

## Geographical.

IN an address to the British Association recently, Sir C. S. Wayville Thompson, F. R. S., its president, after briefly reviewing the efforts made by different countries and individuals, in the work of exploration, deep-sea sounding, and Arctic discovery, and of the researches carried on by the staff of the *Challenger*, he gave an account of the

### General Oceanic Circulation.

All recent observations have (he said) shown us that the vast expanse of water which has its centre in the southern hemisphere, is the one great ocean of the world, of which the Atlantic with the Arctic Sea and the North Pacific are merely northward extending gulfs; and that any physical phenomena affecting obviously one portion of its area must be regarded as one of an interdependent system of phenomena affecting the ocean as a whole. Shallow as the stratum of water forming the ocean is, it is very definitely split up into two layers. At a depth varying in different parts of the world, but averaging perhaps 500 fathoms, we arrive at a layer of water at a temperature of  $40^{\circ}$  Fahr., and this may be regarded as a kind of neutral band separating the two layers. Above this band the temperature varies greatly over different areas, the isothermobathic lines sometimes tolerably equally distributed, and at other times crowding together towards the surface; while beneath it the temperature almost universally sinks very slowly with increasing slowness to a minimum at the bottom. The causes of natural phenomena, such as the movement of great masses of water, or the existence over large areas of abnormal temperature conditions, are always more or less complex, but in almost all cases one cause appears to be so very much the most efficient that in taking a general view all others may be practically disregarded; and speaking in this sense it may be said that the trade-winds and their modifications and counter-currents are the cause of all movements in the stratum of the ocean above the neutral layer. This system of horizontal circulation, although so enormously important in its influence upon the distribution of climate, is sufficiently simple. One of the most singular results of later investigations is the establishment of the fact, that all the vast mass of water, often upwards of 2,000 fathoms in thickness below the neutral band, is moving slowly to the northward; that in fact the depth of the Atlantic, the Pacific, and the Indian Oceans are occupied by tongues of the Antarctic Sea, preserving in the main its characteristic temperatures. The immediate explanation of this unexpected phenomena seems simple. For some cause or other, as yet not fully understood, evaporation is greatly in excess of precipitation over the northern portion of the land hemisphere, while over the water hemisphere, and particularly over its southern portion, the reverse is the case; thus one part of the general circulation of the ocean is carried on through the atmosphere, the water being raised in vapour in the northern hemisphere, hurried by upper wind currents to the zone of low barometric pressure in the south, where it is precipitated in the form of snow or rain, and welling thence northwards in the deepest channels on account of the high specific gravity dependent on its low temperature, it supplies the place of the water which has been removed. The cold water wells northward, but it meets with some obstructions on its way, and these obstructions, while they prove the northward movement, if further proof was needed, bring out another law by which the distribution of ocean temperature is regulated. The deeper water sinks slowly to a minimum at the bottom, so that if we suppose the temperature at a depth of 2,000 fathoms to be  $36^{\circ}$  F., the temperature at a depth of 3,000 may be, say,  $32^{\circ}$  F. Now, if in this case the slow current meet on its northward path a continuous barrier in the form of a submarine mountain ridge rising to within 2,000 fathoms of the sea surface, it is clear that all the water below a temperature of  $36^{\circ}$  will be arrested, and, however deep the basin beyond the ridge may be, the water will maintain a minimum  $36^{\circ}$  from a depth of 2,000 fathoms to the bottom. In many parts of the ocean we have most remarkable examples of the effect upon deep-sea temperature of such barriers intersecting cold draughts, the most marked instance, perhaps, a singular chain of closed seas at different temperatures among the Islands of the Malay Archipelago; but we have also a striking instance nearer home. Evaporation is greatly in excess of precipitation over the area of the Mediterranean, and consequently, in order to keep up the supply of water to the Mediterranean, there is a constant inward current through the Straits of Gibraltar from the Atlantic; I need not at present refer to an occasional tidal counter-current. The minimum temperature of the Mediterra-

nean is about  $54^{\circ}$  F., from a depth of 100 fathoms to the bottom. The temperature of  $54^{\circ}$  is reached in the Atlantic at the mouth of the Straits of Gibraltar at a depth of about 100 fathoms, so that in all probability future soundings will show that the free waterway through the Straits does not greatly exceed 100 fathoms in depth.

### The Depth of the Sea, and the Nature of Modern Deposits.

It seems now to be thoroughly established by lines of trustworthy soundings which have been run in all directions, that the average depth of the ocean is a little over 2,000 fathoms, and that in all probability it nowhere exceeds 5,000 fathoms. Within 300 or 400 miles of the shore, whether in deep or in shallow water, formations are being laid down, whose materials are derived mainly from the disintegration of shore rocks, and which consequently depend for their structure and composition upon the nature and materials. These deposits imbed the hard parts of the animals living on their area of deposition, and they correspond in every way with sedimentary formations with which we are familiar in every age. In water of medium depths down to about 2,000 fathoms, we have in most seas a deposit of the now well-known globigerina-ooze, formed almost entirely of the shells of Foraminifera living on the sea surface, and which after death have sunk to the bottom. In depths beyond 2,500 or 3,000 fathoms no such accumulations are taking place. The shores of continents are usually too distant to supply land detritus, and although the chalk building Foraminifera are as abundant on the surface as they are elsewhere, not a shell reaches the bottom; the carbonate of lime is entirely dissolved by the carbonic acid contained in the water during the long descent of the shells from the surface. It therefore becomes a matter of very great interest to determine what processes are going on, and what kind of formations are being laid down in these abyssal regions, which must at present occupy an area of not less than ten millions of square miles. The tube of the sounding instrument comes up from such abysses filled with an extremely fine reddish clay, in great part amorphous, but containing, when examined under the microscope, a quantity of distinctly recognisable particles, organic and inorganic. The organic particles are chiefly siliceous, and for the most part the shells or spines of radiolarians which are living abundantly on the surface of the sea, and apparently in more or less abundance at all depths. The inorganic particles are minute flakes of disintegrated pumice, and small crystalline fragments of volcanic minerals; the amorphous residue is probably principally due to the decomposition of volcanic products, and partly to the ultimate inorganic residue of decomposed organism. There is ample evidence that this abyssal deposit is taking place with extreme slowness. Over its whole area, and more particularly in the deep water of the Pacific, the dredge or trawl brings up large nubbles very irregular in shape, consisting chiefly of iron and peroxide of iron and peroxide of manganese, deposited in concentric layers in a matrix of clay, round a nucleus formed of a shark's tooth, or a piece of bone, or an otolith, or a piece of siliceous sponge, or more frequently a water-logged fragment of partially decomposed pumice. These nodules are evidently formed in the clay, and the formation of the larger ones and the segregation of their material must have taken them a very long time. Many of the shark's teeth to which I have alluded as forming the nuclei of the nodules, and which are frequently brought up uncoated with foreign matter, belong to species which we have every reason to believe to be extinct. Some teeth of the species of *Charcharodon* are of enormous size, four inches across the size, and are scarcely distinguishable from the huge teeth from the tertiary beds of Malta. It is evident that these semi-fossil teeth, from their being caught up in numbers by the loaded line of the trawl, are covered by only a very thin layer of clay.

**AFRICA AGAIN CROSSED.**—A Portuguese explorer, named Pinto, has recently arrived at Transvaal in Southeastern Africa, having crossed the continent on an exploring expedition, travelling from west to east. The latitude of his course is not given, nor, as yet, any particulars in regard to his observations and discoveries. His route, however, must have been many degrees south of Stanley's route, and will, no doubt, add much to our rapidly increasing knowledge of the geography of Central Africa.

**CEMENT FOR CAST IRON.**—Five parts of sulphur, two parts of graphite, and two parts of fine iron filings, are melted together, taking care that the sulphur does not catch fire. The parts, previously warmed, are covered with the cement, reduced to a pasty consistence on a fire, and firmly pressed together. This cement, it is said, is very well adapted to fill out leaks in cast iron vessels.