A Dry Process for the Treatment of Complex Sulphide Ores.*

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The class of ores to which our process is applicable is that in which zinc blende and galena predominate. substantial silver values being also generally present; these, commonly known as "complex sulphide ores," are typified by the Broken Hill deposits. The latter indeed are of unusually refractory character, the metallurgical difficulties attending the separation of the lead and zinc being increased by the intimate intercrystallisation of the minerals as well as by the presence of ferrous sulphides, garnet, rhodonite, etc., in considerable quantity.

It is unnecessary to review at length the many attempts to treat these ores, the more important later efforts being well known to members of this Institution; and much valuable information as to the types and values of the Broken Hill deposits is to be found in Mr. Ashcroft's paper.†

Before entering into the details of our process it is advisable to briefly indicate the methods at present employed for recovering the major values from such ores. They are all comprised under the head of concentration, the usual various types of apparatus, both wet and magnetic, being employed. Concentration, indeed, has here been carried to a state of high perfection, but however ingeniously applied, it cannot, owing to intercrystallisation and the slight differences in gravity between several of the minerals, obtain sharply demarcated products; hence it can never be more than partially successful. Even supposing the bulk of the galena to be capable of close separation, a large proportion of the silver would still follow the blende, and thus be lost in the subsequent treatment of this mineral for the commercial production of spelter.

Present systems consist therefore in the mechanical separation of the largest yield of galena which shall carry only such blende as is incapable of giving rise to serious smelting trouble. These lead (silver) concentrates are smelted in the usual manner, and constitute the only product of commercial value derivable from the ore. The other bye-products are zinc middlings, siliceous tails, and slimes; each is more or less contaminated with all the various minerals of the original ore. Thus, whilst the galena concentrates carries several per cent. of zinc, the zinc middlings similiarly hold large amounts of lead and silver, but are nevertheless of little or no present value; samples which have come before us have averaged 25 to 27 p.c. of zinc, about 12 p.c. of lead, and 10 to 12 oz. of silver. The slimes are more or less representative of the whole ore-bulk, and may even be somewhat enriched in zinc and silver; large parcels dealt with by us have been as high as zinc, 25 p.c., lead, 24 p.c., silver, 26 oz.; but the general run is lower, say, zinc, 20 to 22 p.c., lead, 17 to 19 p.c., and silver 15 to 18 oz. per ton. Slimes are also at present practically valueless. Chairmen of the various mines are apt to describe these middlings and slimes as a reproach to the metallurgist, and to picture to their shareholders visions of the potential wealth which these huge accumulations represent, realisable when once the process for their successful reduction shall be discovered.

At the various Broken Hill mines reduction work is now limited to concentration, the leady concentrates being shipped to coastal smelting works, where they are reduced to bullion with other purchased ores. Nett recoveries do not probably exceed 60 to 75 p.c. of the lead, and 55 to 65 p.c. of the silver; with the exception of small parcels shipped to Europe periodically, no zinc is recovered, though on this point it is difficult to obtain figures.

The economics of the problem have not greatly altered from those outlined by Mr. Ashcroft in 1898, when he showed that, with the then metal prices, a profit of 15s. was all that was realisable from an ore value of some £9 per ton. Since that date it is true that considerable fluctuations in prices have occurred; zinc rose to £28, but though this was a useless boon to Broken Hill, lead appreciated to £16, and for a while permitted of good dividends. This period was shortly succeeded by a still more serious fall, lead receding to a lower level in 1901 than had been known for many years, whilst silver has recently touched its lowest recorded price. Indeed in 1901 all the Broken Hill mines with the exception of the Proprietary and Central Companies were for a while shut down. Although both lead and zinc have exhibited a slow rise of late months, the general outlook cannot be considered much brighter than Mr. Ashcroft had to face in 1898. Nor do the ore supplies show any tendency to increase in value. An average of 17 p.c. lead, 24 p.c. zinc, and 13 oz. of silver per ton may now be regarded as a general type of available material.

The greatest advances of late have been in the direction of magnetic separation; various types of magnetic concentrators are now under trial and in use at the different mines, by which a closer saving is possible, and the further concentration of the middlings into what may be considered as a very inferior type of zinc blende ore can be effected. The inferiority of these zinc concentrates lies in the continued presence of considerable percentages of lead, and frequently of as much as one-third the silver originally held by the ore.

By one type of magnetic concentrator known to us the galena and quartz are obtained together, a more or less impure blende as the second product, and the bulk of the rhodonite in a third; the lead product then undergoes wet dressing to separate the silica. Starting with 100 tons of ore, about 40 tons of blende product are obtainable, assaying 40 to 45 p.c. of zinc (about 70 to 75 p.c. of the total in the ore), about 7 p.c. of lead, and from 10 to 12 oz. of silver. This product is bought in limited quantities by European smelters, but we are unable to say whether they pay for the silver or exact a fine for the lead. In this country nothing would be paid for the silver, and it is doubtful if the English zinc smelter would under any circumstances treat an ore containing 7 p.c. of lead. It is probable that on the Continent this product is mixed with pure blende ore in order to reduce the lead to a possible smelting charge. 16 to 20 tons of galena concentrates are produced after water dressing, the first product containing about 75 p.c. of the original lead and 45 to 50 p.c. of the silver. The lead product is of course subject to the usual smelting losses, which may vary from 7 to 10 p.c.

A second system, investigated rather with the idea of obtaining the richest mixed galena-blende product for our own use than with the object of effecting the sharpest possible separation of each mineral, was able to produce from zinc middlings (assaying 30 p.c. zinc, 8½ p.c. lead, and 12 oz. silver) a mixed concentrate amounting to 65 p.c. of the original ore weight, and carrying 39 p.c. of zinc, 11½ p.c. of lead, and 14½ oz. of silver; equal to total recoveries of 85½, 87, and 81 p.c. respectively. This was obtained by the mixing of a more with a less leady concentrate.

The foregoing is a brief sketch of the recoveries now obtainable in Australia, and given to indicate the possible scope of inventions for remedying the unsatisfactory results realised even by the best systems of concentration.

In the cases of the many huge deposits of complex ore known to exist in other localities, but hitherto unworked, present Australian methods would not necessarily be followed as preliminary steps in our own or perhaps other processes. The Broken Hill products and accumulations are the outcome of evolutionary concentration methods; but in many instances complex ores are capable of direct reduction without the need of mechanical separation, or at most but that of barren silicious gangue if desirable.

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†Transactions, Vol. VI, p. 282.