LI1ONITE ORE ORIGIN

secondary, and not to attempt to say which class is the more important.

Secondary concentration of the iron ores.—The present workable iron deposits are the products of alteration of the original segregations of pyrite by descending waters carrying oxygen and carbon dioxide in solution. Some of the sulphide was changed directly to limonite, forming a spongy ore characteristic of gossan deposits; other portions were altered to limonite that was taken into solution and metasomatically replaced part of the associated quartzite or was precipitated in open spaces as stalactites of limonite; and still other portions were converted into siderite and precipitated as bombshell ore or compact rounded concretions. Numerous specimens illustrating each of these processes have been found in the vicinity of the abandoned iron mines.

The following chemical reactions illustrate some of the probable changes which took place.

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\begin{align*}
\text{FeS}_2 + 7O + H_2O &= \text{FeSO}_4 + H_2SO_4 \\
6\text{FeSO}_4 + 3O + 3H_2O &= \text{Fe}_2(\text{SO}_4)_3 + 2\text{Fe(OH)}_3 \\
2H_2O + \text{FeSO}_4 + \text{CaCO}_3 &= \text{FeCO}_3 + \text{CaSO}_4 + H_2O \\
\text{FeCO}_3 + H_2O + CO_2 &= \text{Fe(HCO}_3)_2 \\
\text{Fe(HCO}_3)_2 + \text{CaCO}_3 &= \text{FeCO}_3 + \text{Ca(HCO}_3)_2 \\
2\text{Fe(HCO}_3)_2 + O + H_2O &= \text{Fe(OH)}_3 + 2\text{CO}_2
\end{align*}
\]

In most places the descending waters probably deposited the iron minerals in more concentrated bodies than had been done in the primary mineralization, yet this may not have been true everywhere. In some places where large deposits of pyrite existed, the mineral waters that resulted from the oxidization and solution of the pyrite probably were dispersed and lost.

As siderite is not stable in the presence of highly oxygenated surface waters, it has practically all been changed to limonite near the surface but still persists a short distance below the ground-water level. In many of the mines, siderite nodules partly altered to limonite can be found.

Pyrolusite occurring with the limonite has had a similar origin. It probably existed in the pyrite and on oxidation was changed to its present form. Part of the manganese has been segregated to form masses of practically pure manganese oxide, but the bulk of it is intimately mixed with the limonite.

In places large rounded masses or small botryoidal segregations of secondary chalcedony are abundant. These masses occur in the clay and may have been formed by ascending waters at the time the pyrite was concentrated or more recently by descending waters. Lack of information regarding their distribution in depth prevents any positive conclusion.

In some of the mines in the limestones there is every indication that the limonite deposits are the result of precipitation from descending waters alone, no pyrite ever having been present in the immediate locality, as the limestone floor gives no indication of the presence of deep fissures through which ascending waters might have brought pyrite. In such places the deposition of the limonite has been pro-