

| | Chemical Formulæ. | Metallie Copper p.c. |
|--------------------------|--|----------------------|
| 1. Oxides..... | | |
| Cuprite..... | Cu ₂ O | 88.7 |
| Melaconite..... | Cu O | 79.8 |
| 2. Hyd Carbonates..... | | |
| Malachite..... | Cu ² CO ₃ x H ₂ O or Cu CO ₃ x Cu O x H ₂ O | 57.33 |
| Azurite..... | Cu ₃ C ² O ₇ x H ₂ O | 55.16 |
| 3. Hyd Orichlorides..... | | |
| Atacamite..... | Cu Cl ₂ x 3 Cu ₂ H ₂ O | 59.48 |
| 4. Hyd Silicates..... | | |
| Chrysocolia..... | Cu Si O ₃ x 2 H ₂ O | Variable |
| 5 Sulph des..... | | |
| Chalcocite..... | Cu ² S | 79.79 |
| Chalcopyrite..... | Cu fe S ₂ | 34.6 |
| Bornite..... | Cu ₃ fe S ₇ | Variable |
| Tetrahedrite..... | Cu ₃ sb ₂ S ₇ | Variable |

The last mentioned mineral is very variable in its composition as it sometimes contains as much as 30% silver replacing copper and a variety from Spain contains as much as 10% platinum and frequently mercury.

Extraction.—There are two classes of processes for the extraction of copper from its ores, viz., the dry and wet classes.

The dry class of processes includes those consisting of a series of calcinations and fusions varying in number with the composition of the ore treated and is divided into two methods.

The *Welsh Method* in which the ore is generally treated in reverberatory furnaces, and the *Continental Method* where shaft furnaces are principally used.

The *Welsh Method* as conducted at Swansea consists of a series of calcinations and fusions (generally six in number) and is based upon the fact that copper has a stronger affinity for sulphur than iron, and iron a stronger affinity for oxygen than copper. The process is applicable where different ores can be procured to mix with the copper pyrites which is the chief ore smelted at Swansea. The mixture of ores must not contain less than 8% nor more than 14% copper for if it contain less than 8% the quantity of fuel is large in proportion to the copper produced and if greater than 14% copper is liable to pass into the slag.

The following are the processes as conducted at Swansea.

1st. *Calcination* of ores to drive off water, carbonic acid and sulphur and to oxidize iron.

2nd. *Fusion* of calcined ores with slag from No. 4, products coarse metal containing from 30% to 33% copper and ore furnace slag.

3rd. *Calcination* of coarse metal, after granulation or crushing, to drive off more sulphur and oxidize more iron, product calcined coarse metal.

4th. *Fusion* of calcined coarse metal with oxidized ores (Cuprite) and slags from Nos. 5 and 6, resulting products fine or white metal and metal slag containing about 2% copper.

5th. *Calcination* of fine metal followed by fusion, products blister copper containing 95% copper and roaster slag which goes back to No. 4.

6th. *Refining* and toughening, products copper and refinery slag which goes back to No. 4.

I. *Calcination.*—The reverberatory furnaces for this process, are built with a low roof and bed or hearth measuring from 16'-20' x 12'-14' being intended to take a charge of 3-7 tons of ore in the accompanying drawing (Figs 1 & 2) a calciner is represented having the parts exposed to heat built of fire brick and clay. Referring to drawing bb are openings to admit the charge and are closed with tile during the working of

the furnace, C C hoppers for reception of ore, DD projections to prevent the ore collecting between the doors E E, F fire grate, G the fire bridge built with a flange to prevent the portion of ore near it from becoming overheated, H H are the flues which conduct away the vapors and products of combustion, K K holes in the hearth through which the ore may be raked into the chamber M after the calcination is complete, M is connected with the flues through which any gaseous matters evolved during cooling may escape.

The fuel used at Swansea is a mixture of anthracite with 25 % cake coal, and the calcination takes from 12 to 20 hours. During that time the ore is frequently stirred to prevent fusion and to expose new surfaces to the action of the atmosphere. At the high temperature to which the furnace is raised the arsenic volatilizes as arsenious anhydride (As₂ O₃) and about half the sulphur as sulphurous anhydride (So₂) both passing out by the chimney. Much of the iron meantime becoming oxidized while copper is left as a sulphide with a small quantity of oxide.

II. *Fusion of Calcined Ore.*—The object of this process is to slag off the oxide of iron formed during calcination, and here the silicious ores may be advantageously added to the charge, provided they do not contain sulphur. It will be remembered that during the last process a quantity of oxide of copper was formed which would at a high temperature pass into the slag, thereby, entailing loss, if it were not that sulphide of iron remained from the calcination and at the high temperature necessary to fuse the slag the iron is oxidized passing into the slag and sulphide of copper is formed.

The furnace (Figs. 3 and 4) in which the above reaction takes place is, as in process No. 1 reverberatory with an oval-shaped hearth $\frac{2}{3}$ size of the last sloping from all directions towards a depression at the top hole h and surrounded by low walls supporting a low, arched roof provided with a hole for introducing the charge from the hopper C. The hearth is separated from the fire grate, at one end by a bridge while at the other end it communicates by the flue D with the chimney M, at F there is an opening protected by iron plates and fire-clay through which the interior of the furnace is inspected and the slags drawn off. The matt or coarse metal is run off through the tap hole h into water for granulation, or into moulds and the pigs of metal afterwards crushed for subsequent treatment.

The charge is :

| | |
|-------------------------------------|---------------|
| Calcined Ore..... | 17 to 18 Cwt. |
| Oxides, Carbonate and Silicates.... | 3 Cwt. |
| Slag from No. 4..... | 5 " |

The coarse metal as before mentioned usually contains from 30 to 33% copper and forms about 55% of the charge.

III. *CALCINATION.*—This calcination has the same object in view as No. 1, that is, oxidation of iron and conversion of about half the sulphur into sulphurous anhydride which is driven off, leaving copper sulphide and oxide of iron with some unchanged sulphide of iron, a calciner is used and the roasting continues from 24 to 30 hours with frequent stirring during that time.

IV. *FUSION.* The principles involved here are the same as in No. 2, viz., a double decomposition of sulphide of iron and oxides of copper, here introduced