The Basins of the Atlantic Ocean — A Science Classic

Oceanography

Report on Temperatures. By Staff-Commander T. H. Tizard, H. M. S. Challenger. GENERAL SUMMARY OF ATLANTIC OCEAN TEMPERATURE. H. M. S. Challenger Report No. 7, 1876.

One of the most remarkable scientific expeditions ever undertaken was the voyage of H. M. S. "Challenger" which sailed the seas from 1872 to 1876. A full complement of scientists to study all the interesting material obtained was carried around the world, and oceanography was established on a footing equal to that of other departments of knowledge of our globe. The account here reproduced from one of the "Challenger" reports gives the first attempt to map the bottom of the whole Atlantic Ocean.

OVER a great portion of the Atlantic, the bottom temperature has this peculiarity. If the depth be less than 2,000 fathoms we find the temperature at the bottom lower than that of any intermediate depth, but when the depth exceeds 2,000 fathoms we find that the bottom temperatures are nearly the same as they are at that depth, no matter how much the depth may exceed 2,000 fathoms, and this holds good for three-fourths of this ocean. In the remaining fourth the temperatures obtained at the bottom are much lower than in the other parts, and this fourth is not at either extreme, where there is a large amount of surface cold, but occupies the whole of the western portion of the South Atlantic as far north as the Equator.

The results of these temperatures may be classified as follows:

If an imaginary line be drawn from French Guiana to the western-most island of the Azores, and from thence nearly due north; on the western side of this line the extreme range of our temperatures, at depths exceeding 2,000 fathoms, is only 1°, viz., from 34°.4 to 35°.4. Thirty-two observations of bottom temperature at these depths were obtained in this portion of the Atlantic, and in only one instance did the thermometer give so high a result at 35°.4, and in two instances so low a result as 34°.4, and the two cases where these low readings were obtained were very unsatisfactory. . . . We therefore think ourselves justified in assuming that in that portion of the Atlantic west of the imaginary line the bottom temperature at depths exceeding 2,000 fathoms is uniform a 35°.

In that part of the North Atlantic on the eastern side of the line joining French Guiana with the Azores, etc., 27 observations of bottom temperatures were obtained at depths exceeding 2,000 fathoms. The extreme range of the whole 27 observations is 1°, from 34°.8 to 35°.8, their mean being 35°.3. As (on the western side of this imaginary line) these differences are so slight, and a degree of the thermometer is so small, that the discrepancies may easily be ascribed to errors of eye in reading, more especially when we consider that of the 27 results 16 agree to 0°.3, only varying from 35°.2 to 35°.5, and those that differ are not concentrated in any particular locality, but are distributed over the whole of the North Atlantic east of the imaginary line, we think ourselves justified in assuming that in this portion of the Atlantic the bottom temperature at depths exceeding 2,000 fathoms is uniform at 35°.3.

Similar results to these were obtained by the German Frigate "Gazelle" in the eastern part of the South Atlantic, eastward of a line joining Tristan da Cunha with Ascension. . . .

Between Tristan da Cunha island and the Cape of Good Hope four soundings were obtained at depths exceeding 2,000 fathoms, and here the bottom temperature was much colder, varying from 32°.9 to 34°, the mean being 33°.5. It is therefore nearly certain that the uniform bottom temperature of 35°.3, which exists in the whole of the eastern portion of the Atlantic, does not extend farther south than an imaginary line joining Tristan da Cunha with the Cape of Good Hope.

It will thus be seen that a nearly uniform bottom temperature is found over three-fourths of the area of the Atlantic. In the remaining fourth, viz., from the east coast of South America to a line joining Tristan da Cunha with Ascension, and from the Equator to the southward, the bottom temperature was invariably colder than that of any intermediate depth, no matter whether the depth was 500 or 2,900 fathoms; and this temperature was found to vary from 31° to 33°.5, a bottom temperature of 32°.4 being found as far north as latitude 1° 45′ S. in 2,475 fathoms, between St. Paul's rocks and Fernando Noronha island and another of 32°.7 being found in 2,350 fathoms, in latitude 2° 42′ S., between the island of Ascension and the Equator.

It appears, therefore, that the high-bottom temperature obtained in this portion of the South Atlantic (where the depth exceeds 2,000 fathoms) is colder than the lowest bottom temperature obtained in any portion of this ocean (excepting in one instance the "Porcupine" having obtained a temperature of 29° close to the Faroe islands), and that water of a temperature of 32°.5 extends in the western part of the South Atlantic nearly to the Equator, whilst in the remainder of this Ocean the average bottom temperature is 2½ degrees warmer, and this difference appears to be, so far as has yet been ascertained, divided by a pretty sharp line, on one side of which we get the cold water and on the other side the comparatively warm water. . . .

The question then arises as to the cause which confines the cold water to the bottom portion of the western half of the South Atlantic.

An examination of the soundings which have been taken in this ocean, combined with the results of the bottom temperatures, leads to the conclusion that there are a series of ridges dividing its bed into two basins, one of which occupies the whole of the western portion of the North Atlantic, whilst the other extends the whole length of the ocean on its eastern side; and that the cold water in the western portion of the South Atlantic is due to there being no obstruction between the bed of this portion of the ocean and the bed of the Antarctic basin; in fact, that this is a kind of tongue of the Antarctic basin. For example, if the direction of the imaginary line from French Guiana to the Azores, and from thence northward, be followed on a chart showing the soundings ob-

tained in the Atlantic, it will be seen that close to this line, and along its whole extent, there are a series of soundings of less than 2,000 fathoms; these soundings are not sufficiently numerous to prove by themselves alone the continuity of the ridge of less than 2,000 fathoms in depth, but taken in conjunction with the bottom temperatures, they may be considered as being sufficient evidence.

Between the west coast of Ireland and the south point of Greenland (Cape Farewell) are a series of soundings of less than 2,000 fathoms, and the ridge stretching north from the Azores meets the other ridge between Ireland and Cape Farewell, and and so encloses a deep basin in the western part of the North Atlantic, the water in which is cut off from the cold stream at the bottom of the tongue of the Antarctic basin. The existence of the ridge between French Guiana and the Azores was originally discovered by the U. S. Ship "Dolphin."

Between Tristan da Cunha and Ascension island a series of soundings were obtained in March, 1876, which show that a ridge of less than 2,000 fathoms in depth extends between those islands and from one or two other soundings obtained north of Ascension by the "Hydra" and German Frigate "Gazelle," this ridge may be extended in a N.N.E. direction from the position of lat. 2° S., long. 2° S. and 10° W. Between this position and St. Paul's rocks various soundings have been taken, nearly all of them under 2,000 fathoms, so that the ridge takes a W. by N. direction from the position of lat. 2° S., long, 10° W., to St. Paul's rocks.

Westward of St. Paul's rocks towards the Dolphin ridge there are no soundings, but it is probable that the ridge continues in a W.N.W. diection from St. Paul's rocks until it joins the Dolphin ridge, as north of this line the bottom temperatures are 2½ degrees warmer than they are south of it.

To distinguish these ridges we propose to call the one between Tristan da Cunha and Ascension the "Challenger ridge," and the one joining the Dolphin and Challenger ridges the "Connecting ridge."

Between Tristan da Cunha Island and the coast of Africa there also appears to be a ridge running irregularly to the northeastward from Tristan da Cunha to the African coast. Only two soundings have been obtained on it, one by the "Hydra," of 1,800 fathoms, and the other by the "Gazelle," of 1,950 fathoms. But as all the temperatures south of the ridge are more than a degree colder than those north of it, we may conclude that it is continuous from Tristan da Cunha to the African coast.

This view of the division of the Atlantic into basins is also confirmed by the serial temperature soundings; for if the mean of the temperatures obtained at depths below 1,000 fathoms be taken either in the North or the South Atlantic, the curve of these mean temperatures will be very nearly a straight line, which, if produced, gives us the least depth at which the mean bottom temperature of the Atlantic basins should be found, and, consequently, the greatest depth of the ridges separating those basins from each other, and from the tongue of the Antarctic basin.

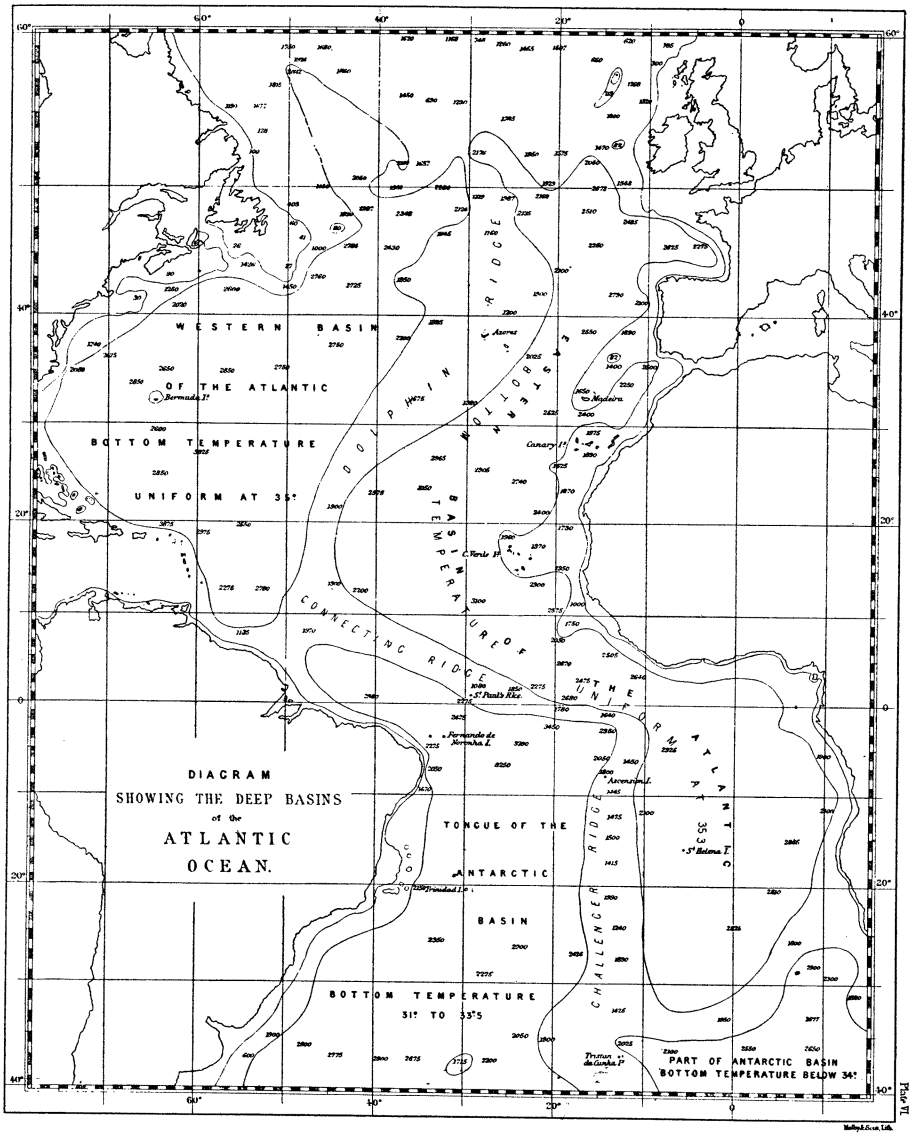
If the mean results be plotted, and a curve drawn it will be seen that this, the mean temperature curve, is a straight line, and that if it be produced it cuts the isotherm of 35° at 2,000 fathoms, and that of 35°.3 at 1,850 fathoms. . . .

The same process applied to the temperatures of the North Atlantic gives nearly similar results. . . .

Both these curves cut the temperature of 35°.3 at the same depth, viz., 1,850 fathoms.

As this is the mean bottom temperature of the eastern basin of the Atlantic, this appears to indicate that the ridge which separates this basin from the western basin of the North Atlantic as well as from the western part of the South Atlantic cannot exceed 1,850 fathoms in depth, and that in this basin the temperatures from that depth are uniform to the bottom.

The temperature line of 35°, or the mean bottom temperature of the Western Atlantic basin, is reached at the depth of 2,000 (*Turn to page* 108)



Chinese and Occidentals Agree on Skull

Anthropology

Peking Man is Pronounced Advanced Human Type

THE skull of *Sinanthropos pekinensis,* or "Peking Man," which was found early in December in a cave 40 miles from Peiping, represents a considerably more advanced type of human being than *Pithecanthropus erectus,* the so-called ape-man of Java. On this point all the scientists, both Chinese and Occidental, who gathered at Peiping recently to discuss the much-controverted cranium, found themselves in substantial agreement.

Prof. Davidson Black, who has been slowly disengaging the skull from the matrix of travertine in which it was embedded when found. stated that it is of about the same length as the Javanese skull, but that its eminences, or bulges, on both front and sides, indicate both a larger and a more highly developed brain than *Pithecanthropus* could have possessed. He estimated the difference in cranial capacity to be about 25 per cent. in favor of Peking Man.

In other respects, the skull is still of a primitive character, in Prof. Black's opinion. The very pronounced eyebrow ridges are shared with *Pithecanthropus* and also with Neanderthal Man. The lower jaw of the particular skull discovered in December is missing; but two fragmentary jaws found in 1928 are of a massive, primitive type.

W. C. Pei, the young Chinese geologist who carried on the excavations and actually discovered the skull on the last day planned for excavation in 1929, told of the toil of himself and his large crew of Chinese helpers in the cave, or more properly the fissure, of Chou Kou Tien. The skull was found in a side pocket opening out of a shaft that was dug down through a mass of fossil-filled debris that choked up this deep vertical fissure in a limestone formation. Previous excavations, followed by Mr. Pei's own diggings during the season, have turned out fossil bones of a great variety of animals, including insectivora, bats, dogs, bears, hyenas, rodents, horses, elephants, rhinoceroses, deer, beaver and a saber-tooth tiger. One notable find of the present season was the complete skull of a rhinoceros, with the lower jaw still in place.

Pére Teilhard de Chardin, S.J., one of the discoverers of Piltdown Man in England twenty years ago, has gone over the geological evidence and is convinced that the skull belongs to the Pleistocene, or Ice Age, probably early Pleistocene.

"In Chou Kou Tien," he said, "stratigraphical and paleontological evidences suggest that the deposits of the cave are much older than the time during which the Neanderthal man was living in Belgium, France and Spain. When the cave was inhabited and gradually filling, the hyena, rhinoceros and horse which were still alive were distinctly connected with the Tertiary fauna of China: *Machairodus* (the saber-tooth tiger) a characteristic Quaternary animal spread world-wide, was still wandering in the western hills."

Basins of the Atlantic—*Continued*

fathoms by the mean temperature curve of the South Atlantic, and at 1,950 fathoms by that of the North Atlantic. This shows that the ridge separating the western North Atlantic basin from the South cannot exceed the depth of 2,000 fathoms, and that from that depth to the bottom the temperatures in this basin are uniform. . . .

As salt water at its temperature of congelation is denser than at any higher temperature; its temperature of maximum density being about 2° lower than its temperature of congelation, the water just before it congeals being heavier than the water at any higher temperature would sink, and would in time (did no other cause intervene) occupy the whole of the space in the ocean not influenced by the sun's heat. That is that the whole volume of the ocean, excepting a wedge of the maximum depth of 100 fathoms, would be at about the temperature of the freezing point of salt water. But in considering the effect of the heat imparted to the surface we have also to consider the effects of evaporation and precipitation. Where the heat is greatest, there evaporation takes place quickest, and consequently although the surface water may be warmer, yet by reason of its increased salinity it may be also denser than the water beneath, so that it would sink and impart its heat by convection to the subjacent layers. But all the water evaporated from the surface is also precipitated again, not necessarily in those parts from which the greatest portion has been evaporated, consequently it appears that the salinity and denseness of the surface water depends on at least three factors: its temperature, the amount evaporated, and the amount of rain precipitated. Where the amount evaporated greatly exceeds the amount precipitated, there the surface film constantly descending imparts its heat to the water beneath, but where the precipitation is nearly equal to or exceeds the evaporation there we might expect the warm water to remain on the surface and the isotherms to occupy but a small space in depth.

In the equatorial regions it appears that although the evaporation is very great still the precipitation is also, as a rule, more than in any other part of the world, so that, although it may not be equal to the amount evaporated, it is still sufficient, in conjunction with the temperature, to prevent the surface film becoming denser than that below, so that the heated water remains on the surface. Were this water to remain in the same position an excess of evaporation over precipitation would doubtless in time render its salinity sufficient to cause it to sink, but this water is, from the friction of the trade winds, aided by the earth's motion, constantly being propelled to the westward, and meeting on the western side of the Atlantic with an obstructing point of the South American continent is deviated to the northward, so that the greater part of this heated surface film is forced into the North Atlantic with sufficient violence to cause a rapid current to issue from the Strait of Florida, which current is familiarly known by the name of the Gulf Stream, and the impetus thus given to these equatorially heated waters appears to be, not only sufficient to supply that stream, but to cause a slower movement to the northwestward outside the islands of the Caribbean sea, which water eventually joins the southern side of the rapidly moving Gulf Stream.