish water on the ice cakes. One of the pools from the margin of which diatom-bearing dirt was obtained is shown in the photograph, fig. 1. Some of the species may attach themselves to the under surface of the ice as observed by Vanhoffen in the early winter while it is thin, become frozen in and reach the upper surface by the melting of the upper layer of the ice in early summer.

The siliceous tests of these minute plants comprise an important component of the fine-textured sediments which the annual melting of the Bering Sea floes is sifting down on the sea bottom.

The nearest locality to Bering Sea from which diatoms have been found on floe ice is near Cape Wankarema, west of Bering Strait about 200 miles.

Comparison of the species in the dirt from Bering Sea ice with those collected from the ice floes near Cape Wankarema by Kjellman of the Vega expedition and by Nansen during the drift of the Fram affords some interesting data on the relationship of floras found on the ice in the Arctic Ocean and in the Bering Sea. But one species, *Coscinodiscus curvatulus*, is common to the Bering Sea diatoms from the ice near Cape Romanzof, and those collected by Kjellman and Nansen in the Polar basin; nine species of the Bering Sea ice flora occur in the Pacific south of Bering Sea; two are found in the southern part of Bering Sea; one, *Navicula fontinalis*, is not recorded from the Pacific by Mann.*

It is thus seen that the affinity of this ice diatom flora is very decidedly with that of the Pacific flora to the south and not at all with that of the Polar sea. This is especially significant when it is recalled that the diatom fauna of Cape Wankarema, which is only about 400 miles from Cape Romanzof, bears the closest resemblance to the diatom fauna of the east coast of Greenland. The identity of the large number of species from the two localities was an important part of the evidence which led Nansen to formulate the theory of ice drift across the Polar basin from the Siberian toward the Greenland coast, which his journey afterwards demonstrated to be true. The two samples of mud collected by Nansen from the floe ice east of Greenland during his expedition to Green-

* Albert Mann, Report on the Diatoms of Albatross voyages in the Pacific Ocean, 1888–1904. Contr. from the U. S. Nat. Herbarium, vol. x, pt. 5, pp. 225–419, pls. 44–54.

land in 1889 contained 16 species of diatoms, 12 of which were known elsewhere only from floes at Cape Wankarema.*

In contrast with this remarkable resemblance between the Wankarema and the E. Greenland diatom floras which are separated by the entire breadth of the Arctic Sea, we find between the Wankarema and Bering Sea floras almost complete unlikeness, there being but one species common to both. This sharp contrast between the diatom floras occurring on the ice to the northwest and to the south of Bering Strait affords convincing evidence that no definite marine current connects the two areas which could carry the Wankarema flora southward or the Bering Sea flora northwestward. On the other hand, the close resemblance of the Bering Sea ice diatoms to the Pacific flora which is shown by more than nine species common to the two, indicates a close relationship through marine currents with the Pacific Ocean.

Dall's conclusions regarding the movement of water in the southern part of Bering Sea corresponds with the evidence of the diatoms in this respect. He states:† "My own conclusion from a study of the data is that the general tendency of the water in Bering Sea is to the southward and where deep enough as in the western part of the sea it forms a tolerably well defined current." The ice drift in the vicinity of Cape Wankarema, on the other hand, was shown by the drift of the Jeannette to be to the northward or away from Bering Strait. These opposite tendencies of the currents in the two areas explain the contrast between the diatoms of Cape Wankarema and Cape Romanzof.

* H. H. Gran, Diatomaceæ from the ice floes and of the Arctic Ocean: The Norwegian N. Polar Exped., 1893-96, vol. iv, p. 6, 1904.

† Report U. S. Coast and Geodetic Survey for 1880. Appendix No. 16, p. 315.