

admixtures of lower oxides of manganese when laid down in landward waters,<sup>1</sup> where the supply of oxygen is competed for by much organic matter. The hydration  $\text{MnO}_2 \cdot \frac{1}{2}\text{H}_2\text{O}$  is assumed by Murray and Renard, and  $\text{Fe}_2\text{O}_3 \cdot 1\frac{1}{2}\text{H}_2\text{O}$  (limonite) for the accompanying ferric oxide. Deep-sea nodules are never purely manganic, but contain inclusions of clayey and other matters, and always a considerable proportion of iron. The mean of forty "Challenger" analyses works out at 29.0 per cent of  $\text{MnO}_2$  and 21.5 per cent of  $\text{Fe}_2\text{O}_3$ , soluble in hydrochloric acid. As a rule, then, surcharged waters hold both iron and manganese ready to be deposited simultaneously. The mode of formation of these nodules and the origin of the manganese from volcanic minerals have been thoroughly elucidated by Murray and Irvine.<sup>2</sup>

It should be noted that these oxides need by no means necessarily assume a concretionary form. They are very commonly found as thin incrustations on granular and fragmentary objects. Furthermore many, if not most, of the pelagic clays contain intimate admixtures of finely-divided brown manganese and occasionally of limonitic iron. Here the supersaturation would seem to have been so high as to transgress the metastable limit, whereupon the oxides have precipitated themselves without the intervention of nuclei; they certainly must have been precipitated from solution.

Manganese originates in the form of silicates and comes to rest exclusively in the form of peroxide. It is imported, on the one hand, from land as detritus or in solution; but in the terrigenous areas of the bottom, where reducing conditions prevail, as a rule, it tends to exist in the suboxidized, *i.e.* soluble, form. Hence much of the terrigenous manganese will be carried on to the deeper oxidizing waters before it can deposit. There is thus a constant accession of manganese from land to the pelagic deposits. In the second place, manganese comes into the floor of the ocean from certain basic volcanic minerals of vitreous habit, and these are to be regarded as the principal source of ferromanganic nodules. These basic glasses are the only primary minerals in the deep sea which contain important amounts of manganese. It so happens that they are common in the Pacific, less common in the Indian Ocean, and rare in the Atlantic. Consequently the greatest abundance of manganese peroxide, pulverulent and nodular, is met with in mid-Pacific.

Phosphatic concretions are of very localised occurrence and

<sup>1</sup> Buchanan, *Trans. Roy. Soc. Edin.*, vol. xxxvi. p. 459, 1892.

<sup>2</sup> *Trans. Roy. Soc. Edin.*, vol. xxxvii. p. 721, 1894.