been cemented by limonite that was precipitated in the cavities and forms a limonite breccia. In many specimens fragments of sandstone or jasper have themselves later been replaced by limonite. In ore of this kind small particles of secondary vein quartz are more common than in the other kinds of ore, although quartz is not common in any of the limonite ores. The secondary quartz shows that part of the siliceous material removed by the solution of the original rock was precipitated in the cavities of the iron ore.

In the valley-ore mines, tubes of limonite that inclose more or less sand are common. This variety is known as pipe ore and was the principal ore mined in many places. The largest tubes are a foot in diameter, although most of them range from one to two inches. Pieces more than eight inches long are rare but as the pipes are invariably broken at each end they may originally have been several feet long.

Fragments of limonite in the form of irregular particles or plates are invariably present in large quantities. They represent broken pieces of all the kinds of ore that have been described. As the rock disintegrates and clay and iron ore are formed, there is a tendency for the entire mass to move down the slopes, which results in the breaking of the more fragile pieces of ore. The loss in bulk that takes place as the rock undergoes changes in composition also permits the downward settling of the material and the breaking of many of the masses of ore. The larger pieces of the fragmental ore are recovered in the washers, but the finer ones are lost. Ore of this kind is known as "wash ore."

COMPOSITION

Minerals associated with the ores.—The composition of the limonite ores is extremely variable and depends largely on the physical character of the material. The presence of certain minerals closely associated with the limonite also determines the composition. The impurities in the ore comprise only a small number of minerals, principally quartz, jasper, clay (kaolin), pyrite, pyrolusite, and wavellite.

Siliceous matter of different kinds can be detected in almost all the mountain ores. In some places it represents the fine grains of sand of the original sandstones or sandy limestones, in others secondary chert or jasper, and in still others vein quartz. Clay fills many of the cavities in the ore, and much of it is not removed in passing through the log washers. Very small particles of pyrite can be seen with the naked eye in some specimens, particularly in the ore from the lower levels of certain mines.

Pyrolusite is intimately associated with the limonite and is generally detected by the dark color of the ore. Occasionally dendritic crystals