ered in a nearly pure state; and that a single refining operation yields ingot-copper of the very highest grade and value. To the public at large, therefore, should be afforded the opportunity of realizing that the metallurgical operations at Lake Superior do not furnish a standard that can properly be compared with any other mining district in the world.

Mr. Muir is grappling in Australia with almost exactly the same problem as that which confronts many of us in the United States. For, although we have the unusually rich and extensive copper areas of Montana, Arizona and Utah, we have also far greater areas of low-grade, disseminated and highly silicious sulphide ores, situated far from a market and from fuel, and too often scantily supplied with water.

In order to narrow the field of enquiry, it may be well to enumerate all the methods that seem to have any claims at all to consideration, in connection with the treatment of the ores in question. We may then eliminate all those processes that, on examination, appear economically inapplicable, and consider the few that then remain. (1) Direct smelting; (2) mechanical concentration, followed by the smelting of the concentrates and the lixiviation of the tailings; (3) lixiviation of the ore direct, with a solution of ferrous chloride and salt; (4) lixiviation of the ore direct, with hydrochloric and sulphuric acids, which are regenerated in the solution by the precipitation of the copper from a chloride solution by means of sulphurous acid; (5) lixiviation of the ore direct, with sulphuric acid; and (6) the Rio Tinto method of gradual lixiviation in heaps.

1. *Direct Smelting.*—Wherever it is in any way practicable, the American metallurgist prefers smelting to any form of wet process. The perfect continuity of the operation, the ease and simplicity with which the unpulverized ore pursues its steady course from the mine to the blast furnace, from the blast furnace to the converter, and from the converter to the refinery, lend themselves to operations on a very large scale, and permit the substitution of mechanical appliances for hand labour to an extent unapproachable in any other method. Another great advantage of smelting (absent in the present case) is the almost complete recovery of the precious metals present, with but little extra cost.

Nor need we be deterred from the employment of direct smelting, by even a very considerable excess of silica, and a corresponding deficiency of iron in the ore. Perhaps this was most clearly pointed out by Mr. F. R. Carpenter in the Deadwood and Delaware smelter, South Dakota, U.S.A. He demonstrated conclusively that highly silicious ores, containing a little pyrites, and with extremely expensive coke could be smelted direct in the blast furnace, with the production of slags containing 50 per cent. of silica, 30 per cent. of lime and magnesia, and only 16 per cent. of ferrous oxide. The lime and magnesia were added to the ore in the form of barren dolomite; 20 to 30 tons of ore produced one ton of matte; the slags were exceedingly clean; and the precious metals and copper (very little) that were contained in the ore, were almost entirely recovered in the matte.

The most interesting features of this unusual type of smelting are the fusibility of the very acid silicate of lime and magnesia with but little iron, and the high rate of matte concentration. The latter result is due to the very acid slag which decomposes the pyrites present, carrying their iron contents into the slag as ferrous oxide. It is not always understood by blast furnace smelters that, other things being equal, an acid slag means a high-grade matte, while a basic slag is accompanied with a low-grade matte.

The writer has only gone into this detail in regard to the direct smelting of very silicious ores in the blast furnace in a raw state, in order to call the attention of metallurgists to possibilities that may solve certain difficult metallurgical problems.

In the case cited by Mr. Muir, however, it may be feared that the absence of silver or gold in the ores, and the non-existence of limestone ores for fluxing purposes, with the high cost of fuel, would compel us, most reluctantly, to give up the idea of direct smelting.

2. *Mechanical Concentration, followed by the Smelting of the Concentrates and the Lixiviation of the Tailings.*—The writer has met with, or been cognizant of, so many difficulties and failures in attempting to concentrate low-grade, disseminated sulphide ores of copper, that he has always advised exhaustive mill tests on a large scale before venturing to employ this method. It is only suitable for very exceptional ores and conditions.

Mr. Muir's results seem to be stronger arguments against the employment of this process than any that the writer could adduce. Without attempting to analyse his experiments in detail, the writer would simply point out that the results of Mr. Muir's concentrating tests show a saving in the concentrates amounting to about 20 per cent. of the original copper contained in the ore, and a loss of nearly 80 per cent. in the tailings. This, of course, means no concentration whatever, and there must be some reason, not apparent to the writer, why Mr. Muir attempted to concentrate at all.

If a portion of the copper in the ore were present in the shape of some mineral that would exercise an injurious effect upon the subsequent lixiviation, and if this mineral had a higher specific gravity than the remainder of the sulphides present, there might be some question of attempting to remove it by concentration. But, as the 20 per cent. of the copper that was removed by concentration had, as the writer understands, exactly the same chemical composition as the 80 per cent. left in the tailings, he fails to see the use of employing concentration; nor does he believe that these ores should be subjected to concentration. (It will be understood that the writer is referring solely to the ordinary methods of wet concentration in making this statement, and that he is not expressing any opinion as to the results that might