DIE TIEFENVERHÄLTNISSE DES OFFENEN ATLANTISCHEN OZEANS

(DEPTH CONDITIONS IN THE OPEN ATLANTIC)

by

TH. STOCKS and G. WÜST.

The International Hydrographic Bureau has received a reprint of a paper forming Part I of the Third Volume of the results of the *Meteor* Expedition. It accompanies a fine bathymetric chart in colours, on a scale of 1: 20.000.000, and describes the methods by which the latter was drawn up. The chart is on Lambert's equivalent azimuthal projection, with centre on the equator; its scale in the region of the equator is about half that of the General Bathymetric Chart of the Oceans published at Monaco, and in middle latitudes about a third. The differences in scale of the two charts, and in their objects, are sufficient to explain many of the differences between them. It is of interest moreover to compare this new chart with sheets A_1 and A'_1 of the General Bathymetric Chart of the Oceans, third editions of which the International Hydrographic Bureau has recently completed.

In the Monaco chart, efforts were made, by inserting as many soundings as legibility permitted, to give as complete and accurate a picture as possible of our knowledge of the bottom relief as obtained exclusively from soundings; Messrs. STOCKS & WÜST, in their chart, have attempted to give a general view of the bottom formation of the ocean, to serve as a basis for the oceanographic and geological exploitation of the material collected by the *Meteor* Expedition. Thus, in the latter chart, only a small number of figures has been inserted; the contour lines have been drawn at 500 m. intervals, neglecting the minor details, generalising, and even occasionally stretching the forms a trifle to make them stand out better. This, to our way of thinking, increases the hypothetical character of many of these contours; the authors, however, are far from denying this character and have, indeed, brought it out very well by representing the contour lines in those parts where their trace is more uncertain than usual by fine pecked lines, or even by interrupting them, and by indicating them by the colour only in those places where information is lacking altogether. It is obviously necessary to draw contour lines to be able to appreciate the main bottom forms at a glance, but we may be certain that any new sounding profile will necessitate their modification, often in no small degree. The fact of having very closely spaced soundings on profiles lying from 300 to 500 miles apart, and only sporadic soundings between them, does not make it possible to discover how the very numerous inequalities of the bottom which the profiles reveal are connected between one profile and another. On page 17 the authors show two completely different drawings of contour-lines, which they obtain in the region south of Ascension with the same soundings. In the first drawing, the method known as that of valleys and spurs leads them to include all the neighbouring inequalities in the general system of the great ridge by enveloping curves; in the second, the elevations and depressions have been connected together from one profile to another through this region which is poor in soundings, thus supplementing the principal ridge by a series of narrow crests and depressions approximately parallel to it. We think we may agree with the authors that both solutions are equally incorrect.

Very often the echo soundings along the profiles show, on the crests, differences of 800 to 1000 m. within distances of 10 km.; and in the basins, differences of 200 to 300 m. within the same interval. The bottom of the sea is thus not flat as has been thought, and nothing but profiles which are but a few kilometres apart would enable us to understand the connection between the different inequalities of the bottom and to draw the isobaths every 500 m. with some approach to truth. What then would become of the various rises and basins which the present generalisation causes to appear quite clearly ?

Certainly, the great Atlantic ridge which traverses the whole length of this ocean is an indubitable and particularly remarkable characteristic thereof. We are far from being acquainted with all its summits and we do not know whether, if we confine it within 4000 m. isobaths, breaks must be shown in these or not. A curious fact is that no profile obtained by echo has shown any. And so we have not thought it necessary to indicate on the Monaco chart either the break, which appears to be rather improbable, which Messrs. STOCKS & WÜST show as hypothetical near Lat. 8° N., nor even the one which they call the "Romanche Furrow". The latter would cut the ridge near the Romanche Trough at a depth of more than 4500 m. In this very uneven region soundings are rare and the rise, if it is not broken, is certainly very narrow; but it is not

without interest to state that the existing soundings are insufficient to prove the existence of the "Romanche Furrow".

We must call attention to the fact that in cases where soundings are insufficient the authors have frequently had recourse to the notion of *potential bottom temperature* to assume the existence of breaks or sills, enabling or preventing exchanges of water from taking place, and explaining the temperature differences observed. Therein we have a most interesting question, which has been very completely discussed by WÜST in *The Hydrographic Review*, Vol. X, No. 2, November 1933, pp. 209-218; but it is still merely a hypothesis which appears to us to require verification by an absolutely independent examination of the depths.

We associate ourselves fully with the hope of the authors when they say that one of the most profitable undertakings would be a systematic sounding, by closely spaced transversal profiles, of a portion of the main ridge, and that it is desirable that the work of the *Meteor* be continued by interpolating new profiles spaced about 60 miles apart.

Messrs. STOCKS' and WÜST'S book contains a list of the documents utilised in the plotting of the rough sheets, which were on a scale four times that of the final publication (those of the International Hydrographic Bureau are on a scale 10 times that of the General Bathymetric Chart). We see in it an interesting demonstration of the progress made since 1912 (the date of the publication of MAX GROLL'S chart) in the knowledge of the forms of the sea bottom, but also an indication of the considerable task which remains to be accomplished, both in the area remaining to be sounded and in the necessity for numerous researches into matters of detail.

One of the regions in which the state of knowledge has advanced most is the Scotia Sea, which presents so many analogies with the Caribbean Sea, and in which the extensive work done since 1926 has defined the great morphological lines and settled many details.

On the continental slopes, echo soundings have generally shown steeper gradients than were expected, and have brought to light new furrows, veritable canyons gashing the continental plateau.

The chart under discussion shows us the two great east and west Atlantic depressions divided into a certain number of basins by rises joining the great ridge to the continent and sometimes taking the aspect of a grid. It is a convenient division for oceanographic study, but we must not exaggerate its morphological importance. The soundings are often insufficiently numerous for the existence of certain rises to be other than hypothetical. Some of them appear to be, and could perhaps be compared, as Alexandre SUPAN has done, with watersheds which are hardly apparent on the spot. Their presence is particularly called for by observations of *potential bottom temperature*. The Walfisch and the Rio Grande Ridges are the most typical and the least disputable examples.

In a general way, the deeps of more than 6000 m. are of smaller area than had been thought, and it is possible that new soundings will narrow them down even further. Sounding by line in such depths was of special difficulty, and the drift of the ship during the great length of time occupied by the sounding might be the cause of too great an estimate of the depth. The two deepest trenches are the Puerto Rico Deep, and the South Sandwich Deep. The 6000 m. isobath of the Puerto Rico Deep extends roughly 2° further eastward on the chart of the International Hydrographic Bureau than on that of Messrs. STOCKS and WÜST, on account of the utilisation of an echo profile taken in March 1933 by the *Atlantis*, of the Woods Hole Institution.

The terminology of the General Bathymetric Chart of Monaco uses, in principle, the French translation of the German terms defined in 1903 by Dr. SUPAN (*). The name *Seuil de l'Atlantique* has been retained in the 3rd edition, rather than that of *dorsale* (*Rücken*) used by Messrs. STOCKS and WÜST, which it appears to us should be reserved for a narrower elevation than a rise, with steeper slopes. Furthermore, we do not wish, except for very good reason, to change a nomenclature established by particularly competent geographers. This is why we have retained the name, *Crête de Walfisch*, as it existed in the 2nd edition (September 1913) of Sheet *A'IV*, instead of the name *Walfisch-Rücken* used in the German chart. We have deleted the names *Dépression de l'Atlantique Est* and *Dépression de l'Atlantique Ouest*, simply to make the chart clearer.

We have also retained the names of the chief deeps which recall celebrated oceano-

(*) *See* The Hydrographic Review, *Vol. V, No. 2, Nov.* 1928, *pp.* 9-23.

graphers. The German authors have replaced them by names of basins describing their geographical positions. Their method has undoubted advantages : but this division into basins often seems somewhat complicated and is also, in many places, of a hypothetical character. In a few respects the authors have modified SUPAN's nomenclature : (1) in adopting the terms *Labrador Rise* and *Newfoundland Rise* instead of Newfoundland Ridge and South Newfoundland Rise which were apt to be confusing ; (2) to the northward of the Azores Plateau they draw a distinction between the *Spanish Basin* and the *West Europe Basin*, separated by the *Biscay Rise ;* (3) they denote by *Puerto Rico Rise* a small bulge which separates the North American Basin from the Guiana Basin.

As we have already said, for reasons of clearness we have avoided overloading our chart with names covering large surfaces ; in return, we have distinguished the greater part of the less extensive banks by names, which are generally those of the vessels that discovered them. To those shown on the 2nd edition we have added : Kelvin Bank ; Ampère Bank, an extraordinary elevation rising to 60 m. among depths of nearly 4000 m., discovered on 4th March 1935 by the French Cable Ship of that name (*) ; also the Echo Bank, Tropic Bank, Schmitt-Ott Rise and Admiral Zencker Bank, discovered and named by the *Meteor*. The naming of these details did not enter into the framework imposed upon themselves by the authors of the German chart. The latter, with its accompanying study, will be found to have caused a distinct advance in the oceanography of the Atlantic.

P. V.

(*) *See* International Hydrographic Bulletin *No. II, March-April* 1935, *pp.* 33-34.