

first interpretation, and we shall endeavour to show that this view accords best with all that is known with respect to the distribution and conditions under which these ferromanganic concretions are found at the bottom of the ocean.

It may be accepted as a fact that all the hydrated oxides of manganese found at the surface of the globe as coatings, concretions, or depositions, as well as the greater part of the hydrated oxide of iron, have their original source in the decomposition of the crystalline rocks containing these two metals in the form of silicates or anhydrous oxides. This decomposition takes place generally under the action of water, almost always containing carbonic acid. It is not necessary to insist upon the wide distribution of iron in volcanic rocks; manganese is rarer in these rocks, but is found as a constituent of pyroxenic, amphibolic, and peridotitic minerals, and also of some varieties of magnetic and titanitic iron, which are all so abundantly distributed on the bottom of the sea.

It is well known that, under the influence of water charged with carbonic acid, such silicates are decomposed at ordinary temperatures, and that the contained protoxides of iron and manganese are transformed into soluble bicarbonates, leaving a residue in which the hydrated silicate of alumina plays a large part. As soon as the loosely-combined carbonic acid is given off from the bicarbonates, the carbonates are precipitated and rapidly absorb oxygen, becoming hydrates corresponding to higher oxides of the metals, the remaining carbonic acid being of course set free. The metals are now in the form of compounds which are insoluble in water. Such is the order in which the formation of manganiferous and ferruginous minerals takes place on land surfaces, forming coatings, concretions, and dendrites on ancient and recent and other eruptive rocks and minerals.

In the case of the manganese deposits of the deep sea, there are many indications that an identical interpretation of the phenomena may be given. It may be granted that the manganese in solution in the superficial layers and in the whole mass of the ocean might contribute a small part to the deposits of great depths, still the great bulk of the oxides of manganese in these deposits has evidently had another origin. The greater part of the manganese and iron of these deposits almost certainly comes directly, along with clay, from the alteration of the manganese and iron-bearing silicates scattered over the bed of the ocean, and especially from those of volcanic origin. In describing the rocks and mineral particles, and in speaking of the formation of clay, we have shown that the alteration which these substances undergo in sea-water may be compared in all respects with the general processes just indicated. We have laid special stress on the occurrence in the deposits of volcanic materials, generally in a vitreous condition and of a spongy nature, or in microscopic fragments. On the other hand, we have shown that nearly all these rocks and minerals are decomposed or in process of alteration, and that they nearly all contain protoxides of iron and manganese combined with silicic acid, as for instance in augites, hornblendes, magnetite, and the easily alterable basic volcanic glasses. It is known besides that sea-water contains free or loosely-combined carbonic