

Origin of the Manganese and Manganese Nodules.—The source of the manganese, and the mode of formation of the ferro-manganic concretions in marine deposits, have been the subjects of numerous publications.

In 1877 Murray¹ referred to the association of manganese with abundance of basic volcanic debris at the bottom of the ocean, and attributed the origin of the manganese nodules to the oxidation of the carbonate of manganese arising from the decomposition of manganiferous rocks, and its subsequent deposition in concretionary form.

In 1878 Gümbel² analysed some nodules sent to him by Willemoes-Suhm, a distinguished naturalist of the Challenger Expedition, who died at sea. He recalls that Forchhammer had made known the presence of manganese in sea-water, and that Bischof had shown the presence of the same substance in the ashes of *Zostera maritima*. But he does not admit the concentration of manganese under the influence of organisms, because it is dissolved in sea-water in such small quantity, and because the manganese is found in great abundance over a large area of the sea-bed. He refers the formation of the nodules to the influence of submarine springs holding manganese in solution, which is precipitated on contact with the sea-water. Agglomerates of a rounded form are thus produced by repeated turnings and rollings in the clay and water.

In 1881 Buchanan suggested that the manganese nodules originated through the intervention of organic substances, which changed to sulphides the sulphates of the sea-water, thus causing the formation of sulphides of iron and manganese, these becoming subsequently oxidised. Recently in 1890 he repeated this view.³

In 1882 Boussingault⁴ discussed the formation of coatings of manganese in various regions, due to the presence of water charged with compounds of this element. He rejects the views of Buchanan and Gümbel as insufficient to explain the facts, and holds that the submarine concretions and manganiferous coatings are derived from the carbonates.

In 1883 Dieulafait⁵ rested an explanation on the fact that sea-water collected between New York and Marseilles, as well as in the Red Sea and Indian Ocean, deposited in the

¹ *Proc. Roy. Soc. Edin.*, vol. ix. pp. 255–258, 1877; also *Proc. Roy. Soc.*, vol. xxiv. p. 529, 1876.

² Gümbel, "Die am Grunde des Meeres vorkommenden Manganknollen," *Sitzb. d. k. bay. Akad. d. Wiss., Math.-phys. Cl.*, 1878, ii. pp. 189–209; also *Neues Jahrb. f. Min., &c.*, 1878, p. 869. See also: "Die mineralogische-geologische Beschaffenheit der auf der Forschungsreise S.M.S. 'Gazelle' gesammelten Meeresgrund-Ablagerungen," pp. 33–36, Berlin (no date).

³ *Brit. Ass. Report* for 1881, pp. 583–4; *Proc. Roy. Soc. Edin.*, vol. xviii. pp. 17–39. With reference to this view it may be stated that in our experiments at the Scottish Marine Station it was found that manganese dioxide, when exposed to the action of sulphuretted hydrogen or alkaline or earthy sulphides, becomes reduced to a lower oxide; this reaction takes place when the manganese nodules themselves are so exposed. For example, powdered manganese nodules were introduced into sea-water, along with decomposing mussel-flesh; in a few days the sulphates present in the sea-water had been reduced to sulphides, which firstly altered the manganese peroxide to protoxide, which, being soluble in the carbonic acid (the product of the oxidation of the organic matter), remained as soluble bicarbonate of manganese in the sea-water, while the iron sesquioxide present in the nodules was thrown down as insoluble sulphide. It does not therefore seem possible that the nodules can be formed in the way indicated by Buchanan (Murray and Irvine).

⁴ "Sur l'apparition du manganèse à la surface des roches," *Annales de Chimie et de Physique*, 5th ser. tom. xxvii. pp. 289–311, 1882.

⁵ "Le manganèse dans les eaux de mer actuelles et dans certains de leurs dépôts; conséquences relatives à la craie blanche de la période secondaire," *Comptes Rendus*, tom. xcvi. p. 718, 1883.