GEOPHYSICAL STUDY OF SUBMARINE GEOLOGY

(Extract from a Discourse by Dr. E.C. BULLARD, Smithsonian Fellow of the Royal Society, in "Nature", N° 3681, London, 18th May 1940).

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The sloping edge of the shelf is cut into by a remarkable series of submarine valleys. The existence off the coast of America and elsewhere of these valleys has been known for many years, but it is only recently that much attention has been paid to them. They are steep-sided features generally with flat bottoms, often lying several thousand feet below the level of the sea bottom on each side.

The origin of these features has been the subject of considerable controversy. It has been maintained that they were cut by rivers at a time when the level of the sea was much lower than at present. The recent surveys, which show the valleys to extend to the 1,000-fathom line, make the necessary lowering of the sea so great that this hypothesis must be abandoned. The difficulties of supposing the land to have been raised 6,000 ft. and lowered again are no less severe. Such a change must have left its mark on the flat-lying sediments of the coastal plain and have caused changes in the drainage which would be apparent in the present day physiography. We are therefore compelled to believe that the valleys were formed under the sea. Unfortunately, very little is known of submarine erosional processes, largely owing to the lack of detailed surveys and to our scanty knowledge of the nature of the rocks forming the submarine topography.

It is, in fact, not possible to discuss these questions profitably without more information about the nature of the rocks forming the sea floor. Cores up to ten feet long have recently been secured from these rocks by firing a tube into the bottom from a gun lowered from a ship. Such methods are of great importance, but we can scarcely hope to obtain by their aid information about rocks more than a few tens of feet below the bottom of the sea. To penetrate deeper, indirect methods must be used. The most promising of these is the seismic method. In this, charges of explosive are detonated on the sea bottom and the elastic waves produced are recorded by seismographs also placed on the bottom. When an explosion is made, waves spread out from it in all directions, and from the time taken for the waves to travel a known distance their velocity may be found and an indication obtained of the nature of the rock through which they have travelled.

Reflexions of waves from the interfaces between hard and soft rock may also be observed. If a layer of soft rock in which the velocity of the waves is relatively slow overlies a hard rock in which the velocity is high, it is possible for a wave to travel down to the hard rock, along in it, and up again in a shorter time than it can traverse the direct path through the soft rock. It is on the observation of such "refracted" waves that the work done at sea depends. Measurements have been made off the eastern coast of the United States, and to the west of the British Isles, with broadly similar results. In the case of the British Isles, igneous and well-consolidated sedimentary rocks are exposed on land, and measurements at sea near the shore show them to be covered by only a few feet of recent sediments. On going farther from shore, the thickness of the sediments increases steadily until at the 100-fathom line about 150 miles out to sea, the hard rocks are buried beneath more than 8,000 ft. of sediments. Beyond this it was not possible to go with the facilities available, but if the surface of the hard rock be extrapolated for a few miles, it runs over smoothly into the floor of the deep ocean.

It therefore seems that the Continental Shelf is a mass of sediments lying on a gently sloping surface of solid rock, and that the edge of the shelf is simply the edge of the sediments and does not represent a fault line dividing the ocean from the continent. This suggests that the Continental Shelf is growing seaward by deposition of the sediments worn from the land, the level of its surface being determined by the level at which the sediments can just rest without being disturbed by currents and wave motion. If this picture be correct, a particle of sediment brought down by a river is washed hither and thither on the sea floor until at last it comes to rest beyond the edge of the Shelf in water so deep and still that it can no longer be moved. It is probable that such a process would result in the deposition of sediments at an angle too steep for stability and that landslips would occur producing the jumbled topography typical of the edge of the Shelf. Great masses of rocks showing signs of contortion while plastic would also be produced; such rocks have been found in many parts of the world, and may well have been produced in this way.

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The problems to be studied are of great importance for geology. The mapping of a section of the mid-Atlantic Ridge, for example, together with determinations of the velocities of elastic waves in it, could not fail to yield results of great interest. We know already that it includes features which are on a scale comparable with the Himalayas, and such a survey would indicate whether these mountains were a folded range that had never been exposed to denudation, a sunken land mass, or a system of submarine volcanoes. The major rival geological theories, such as the permanence of ocean basins and Continental Drift, involve theories about the oceans. As they are derived almost entirely from data obtained on land, the study of the other two thirds of the earth's surface may be expected to be illuminating.