THE OCEANOGRAPHIC WORK ON THE SECOND PARTIAL VOYAGE OF THE GERMAN NORTH ATLANTIC EXPEDITION, JANUARY TO JULY 1938

by

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(Translated from the German.)

(Extract from "Bericht über die Zweite Teilfahrt der Deutschen Nordatlantischen Expedition des Forschungs - und Vermessungschiffes "Meteor", Januar bis July 1938" — Beiheft to Ann.d.Hydr. u. marit. Met. September 1937.)

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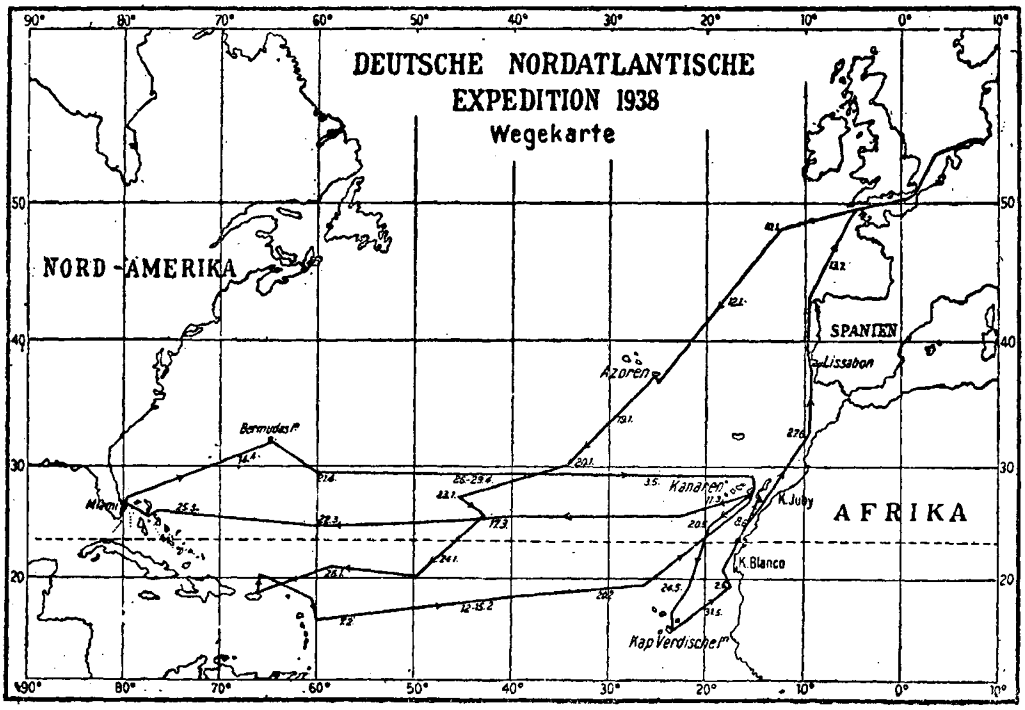
The second partial cruise was carried out in two stages with changes in the personnel of the crew. The first stage, from 6.1. to 10.V.1938, sufficed for the completion of three large profiles which are represented on the chart (plate 1); the second stage, from 14.V. to 21.VII.1938, had as mission the making of two anchor stations of three days duration each and six serial stations as repetitions of stations of the preceding year. These are also indicated in plate I.



The profiles ran in approximately the direction of the zones from 60°W. long., almost to the terminal points of the profiles of the first partial cruise, so that — in the two southern profiles at least — a considerable saving in distance was effected. The junction with the northermost profiles of the great Expedition of 1925 to 1927 is also apparent from the chart. The previous practice of running the profiles perpendicular to the coast line and the Great Mid-Atlantic Ridge — which was decided upon principally for morphological reasons — was abandoned in the new Expedition in favour of the zonal arrangement.

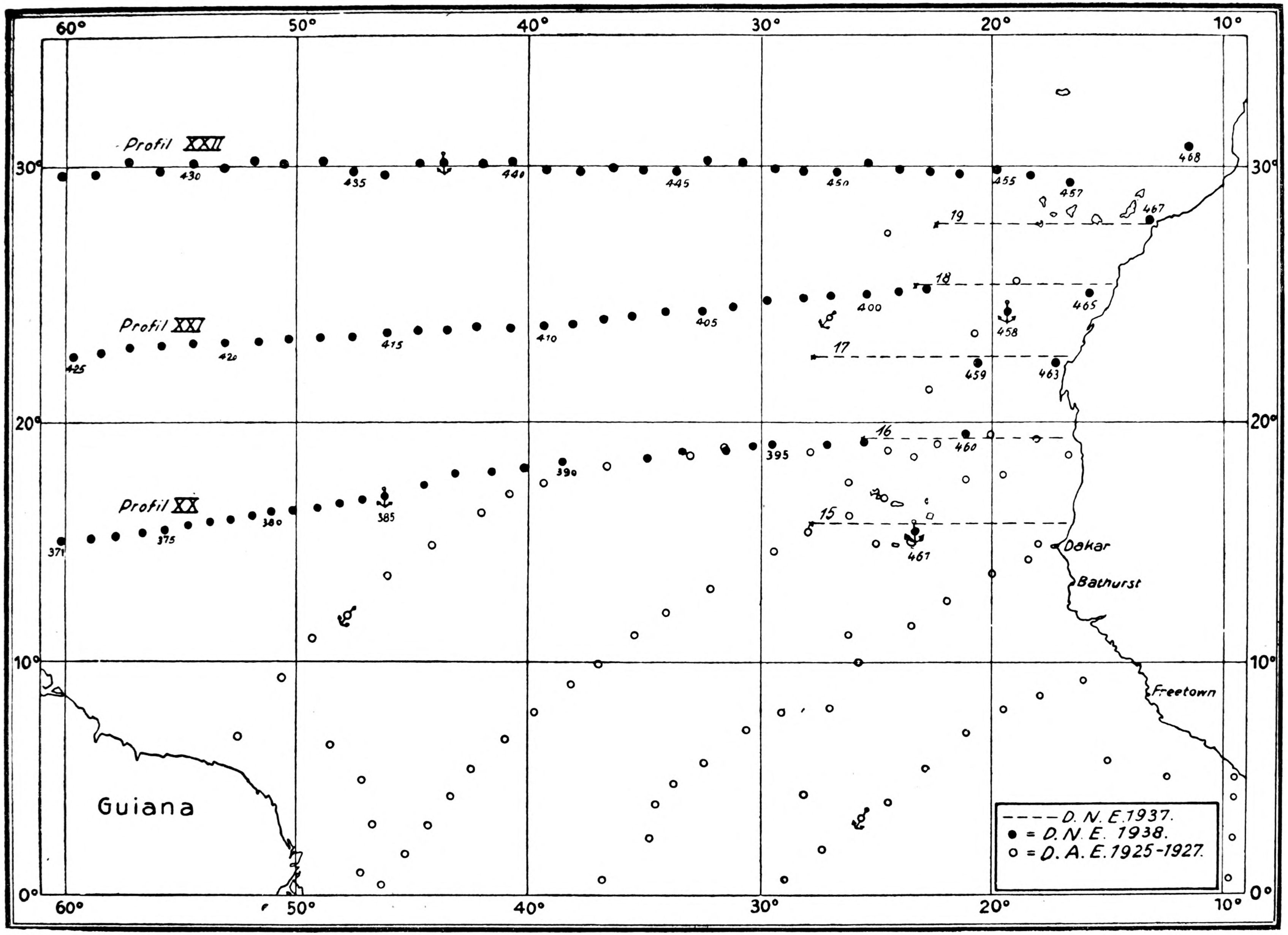


Fig. 1. — Stations of the 2nd partial cruise and preceding Expeditions.

On the whole, in the three profiles, 86 oceanographic stations were made, including two anchor station, each of three days duration.

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The stations of the first profile are spaced at intervals of about 60 nautical miles ; each second station extends to depths of 1500 metres only. Thus the stations at which bottom was reached, have the same intervals between them as those of the Great Expedition; but between each of these a shallow station has been inserted in order to obtain data, in a smaller field of observation, on the troposhere and the stratum of intermediate waters, corresponding to the previous development of our knowledge of the subject. The depths for the water sampler were the same as on the Great Expedition and the first partial cruise; the greatest depth reached was 6000 metres (from station 404 in the southern Canary Basin). Out of 43 stations, 37 reached depths of at least 4000 metres.

The northern anchor station 438 (12 to 15.11.1938) was at a depth of water of 2220 metres, the southern 385 (26 to 28.IV.1938) at a depth of 2850 metres. At both stations, hourly oceanographic series were carried out; thus at station 438, in eight horizontal planes down to a depth of 800 m., at station 385 in the horizontal planes to a depth of 150 m. The series were for the purpose of

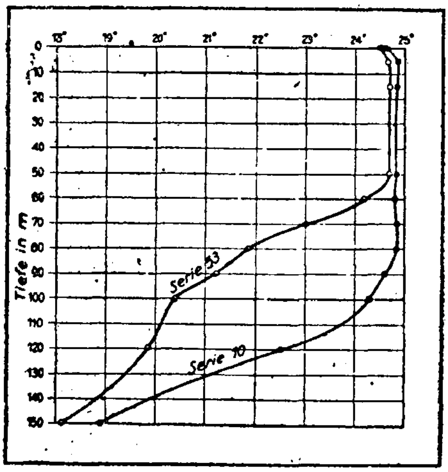

Abb. 2. Vertikale Temperaturverteilung in zwei extremen Serien der Ankerstation 385.

Fig. 2. — Vertical temperature distribution in the 2 extreme series at anchor station 385.

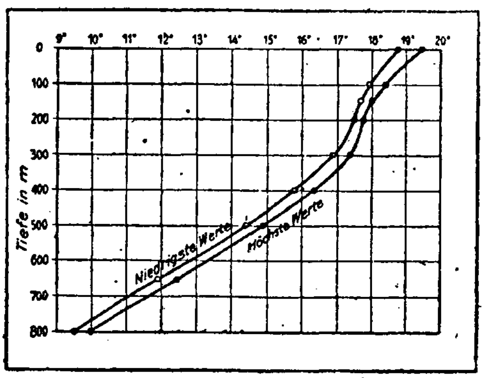

Abb. 3. Extremwerte der Temperatur aus 60 Serien der Ankerstation 438.

Fig. 3. — Extreme temperature values from 60 series at anchor station 438.

determining exactly the position of the "Sprungschicht" (discontinuity layer). Further, at both stations continuous current measurements were taken in eight horizontal planes, to a depth of 800 m., with the recording current meter described by G. Böhnecke. (1)

In the following, we shall therefore report in brief on the preliminary results of the two anchor stations which can now be considered as definitely established.

The difference between the vertical structure in the two anchor stations is considerable, as may already be seen from the vertical temperature curves (Fig. 2 and 3). While at the southern station, a maximum temperature gradient of 0.12° per metre was found, the maximum temperature gradient at the northern station was ten times smaller, or about 0.016° per metre. In accordance with the definition given by Defant, (2) we can only speak of an abnormal increase in the temperature gradient of the vertical curves when the maximum temperature gradient exceeds 0,1° per metre. At the southern station this condition is fulfilled and it possesses, therefore, a well-defined discontinuity layer (Sprungschicht). The northern station, however, does not. This was to be expected since Defant had established the fact that a real discontinuity layer can only exist between 15°N and 15°S.

Under these conditions, a marked difference in the results of the investigations of the periodical temperature changes at the two stations was to have been expected. Since it must be assumed that the periodic changes at a given depth come about as a result of the rising or falling of water which has been tempered elsewhere, the periodic changes will be greatest at that depth where the vertical gradient is a maximum.

At station 385, the periodic changes are so great that the values of the two extreme series could be represented as in Fig. 2. At station 438, on the other hand, the highest and lowest temperatures found at each depth had to be plotted as separate curves in order to make the periodic changes manifest (Fig. 3). If we plot the vertical gradients against the periodic changes, at any depth, then we obtain for both stations the following representation :

Station 385.........	Vertical	grad.	0.12°	Max.	tempor.	var.	3.9°
» 438.........	»	»	0.016°	»	»	»	0.56°
Ratio 385:438.......	»	»	7.4	»	»	»	7.0

The agreement between the ratios of the vertical gradient and the maximum changes at the two stations is noteworthy.

If we plot the vertical curves of temperature for all 60 series at both stations and if we take from each, for every series, the depth of a certain isotherm, then we obtain a definite measure of the vertical displacements of the water. At station 385, the isotherm of 24° varies between the depths of 72 and 105 m., or about 33 metres; at the station 439, the extreme positions of the isotherm 13° are comprised between 578 and 605 metres, or a variation of 27 m. If we multiply the corresponding vertical gradient by these observed depth variations, then the observed periodic variations in the depth of the maximum vertical gradients show the following results :

Station	Vertical gradients	Observed oscillations of depth	Calculated temporary variations	Observed temporary variations
385	0.12°	33 m.	3.96°	3.9°
438	0.016°	27 m.	0.43°	0.56°

(1) "Bericht über die erste Teilfahrt der Deutschen Nordatlantischen Expedition des Forschungs- und Vermessungsschiffes *Meteor*". Beiheft to the *Ann. d. Hydrogr. u. Marit. Met.*, September, 1937.

(2) Book of the *Meteor*, Vol. VI, 1, p. 324.

If we group the 60 values for the depths of the above mentioned isotherms in five series of 12 hours each, and then take average for each hour, we shall obtain the mean depth variations shown in figs. 4 and 5. At station 385, the unreduced temperature values obtained aboard ship had to be used, which results in a 12 hour period practically without perturbations. At station 438, we have had to await the results of the temperature reductions, on account of the very much smaller temperature changes. In spite of considerable perturbations, one can still clearly note the 12 hour periods.

Similar periods can be ascertained in the heading of the ship which was noted for every minute. If we take the mean for the 60 values of each hour, then the mean values of the 60 hours for station 385 are distributed around 65.3° and 19.1°, or varying through 46.2°. Only, while at station 438 they lay between

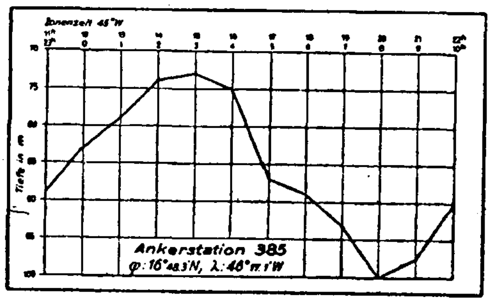

Fig. 4. — Mean depth of the isotherm of 24° from 5 periods of 12 hours.

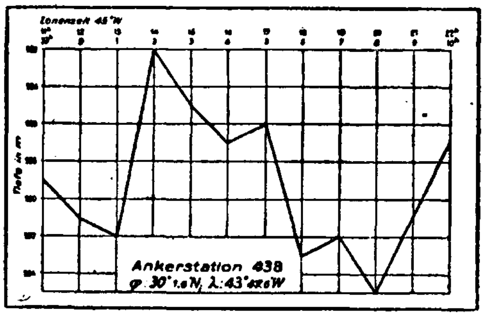

Fig. 5. — Mean depth of the isotherm of 13° from 5 periods of 12 hours.

62.1° and 19.2° or through 42.9°. The agreement between two stations separated from each other in space and time is naturally purely accidental, although the fact that both stations lie in the region of the NE trade-winds may have been a contributing factor. If we group the 60 values in five series of 12 hours each, then the hourly averages show a decided 12 hourly period.

Hourly mean of the ship's heading. Zone time 45° *W.*
Stations 385 *and* 438.

	11h 23h	12h 0h	13h 1h	14h 2h	15h 3h	16h 4h	17h 5h	18h 6h	19h 7h	20h 8h	21h 9h	22h 10h
385	47.3°	51.7°	**52.6°**	51.2°	**50.9°**	**52.0°**	50.6°	48.3°	44.5°	43.9°	**43.3°**	44.3°
438	43.7°	44.2°	**39.4°**	41.9°	**41.5°**	**42.1°**	41.0°	42.7°	45.6°	**48.7°**	46.5°	46.7°

The phases in the periodic parts of the course changes are practically exactly opposite at the two anchor stations, in which we must note that not the lunar hours but the zone times of 45°W longitude were applied for both stations, and that between the first and the second there was an interval of 2 1/2 months. Since, however, the depth variations of the two isotherms in the same zone time of 45°W long. was given, and since, in spite of this, the phases are in agreement, then the relation between the tidal currents at the surface and the vertical displacements, must have been different. In this connection it must be remembered that at station 385, the isotherm of 24° was selected, which lies some 90 m. above the discontinuity layer, while the isotherm of 13° at station 438 lies much deeper, around 600 metres.

Finally, twelve hour periods are clearly shown by the current observations, which have up to now only been evaluated for the station 385. In this case, however, a rather comprehensive elaboration was required to free the periodic changes from the many perturbations. The observed values at each depth — which, as a result of observations being made at several depths, were subject to periodic interruptions — were then analysed by components and a smooth curve drawn through each group of values; from these curves the values were taken for each lunar hour. The 60 values thus obtained (at 800 m. only 24 values), for each component, were then further grouped in five periods of 12 lunar hours and the mean was taken for each lunar interval. In this manner, the periodic current variations which are represented in fig. 6, were deduced for each depth. The phenomenon, clearly marked in the N.-S. component, is somewhat less distinct in the E-W component. This is understandable in that the major axis of the somewhat elongated current ellipse lies nearly north and south. In the case of the N-S components the agreement at 5 m, 15 m, 30 m, and then again

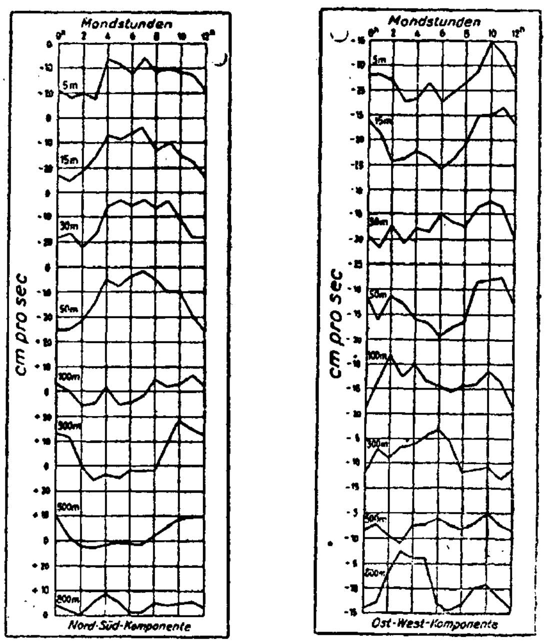

Fig. 6. — Semi-diurnal tidal current at Anchor station 385.

at 300 m and 500 m, is very convincing. The phase in the first four depths, or above the discontinuity layer, is practically diametrically opposite that of the phase in the lower layers. At 1000 m., or in the discontinuity layer itself, the 12-hour period has disappeared, as was to be expected from the change of phase. For the E-W component (which is drawn to double scale), the same condition holds true, although it is not quite so distinct. In particular, the reversal of phase stands out clearly when one compares the depths of 15 m. with 300 m. The further elaboration, in particular a comparison with the northern station, leads to the expectation of further important conclusions regarding the problem of internal waves.

Although they do not belong strictly to the oceanographical work, we shall discuss here the 14 bottom samples which were obtained on the second partial cruise. Their positions, depths etc., are shown in table 2. They have been studied meanwhile by Professor Dr. O. PRATJE and the following conclusions have been reached :

In the greater depths of the North American Basin (5600 metres = 3120 fathoms) (sample N° 3), and in the Guiana Basin (sample N° 1) red deep-sea clay was found. At the western slope of the North Atlantic Ridge, at 3920 m. (2140 fathoms) and 2500 m. (1365 fathoms) depths, there was found a globigerina ooze (N° 2) and a foraminifera sand (No 13). These are examples of the concretion of sediment on submarine elevations. Presumably, in such localities, greater current velocities prevail than in the deeper basins, whereby the clay becomes washed out and enriches the greater depths. The lime deposits (calcareous earth) stand in inverse proportion to the clay content and correspondingly the foraminifera sand becomes the richest in lime, which also contains traces of iron manganese concretions.

Table 2. — Bottom samples from the Ist section of the second partial cruise.

N°	STATION	Date 1938	POSITION		Depth m.	APPARATUS	NATURE OF BOTTOM
1	Profilstat. 379	9. III.	16° 15.0' N	51° 59.7' W	5600	Water sampler.	Red deep-sea clay.
2	— 414	18. III.	23° 55.1' N	44° 58.2' W	3920	— —	Clayish globigerina ooze.
3	— 421	20. III.	23° 18.1' N	54° 36.1' W	5650	— —	Red deep-sea clay.
4	Grundphobe I	26. III.	25° 53.0' N	77° 36.1' W	2620	Percussion tube	White calcareous ooze with foraminifera and pteropoda.
5	— II	26. III.	25° 57.8' N	77° 58.3' W	940	— —	do.
6	— III	26. III.	25° 49.1' N	78° 5.3' W	27	Grab.	Yellow calcareous sand constituted by debris of foraminiferes shell
7	— IV	28. III.	26° 12.5' N	78° 46.5' W	485	Percussion tube	Pteropoda ooze.
8	— V	28. III.	26° 16.2' N	79° 9.0' W	360	— —	Clayish globigerina ooze
9	— VI	11. IV.	26° 0.6' N	79° 34.0' W	125	Grab	Greenish calcareous sand, chiefly shell debris.
10	— VII	11. IV.	26° 34.6' N	79° 59.0' W	140	—	Greenish calcareous sand made up of debris.
11	— VIII	11. IV	27° 25.0' N	79° 33.0' W	700	Percussion tube	Reddish pteropoda ooze.
12	— IX	12. IV.	27° 53.0' N	78° 14.6' W	1030	— —	Grayish pteropoda sand.
13	Profilstat. 438	28. IV.	30° 0.5' N	43° 48.2' W	2500	Deep-sea anchor.	Yellowish globigerina sand.
14	Grundphobe X	3. V.	29° 57.7' N	28° 34.1' W	275	Tallowed sounding lead.	Foraminifera sand and calcareous crust.

The samples from the "great Meteor Bank" (N° 14) were obtained with the Talg sounding machine since all other devices failed. That means that only a thin layer could be raised. The small sample consisted of loose foraminifera shells, or a sort of lime sand and also of several fragments of lime crust.

In the vicinity of the Bahamas — from the Providence Channel and from the Florida Straits — nine samples were taken (Nos. 4 to 12). It is noteworthy that the samples 4 and 5 containing calcerous mud differed from those usually obtained from the ocean bed in the surprisingly low content of foraminifera and pteropod shells, which generally consist of irregular fragments of limestone. In spite of the depths of 2620 metres (1430 fathoms) and 940 metres (510 fathoms), these are undoubtedly debris from the Bahama Reefs, which include inorganic calcerous deposits.

The sediments from the Florida Straits (greenish lime sand, pteropod ooze and sand) are strikingly large grained. They indicate that here, up to depths of 1000 metres, a strong bottom current must be running.

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