On the Organic Origin of the Sedimentary Ores of Iron and of their Metamorphosed Forms: The Phosphoric Magnetites.

Read before the Iron and Steel Institute by W. H. Herdsman, Glasgow.

There is, I am aware, nothing new in attributing the formation of the phosphoric ores of iron to organic agency. The subject, however, has not yet, in my opinion, received the attention which it merits.

I bring it before you, therefore, for consideration and discussion, as these ores are of increasing importance to the steel industry on account of the growing scarcity of non-phosphoric ores, while the sedimentary ores appear to exist in practically inexhaustible quantities, and must form the basis of our calculated supplies in the not very distant future.

The oolitic or pisolitic structure of so many of the sedimentary ores of iron, and the phosphoric character of all, have long led me to see in those features evidences of an organic origin, a view our advancing knowledge of the numerous micro-organisms at work in nature tends to support, bringing, as it does, to our notice many forms apparently adapted to play the part of builders-up of iron ore deposits.

Perhaps the strongest evidence bearing on the subject is afforded by the deposits of bog iron ore which are to be seen in many countries in process of formation, and have been shown to be due to the activity of organisms, generally identified as bacteria, in the ferruginous waters.

There is no doubt that several genera of bacteria have been definitely recognized as habitually precipitating iron from its solutions; they bear names in inverse ratio to their own length (with a list of which I need not trouble you), and are generally known as "the Iron Bacteria." The Russian bacteriologist, Winogradsky, has claimed that the deposition of iron by these bacteria is not a mechanical process, but is due to the physiological activity of the organisms, which liberates energy by oxidizing ferrous oxide in its protoplasm, ferric hydrate being formed, which accumulates in the sheath and gradually passes into the more insoluble ferric oxide. Dr. Hans Mollisch, of Vienna, however, contests this physiological action, and Dr. David Ellis, of the Technical College, Glasgow, the leading British authority on the iron bacteria, is, pending further investigation, in agreement with Dr. Mollisch.

Putting aside, however, the character of the action by which the precipitation is effected, it has been proved that many of the bog ores are almost entirely composed of the ferruginous walls of the thread bacteria B. Gallionella and Leptothrix.

Dr. Mollisch, in a recent work, shows photomicrographs of a Siberian bog ore consisting of the "rust-red" walls of Gallionella Ferruginea and Leptothrix Ochracea; he also shows a similar ore from Plass in Bohemia, which consists largely of the remains of the Chlamydothrix Ochracea. Dr. Mollisch was one of the first to point out that Leptothrix have also the power to store up manganese oxides in their walls, and so form ore masses of this metal. He also noted that the same bacteria can alternately precipitate iron or manganese according to the character of the solutions available.

D. D. Jackson, an American authority, has further described a new species of Crenothrix which he named C. Manganifera, the remains of which in one case he found to consist of 34 per cent. of manganese oxide and 14 per cent. of iron oxide, while in other cases the manganese oxide varied from 30 to 66 per cent., with varying smaller amounts of iron oxide.

We have Dr. Mollisch's authority for the statement that apart from the iron bacteria there are other organisms which have the power to convert soluble salts of iron and manganese into insoluble forms as oxides. He especially mentions certain confervoid algæ, to which class the diatoms also belong, and a marine organism, Cocconeis, which surrounds itself with a brown covering of manganese oxide.

A quite accidental confirmation of the statement that other organisms have the power to deal with iron oxides was afforded me recently, when a sample of iron ore, which, with a number of other mineral samples, was lying on a wooden shelf in a somewhat damp situation in my coach-house, was attacked by a fungus, which Dr. Ellis has been good enough to indentify for me as that of ordinary "dry rot." The whole mass of fungus growing between the shelf and the wall gradually assumed a reddish hue and threw off spores of oxide of iron which covered the shelf below with a red powder, giving, on assay, the same iron contents as the ore attacked.

It is notable that of about ten pieces of different minerals in the same parcel only the iron ore was attacked, and on the iron ore being removed, the fungus gradually resumed its normal colour, and the shower of mineral dust falling from it ceased.

This illustration of the fact that apparently many forms of organisms will act as precipitants of iron oxides may help us to understand the varied forms under which the sedimentary iron ores are found. The differences of the several beds of the Cleveland, Lincolnshire, and other ores may evidently be due to varying climatic and other conditions favouring first one and then another type of organism agent of ore deposition, during the period of their formation. The greater differences which are found between the sedimentary iron ores of the different geological periods may be similarly explained.

During the earlier geological times bacteria, and probably diatomaceæ, may be assumed to have been the principal agents at work, giving us the peroxide and generally siliceous ores of the Cambro-Silurian age; while, with the gradual development of organic life, we have the protozoa and calcareous elements brought into play, the former acting through their organisms, or, as calcareous nuclei, acting chemically, together with numerous molluscs similarly acting, would contribute to the ores of the later periods their more highly calcareous and variable phosphorus contents.

To some it may appear difficult to understand how organisms so minute as bacteria, of which some 500 millions are required to cover a square inch of surface, should be capable of forming ore deposits which often amount to thousands of millions of tons, yet when we learn of the rapidity with which they multiply by fission under conditions favourable to their growth and development, we see that, given those favourable conditions, the dimensions of the deposits can only be