phorus, 0.2 percent sulphur, and 3.26 percent manganese. The iron content ranges from 32 to 54 percent. Very little ore was used which contained less than 36 per cent iron, and a few mines have furnished much ore that ran as high as 50 percent iron. The ores are characterized by a high percentage of silica, ranging from 15 to 30 percent. The phosphorus is usually too high for Bessemer steel; in much of the ore it runs up to approximately 1 percent.

Perhaps the most distinctive feature of the mountain ores is the high content of manganese, which ranges from 2 to 4 percent in most of the mines but may run as high as 15 percent in places, and pieces of practically pure pyrolusite are occasionally found. For this reason the mountain ores were always in demand by the furnaces making basic iron.

Valley ores.—The valley ores differ somewhat in composition from the mountain ores. These differences are mainly in the greater amount of silica and manganese in the mountain ores and the greater amount of magnesia and phosphorus in the valley ores. Most of the ores, after washing to remove the bulk of the loose clay, averaged slightly more than 40 percent metallic iron and ranged approximately from 35 to 50 percent.

ORIGIN

Processes of formation.—Although the limonite iron ores of the Appalachian region have been discussed in hundreds of articles, there is still no entirely satisfactory explanation of their origin. Many investigators have shown a tendency to regard all of them as having a similar origin, which is an incorrect view. Even in a single mine, evidence can sometimes be obtained to prove that limonite has been formed by the oxidation of pyrite, by the oxidation and hydration of siderite, by the replacement of limestone or sandstone, by the segregation of particles of disseminated limonite, or by precipitation in open fissures or other cavities. Under such conditions it is obvious that a theory that attributes the origin of these ores to one process of formation is not sufficient even for certain single deposits and is entirely inadequate for universal application.

The limonite ores are commonly known as residuary iron ores and are supposed by many investigators to represent the insoluble oxidized particles of iron that were originally present in limestones or shales in the form of carbonates or sulphides and were left as a residuum when the mass of the country rock was removed by solution. Such an explanation, however, disregards the concentration of the ores in somewhat veinlike ore bodies. The particles of limonite have not merely been left as a relatively insoluble residuum on the removal of the enclosing rock, but instead, in the main, they have been transported in solution and precipitated in more or less concentrated form in the clays that are plainly of residuary origin. For these reasons the term "residuary limonite ores" is likely to be misleading and is only appropriate if the ores are considered to represent materials that were once distributed through a great thickness of rocks now removed by erosion. The ores themselves have also been dissolved, transported, and precipitated, perhaps several times.