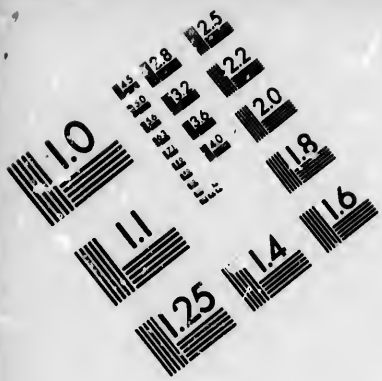

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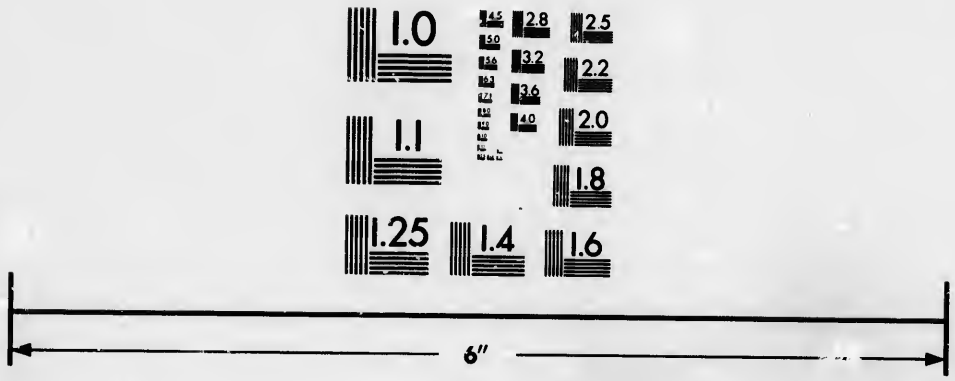

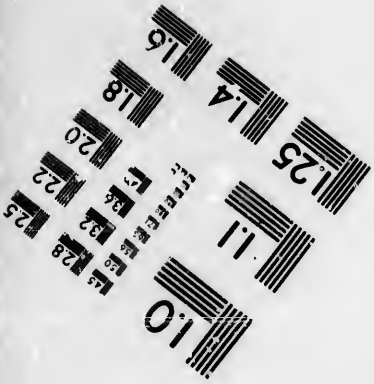

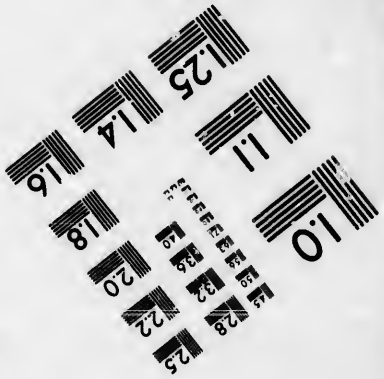

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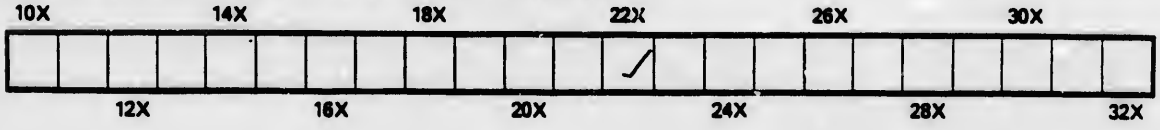

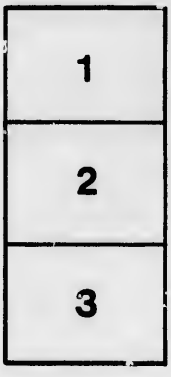

GENESIS OF THE MANGANESE DEPOSITS OF QUACO, NEW BRUNSWICK.

BY CHARLES LIVY WHITTLE.

One of the largest deposits of manganese found in New Brunswick is situated at the extreme point of Quaco Head, which forms the south side of the harbor of Quaco and extends inland as far as determined in a broad, curved band for a distance of over a mile. The association, position and occurrence of manganese ores excepting manganese-bearing veins with certain strata are

remarkably characteristic, at least as pertains to the deposits along our Atlantic coast region. Dawson in his Acadian Geology maps the rocks exposed on Quaco Head as carboniferous, although a small exposure of Trassic sandstone occurs on both north and south sides lying unconformably on the Carboniferous. We are only concerned with the lower horizon. In this, ascending geologically occurs first, a homogeneous melaphyre which though brecciated still remains as a non-schistose rock. Over this, and including in it near its base large angular to sub-angular areas of melaphyre lies a sub-crystalline limestone carrying scattered through it minute veins and round areas of psilomelane and pyrolusite. At its upper portion it is somewhat shaley and carries manganese nodules in great abundance. There are three principal varieties: the first and most common is a porous, cavernous nodule composed largely of wad with scattered areas of bright pyrolusite crystals and showing remains of a concentric structure; the second is a compact mass composed mainly of psilomelane, in structure concentrally arranged about either one or several nuclei. The third and least common variety is in the form of stalactites. Sections of these cut and polished show a central tube more or less irregular as in common stalactites of calcic carbonate with many ramifying cracks now filled with manganese oxide in a purer state than that making the outer portions of the stalactites. When polished the oxide filling these cracks stands salient showing its greater hardness. Over the ore-carrying strata are beds of a bright, somewhat incoherent brick-red slate revealing little evidence of bedding for several feet in vertical thickness. This originally may have been comparable with the deposits of clay that occur at a depth of about 2600 fathoms on the present sea floor. The second variety, or "kidney ore" is very uniform at this locality as regards the presence of phosphorus and iron,—these two elements existing in much less quantity than in the previous variety. Many of the nodules occur as mammillary masses simulating the bunches of grapes, potatoes, etc.

Traversing the strata generally in a north and south direction are several veins of pyrulusite mixed with manganite. It is from these that the purest oxide of manganese free from iron and phosphorus is obtained suitable for decoloring glass. The veins occupy narrow fissures and characteristically vary in width giving a maximum thickness of two inches and thinning down to

mere films. The veins in the limestone are minute threads of ore crossing it irregularly for a short distance and then disappearing, and are associated with numerous round to elliptical areas of the same.

Vermont ores of manganese occurring in Rutland and Winsor counties are similarly associated, although the country rock is Lower Cambrian and their geological position is at the base of the Stockbridge limestone as irregular lenses and small areas of porous earthy ore, carrying a large percentage of iron, in yellow or white clay. The limestone lying conformably on a flinty quartzite affords an excellent water way, and its alteration to clay has liberated the ore so that it can carry now be removed simply with pick and shovel. Here as at Quaco the rock at the base of the ore-carrying stratum is one of the least porous varieties. A section across the ore-bearing horizon in which the Crimora ores are found in Virginia presents the same association as found in Vermont. There again the manganese, occurring mainly as "kidney ore" is found in lenses and scattered masses in yellow clay, the product of a decomposed limestone such as makes the surface of the country in that region, which lies on a micaceous quartzite or quartz schist,—the layer of ore-bearing clay being next the quartzite. In the geology of the Virginias these rocks are classed as Silurio-Cambrian.[1] One stalactite weighing several pounds was given me by a miner at Crimora who assured me he had found it pendent from the roof of a small limestone cavern. In Vermont lenses and geodes of limonite occur with stalactites of psilomelane traversing the interior like bars. These bars in section show concentric bending.

As regards the source of manganese nodules one cannot fail to notice the similarity of the more porous, earthy variety of ore occurring at Quaco to the manganese nodules found by dredging in the deep sea during the voyages of the Challenger and Blake. The two nodules not only resemble each other physically but chemically the resemblance is still more marked. Phosphorus exists in much larger amounts in the deep sea nodules and their specific gravity is less owing to their porosity. Analyses of the ores uniformly show the presence of phosphorus and iron in varying amount. The following are partial analyses of the com-

[1] Rogers, Report reprinted in 1884.

pact "kidney ore" and the porous variety occurring at Quaco made by Dr. A. M. Comey of Harvard College.

Kidney Ore.	*Per cent.*	*Porous Ore.*	*Per cent.*
Manganese Dioxide	71.54	Manganese Dioxide	65.00
Metall[illegible]anganese	58.20	Metallic Manganese	57.15
Insolu... Silicates	8.37	Insoluble Silicates	6.66
Ferric Oxide	2.19	Ferric Oxide	1.75
Phosphorus	0.02	Phosphorus	0.04
Calcium	trace	Calcium	trace
Sulphur	0	Sulphur	0

Three unvarying phenomena are associated with the occurrence of manganese in the three localities above mentioned: firstly, the presence of phosphorus and iron in all varieties: secondly, the distribution of the ores in or with a limestone or red clay horizon; and thirdly, the presence of a practically impervious stratum at the base of the ore-carrying bodies. The first two factors point towards the source of the manganese; the last one indicates the conditions under which manganese deposits were formed and why they occupy their present position as true bedded deposits. In Sir C. Wyville Thomson's contribution to our knowledge of the character of the deep sea phenomena the association of manganese nodules with red clay deposits and the uniform presence of phosphorus and iron in these is mentioned.[1] Analyses made by Mr. Buchanan showed the manganese to be chemically combined as the peroxide and that by a process of substitution earthy peroxide appears to be changing to brilliant acicular crystals of pyrolusite, occurring scattered irregularly through the spongy earthy nodules.[2] This, too, without hydration. Chemically the manganese occurs in the same combination in the porous nodules in the deep sea as in the most porous ores found at Quaco, and it is noticed that the phosphorus is much more abundant than in the compact "kidney ore," being nearly double in quantity. The processes, begun before the induration of the deep-sea deposits and before their elevation from the sea bottom that tend to convert semi-crystalline into well-formed crystalline ore, are still going on in the red, calcareous shale and limestone, and the most porous nodules which simulate so closely both chemically and physically

[1] Voyage of the Challenger, vol. ii. pp. 7-8.
[2] Ibid, p. 8.

the deep sea nodules are but the remains of these. Structurally, evidence of one or several nuclei about which the oxide formed in rude concentric layers still remains as areas of red or white clayey material—the residum resulting from decomposition. In many cases the nodules were undoubtedly organic and careful search will probably reveal fossils; but the zone of manganese ore owing to its being a water way is a zone of decomposition and hydration. Where the strata underlying manganese-carrying rocks are sandstone or other pervous rocks concentration does not take place, the grade is poor, and the ore is apt to occur with large quantites of silica or silicates, as on the Pacific coast, and it is disseminated irregularly so that it is valueless as a marketable ore. The occurrence of melaphyre at the base of the limestone on Quaco Head is paralleled by most of the European deposits; but is not common in this country.

Genetically considered the history of our manganese deposits along the Atlantic coasts seems to me essentially as follows, ignoring the processes which build manganese, iron, and phosphorus into concretionary masses in the great depths of the ocean: Primarily, nearly all manganese occurring as beds must have been derived from the sea water, which is well known to carry an appreciable percentage of it as well as phosphorus and iron. Various dredging expeditions have noted the intimate association of manganese and phosphatic nodules with red, calcareous diatomaceous ooze of the deep sea principally along the 2600 fathoms sounding. —The similarity in appearance and chemical composition of these nodules with those of Quaco have already been pointed out. Going back in the history of this deposit we find it occupying a position comparable to the deeper portions of the ocean floor at present. Alternating strata of calcareous red ooze and limestone having manganese nodules lay on a massive base of malaphyre. These strata have been indurated and elevated, and the manganese which occurred in these as disseminated grains and nodules has by a process of concentration wholly or partially re-concreted into "kidney ore" and stalactitic masses, the impervious character of the stratum below permitting and causing this concentration to take place at or near the top of the impervious layer, as this would be a zone maximum interstitial water. Theoretically stalactites would be entirely reconcreted matter, the "kidney ore" wholly or partially, while the porous varieties would probably con-

tain in some cases remains of the original concretion. A large portion of the manganese of Vermont is of this latter variety. By this process of concentration the percentage of manganese is increased in the "kidney ore" as compared to the earthy varieties, and the percentage of phosphorus and iron is decreased, while in the veins proper the oxide of manganese exists in nearly its pure state but as the sesquioxide.

In a future paper several important deductions resulting from the recognitions of the character of the beds associated with the manganese ores will be brought out.

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