and these alterations should also give birth to the oxides of the manganese nodules, they being in a manner the complement to the formation of clay. These concretions are characteristic of the great oceanic depths, and especially of the red clay areas. Their peculiar form, their nuclei, their mineralogical and organic associations, distinguish them from the similar hydrated minerals of manganese and iron found in shallow water or on the continents, from which they differ also by the small quantity of barium they contain. It is with difficulty that traces of barium can be detected in these oceanic nodules, while it is well known that this is a frequent, sometimes abundant, constituent in terrestrial manganiferous minerals, and even in some nodules from terrigenous deposits.[1] The manganiferous minerals containing baryta must have been derived directly from the action of water on the ancient series of rocks, and this leads in another direction to the same conclusions as to the origin of the deep-sea nodules, for recent volcanic rocks contain little, if any, barium.[2]

In addition to the silicates, and in certain cases organic remains, some at least of the manganese nodules contain many relatively rare elements, such as nickel, cobalt, copper, zinc, lead, thallium, vanadium, as will be seen by reference to Dr Gibson's analysis. The source of these elements must be found in the volcanic rocks undergoing decomposition. They may exist originally either in the silicates or in the magnetic and titanic iron, and, after the alteration of these minerals, may be for the most part precipitated in the form of oxide in the presence of the alkaline sea-waters.

At first sight it may appear strange that these masses of manganese in the form of nodules should be derived from the decomposition of eruptive rocks and minerals, but care should be taken not to form an exaggerated idea of the quantity of manganese present in the deposit relatively to the other substances. In the nodules themselves the percentage of iron often exceeds that of manganese, and in the surrounding deposit the iron is in much greater abundance, indeed, there may be only a trace of manganese. Again, the quantity of clay, both in the nodules and in the deposit, is always very large, sometimes approaching to one-half of the whole.

It must not be forgotten that while the sea-water may dissolve a large number of other substances, and carry them away in solution, the higher oxides of these metals remain insoluble and accumulate in the deposits, for they do not enter in notable proportion into organic circulation; in consequence of their stability they do not undergo any alteration from the various solvents contained in the sea-water with which they are bathed.

Among the considerations which go to show that manganese nodules increase at a very slow rate, the following may be mentioned :—

[1] Commander A. Carpenter dredged off Colombo in the Indian Ocean, in 675 fathoms, small round nodules containing *Globigerina* shells, and 75 per cent. of sulphate of barium (see E. J. Jones, "On some Nodular Stones obtained by trawling off Colombo in 675 fathoms of water," *Journ. Asiatic Soc. of Bengal*, vol. lvi. pp. 209–212, 1887).

[2] But the reason of the absence or rarity of barium may not improbably be that the barium is converted by sea-water into sulphate, which would have no tendency to precipitate along with manganese.