# SOME MORPHOLOGICAL RESULTS OF THE CRUISE OF THE "METEOR" JANUARY TO MAY 1938

by

G. DIETRICH, Berlin, Institut für Meereskunde.

(Extract from "*Bericht über die Zweite Teilfahrt der Deutschen Nordatlantischen Expedition des Forschungs- und Vermessungsschiffes "Meteor" Januar bis Juli* 1938.")

(Translated from the German.)

The morphology of the ocean, as the science of the active physical processes which form the ocean bottom and thereby give it its shape, appears to-day to be rather unequally developed in its various branches. Its descriptive and representative part concerning the topography, where it has been established by soundings, is widely extended, particularly in those regions where the navigational requirements have made such investigations necessary. But the truly scientific side of the oceanic morphology — that is, the explanation of the forms, is to-day still in its beginnings. In this field we are compelled to deal with hypothesis; but the topography alone, supported here and there by a few geological and seismological indications, has up to now permitted too much rein to fancy. Just at the present, we are witnessing a rapid development in the accurate geophysical methods of measurement, on which we can already base most valuable knowledge of the structure of the submarine bottom layers and from which we may expect to derive further conclusions regarding the sub-oceanic structure. First, were the gravimetric measurements at sea, as obtained by Prof. F.A. Vening-Meinesz with his pendulum device (1) in a submarine in the East Indies, and en route back and forth from the station, as well as similar research carried out by the Americans in the Caribbean (2). Possibly these very meticulous measurements, which can be conducted only on submarines may be replaced by the new static gravimetric device of H. Haalck, with which very promising results on board surface vessels have already been obtained (3). Under such conditions we might obtain regional systematic gravimetric measurements conducted in the oceans by various oceanographic expeditions. Further, the seismological methods have also progressed to such an extent of late that valuable knowledge of the submarine crust may be opened up. In particular, the refraction and reflection measurements of the seismic waves resulting from the artificial explosions carried out by the American surveying vessels *Atlantis* and *Oceanographer*, which came to my knowledge when we met off the Florida Coast, will bring a new insight into the geophysical structure of the continental shelf (4). A further development of this method for use in the deep sea is now in preparation. On the other hand, we may expect from the improved geological-mineralogical methods, as well as from the evaluation of the secular magnetic variation, to obtain even more complementary information with regard to the ocean bottom (5).

For the present the investigation of the topography is the most important contribution towards morphology which the expeditions can furnish. Here, as

(1) F.A. Vening-Meinesz. "Gravity Expeditions at Sea 1923-1932," Vol. I and II. Publication of the Netherlands Geodetic Commission, Delft, 1932, 1934.

(2) M. Ewing. "Gravity Measurements on the U.S.S. *Barracuda*." American Geophys. Union, Tr. 1937, pp. 66 and subs. Washington 1937.

(3) H. Haalck. "Messungsergebnisse mit dem statischen Schweremesser auf der Nord- und Ostsee und in Norddeutschland". *Zeitschr. f. Geophysik* 1935, pp. 55 and subs.

(4) M. Ewing, A.P. Crary, P.M. Rutherford. "Geophysical investigations in the merged and submerged Atlantic coastal plain. Part I. Methods and Results." *Bull. Geolog. Soc. of America.* New York 1937, pp. 753 and subs.

(5) Symposium arranged by the American Geophysical Union held at the American Philosophical Society, Nov. 1937. Geophysical Exploration of the ocean bottom. *Proc. Amer. Philos. Soc.* Vol. 79, 1938.

shown by the most recent soundings of the *Meteor,* surprising results are still being obtained. During the entire voyage, soundings were taken every quarter of an hour (or about three nautical miles apart), by means of the directional echo-sounder of the Atlas Werke, Bremen. With increased strength of bottom relief, the intervals were reduced to five minutes and even to one minute, In so for as the necessity for running oceanographic profiles did not interfere, the course of the *Meteor* was laid out at the start to pass through those parts of the ocean where soundings are relatively scarce, as may be seen especially on the run from the approaches to the English Channel to Porto Rico. The Mid-Atlantic Ridge was traversed three times on zigzag courses; on entering and leaving San Juan (Porto Rico), the Great Porto Rico Trench was cut three times and thus the greatest echo depth of 8360 metres (19° 42' N., 65° 55' W.) was sounded. A remarkable depth was also found in the Canary Basin, which at 6435 m. (6) in 24° 49' N. and 32° 37' W. represents the greatest depth known heretofore in the North Atlantic Ocean. A fortunate chance permitted us to traverse a bank at about 30° N., 28 1/2 W. on the Third Profile (XXII) which had not previously been indicated by any soundings whatsoever in that vicinity. With more exact soundings, least water over the bank was found to be 262 m. In its external shape the bank is a large flat plateau which falls off abruptly on all sides to depths of 4000 metres. This tremendous submarine elevation, which was christened the "Great Meteor Bank" (7), is at the same time the greatest

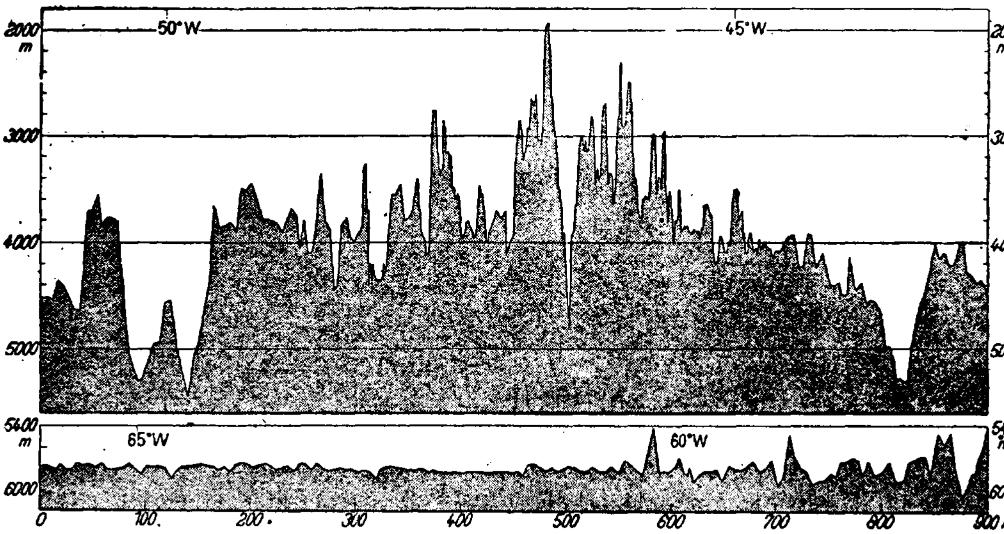


Fig. 1. — Section of the Echo-soungding profile across the North American Basin (24° O' N. 65°53' W. to 23°10' N. 57°10' W.) and of Echo-sounding profile XX across the Mid-Atlantic Ridge (16°14' N. 51°04' W. to 17°18' N. 42°50' W.)
Height exaggerated 100 times).

(6) The soundings cited of the *Meteor,* for 1938, are unreduced echo soundings. They are based on a sound velocity of 1500 metres per second. When reduced to their true velocity, which, in this case, amounts to 1530 metres, we obtain the true depth of 8520 to 8530 metres. This would equal practically to the greatest known depth in the Atlantic Ocean which was obtained by the American cruiser *Dolphin* in 1902, with a wire sounding apparatus, i.e. 8525 metres in 19°35' N., 67°43' W. This, however, was obtained without a bottom sample and was therefore regarded as questionable. (Th. Stocks, G. Wüst : "Die Tiefenverhältnisse des offenen Atlantischen Ozeans". *Wiss. Ergeb. d. Deutschen Atlant. Expedition "Meteor"* 1925/27. Vol. III, I Teil, Berlin 1935, p. 29).

(7) In order to avoid confusion between the steep slope sounded by the German Atlantic Expedition in 1925, in 48°14'5 S., 8°22'1 E., which was called at the time "Meteor Bank", it would be advisable to follow the propos al made by G. Wüst to call this smaller and less steep elevation in the Southern Atlantic Ocean "Meteor Peak". It rises only to 991 m. from the ocean bottom; whereas we are generally used to call such elevations "banks" only when they reach the depth of the shelf limits (that is to say between 50 and 400 metres).

and one of the shoalest banks of the whole open Atlantic. Judging from its nature it probably belongs to those elevations encountered in large numbers on the Azores Plateau and is evidently of volcanic origin.

A number of interesting questions are raised by the sounding profiles over the Mid-Atlantic Ridge. There is revealed over each individual profile an extraordinary strength of relief which stands in sharp contrast with the almost flat bottoms in the inner parts of the deep sea basins. The comparison of the echo-sounding profiles through the Mid-Atlantic Ridge on Profile XX, at about 16° N., and a section of the Profile XXII of the North American Basin, in Fig. I, shows the fundamental difference which exists between the topography of the ridge and the basin.

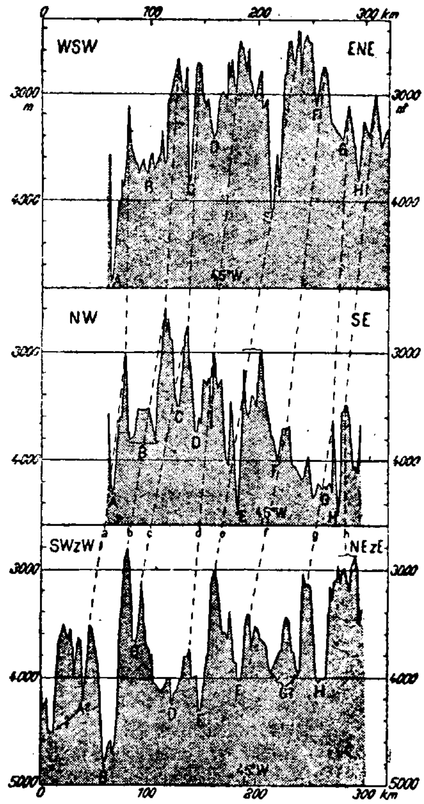


Fig. 2. — Echo-sounding cuts across the Mid-Atlantic Ridge (*Meteor* 1938).
At the top: 26°37' N 45°52' W. at 27°18' N 43°20' W.
In the middle: 26°37' N. 45°52' W. at 25°03' N. 44°09' W.
At the bottom: 23°25' N. 46°13' W. at 25°03' N. 44°09' W.
(Height exaggerated 100 times).

In connection with the strength of relief, there is an enormous difference in the heights separated by short distances from each other. In the example cited above, in Profile XX, the sea bottom in the middle of the Mid-Atlantic Ridge drops from a peak height of 1930 m. to 4790 m., or a total of 2860 metres within a distance of 21 kilometres, i.e. a mean gradient of 8°. The approach to the eastward from one of these depressions attains a maximum gradient of 30°. A certain similitary in the succession of deep depressions is shown with Profile XX and the previous northernmost "Meteor" profile of the year 1927. (8) Such striking depressions in the Ridge occur also in the other five "Meteor" profiles, the most impressive of which is in Profile XXI, where in a stretch of 9 nautical miles, about 23° 50' N., and 46° 10' W., the ocean bottom drops from a peak elevation of the Ridge of 1820 m. to 5460 m.; that is with a mean slope of

12 1/2°, the maximum slope was found to be 34°. Here it was possible to successfully carry the oceanographic series down to 5200 metres in this depression.

On the basis of the sounding profiles on the Ridge, we are enabled to take a stand with regard to the problem of the morphology of the ocean. That is — is it possible to find a certain correlation of form in the continuous up-and-down of the ocean bottom in the region of the Ridge between the profiles ? In other words, are we dealing here with a confused and unrelated rise or with a Ridge which can be resolved into a series of more or less parallel trains of undulations ? Th. Stocks and G. Wüst (9) touch on this problem in the discussion regarding the directives for the establishment of the isobaths in the bathymetric chart of the Atlantic Ocean. They take the intermediary position that, although the possibility of parallel undulations might be recognised, a close correlation of these forms does not appear to be practicable. The soundings taken on zigzag courses passing over this Mid-Atlantic Ridge appear to present this question in a new light. The individual profiles are placed one below the other in Fig. 2. In accordance with this representation, there appears to be a meridional correlation between the forms. Nine continuous undulating trains may be correlated in these three traverses, although the nature of the relationship is very different in individual cases. Probably this is unquestionably the case with the crests a, b, c, d and e, as well as their corresponding valleys B, C, D, E and partly F. Also in echo profile XXI, we can discover corresponding shapes; but already in the northern profile XXII and the southern profile XX, the shapes are altered to such an extent that a definite correlation can no longer be spoken of. Such a diversity in the oceanic relief can only be classified by means of profiles taken very close together. Even in the region of the zigzag courses over the Mid-Atlantic Ridge, the culminating crest has been displaced from the undulation b, in the two southern profile sections, to crest e in the northern profile section. In the individual cases, the sounded heights of the peaks in the 6 profiles were:

| | | | |
|---|---|---|---|
| Profile XXII ......... | 2015 m. | 30°00' N. | 43°48' W. |
| Zig ................... | 2400 m. | 27°04' N. | 44°12' W. |
| Zag ................... | 2580 m. | 26°08' N. | 45°34' W. |
| Course ................. | 2800 m. | 23°58' N. | 45°42' W. |
| Profile XXI ........... | 1820 m. | 23°53' N. | 45°53' W. |
| Profile XX ............ | 1930 m. | 16°45' N. | 46°42' W. |

However, the echo sounding profiles show definitely that there are no closed massive Ridges, such as they necessarily appear on the small scale bathymetric charts. The confused and tangled mass of crests and valleys in the Mid-Atlantic Ridge can be resolved into a series of approximately parallel trains of undulations rising from the ocean bottom which can be followed, at least within certain limits. Since only topographical results are available, we can only suppose, with regard to the structure, that it is a case of trains of folds.

❖ ❖ ❖

(8) Th. Stocks "Die Echolotprofile des "Meteor". *Wiss. Ergeb. d. Deutsch. Exped. "Meteor"* 1925/27, Vol. II, Berlin 1933.

(9) Th. Stocks, G. Wüst "Die Tiefenverhältnisse des offenen Atlantischen Ozeans" *Wiss. Ergeb. d. Deutscb. Atlant. Expedt. "Meteor"* 1926/27. Vol. III, I Part, Berlin 1935. Berlin 1935.