Mining, Metallurgy, Mineralogy

ASSAYING

THE ASSAYING OF GOLD AND SILVER ORES.

A ton of rocks containing one thirty thousandth its weight of gold, or one fifteen hundredth its weight of silver, can in many instances be worked profitably; this is something like one fiftieth of a grain of gold or four grains of silver per pound of rock or ore. A quantity so small, even if in the metallic or free state when diffused through the rock is difficult to detect with any degree of certainty by any physical examination or blowpipe test. Chemical analysis by the wet way is in this connection too slow and expensive, and without the greatest care and most expert manipulation the quantitive results in the case of poor ores are apt to be uncertain. The fire assay is by far the most expeditious, certain and inexpensive method of testing such ores, as well as of quantitatively determining their value.

The apparatus and materials requisite in assaying are as follows:

A balance for weighing ores and fluxes, sensitive to a grain, with a weight of three ounces on each pan, with box of weights.

A finer balance, sensitive to one tenth milligramme, with a weight of one gramme on each pan, with box of weights.

A small crucible or melting furnace, with hood to carry off the fumes produced in roasting ore.

A cupel or muffle furnace.

Crucible, scorifier, and cupel tongs, muffle cleaner, poker, and shovel, and stone hammar.

Brass moulds for making cupels.

Large iron mortar and pestle for breaking and grinding ores. Fine work with very hard ores also requires an agate mortar and pestle.

Brass wire gauze sieves—80, 100, and 120 mesh. Small spatulas, camels hair brush, and glazed paper.

Iron pans for roasting.

Tin samplers.

Moulds for pouring scorified charges.

Crucibles, scorifiers, annealing cups, parting flasks, and test tubes.

Silver foil, lead foil, granulated lead, litharge, floured charcoal, argol, niter, borax glass, boracic acid, bicarbonate of soda, salt, carbonate of ammonia, fine bone ash, and white silicious sand (silica), nitric acid (pure).

The first requisite in any assay is that the whole of the ore or rock to be tested be reduced to a uniformly fine powder or flour and separated from metallic scales or particles, if there be any. This is usually accomplished by breaking with the hammar, and then completing the reduction in the mortar or beneath a muller. The sample in process of reduction is from time to time thrown on the sieve to separate the finer portions and avoid the inconvenience and loss by dust. If any of the metallic particles or scales remain on the sieve these must be weighed and assayed separately, the results first proportioned to the weight of sample of ore taken being added to the results from the powdered ore assay.

The powdered ore should be well mixed together and weighed, then sampled. A handy sampler is made of three or four semicylindrical tin troughs cast six or eight inches long, about three-fourths of an inch in width, and one inch deep, placed parallel at a distance equal to their width, and soldered at the ends to a tin or wire frame or support. When powdered ore is sifted over this half falls through the openings, the other half being retained in the troughs, and the portion caught may in like manner be further divided, so that a large sample is reduced to one of suitable size for assay, the small sample correctly representing the large.*

The method of assaying depends much upon the character of the ore and gangue. If the ore contains any considerable quantity of sulphides, arsenic, or antimony it should be roasted. This is usually performed by spreading the weighed sample of ore on an iron pan, previously coated with oxide of iron or chalk, and gradually heated under a hood to low redness until all fumes cease. Carbonate of ammonia and powdered glass or sand is sometimes added to hasten or complete the action and prevent fusing or agglutination.

The scorification method is preferable in most cases where it can be applied, but owing to the limited quantity of ore that can be conveniently operated upon in this way its use is restricted to comparatively rich ores. Poor or presumably poor ores are best treated in the crucible which permits the working large samples.

With regard to fluxes, litharge (the yellow oxide of lead), carbonate of soda, and borax are the most important. Charcoal and argol as reducing agents, and niter as an oxidizing agent, are used in connection with them. Salt is used as a cover or wash in the crucible. Lead or its oxide, which is a powerful flux, plays a very important part in the gold and silver cupellation assay. In the crucible assay the oxide (litharge) is always used. The ore or the reducing agents mixed with the fluxes react upon it in such a manner that a portion of it is reduced to metallic lead, which, as the contents of the crucible becomes liquefied by heat falls by reason of its greater gravity to the bottom of the vessel, washing down and alloying with the liberated particles of precious metal, so that when the crucible has been cooled and broken a button of lead is found at the bottom, and this button, if the assay has been properly conducted, contains all the precious metals.

In the scorification the metallic lead exposed to a current of highly heated air is partially converted into litharge, which, acting as a flux, liquefies the ore, the liberated gold or silver alloying themselves with the unchanged portion of lead at the bottom of the scorifier.

In the crucible assay the following proportions of flux will be found to work well with most quartzose ores:

Ores	1 A. T.
Litharge	2 "
Bicarbonate of soda	1 "
Argol	2½ grammes

Too much argol will produce too large a button of lead, and too small a quantity the reverse, or none at all. The ore itself acts as an oxidizing or reducing agent in many cases. The use of oxidizers, such as niter, in the crucible are objectionable, and careful attention to the preparatory treatment or roasting will, in most cases, dispense with the necessity of their use. Experience alone enables the assayer to judge of the oxidizing or reducing powers of the ores and the proper proportion of reducing material. Charcoal or flour or mixtures of these may be employed instead of the argol. These reducing agents should be in the finest state of division, and free from lumps and thoroughly dry. This applies equally to all the fluxes. Ores containing much limestone require a considerable addition of borax silica or borax acid (anhydrous); a similar addition to the charge is necessary if the ore be argillaceous—that is, slaty or earthy.

The ore and fluxes having been weighed out they are thoroughly mixed together and put into a dry and warm sand crucible, and covered with about one-quarter inch of dry salt loosely packed down. The crucible is then put into the melting furnace and covered with a good fire. Twenty minutes to half an hour is usually sufficient to accomplish the thorough decomposition and fusion of the ore, and the crucible is removed as soon as its contents are found to be in a state of complete fusion. It is allowed to cool thoroughly, then broken, and the button of lead at the bottom removed and cleaned by hammering it on an anvil. The appearance of the slag will indicate whether or not the decomposition and fusion were properly completed. The button of lead is put aside for cupellation (or scorification if necessary).

For the scorification assay the following charge will in most cases suffice:

Ore	3-10 A. T.
Granulated lead	3 "
Borax	q. s.

Two or three pieces the size of peas are usually sufficient. The ore is mixed with part of the lead in the bottom of the scorifier, the rest of the lead being poured over the top and the fragments of borax placed on top. The scorifier must be large enough to admit the charge without filling it. When placed in the muffle, properly heated, the lead and borax melt, the surface of the former by contact with the air becoming converted into liquid litharge, which with the aid of the borax fluxes the ore, forming a ring of liquid slag, which finally covers the whole surface of the lead. As soon as this takes place the vessel is removed from the muffle and its contents dexterously poured into the iron mould, where it quickly chills, and the lead button is removed and cleaned by hammering. If the buttons are too large to be admitted to the cupel (which should weigh at least as much as the button) they must be scorified down; that is, placed in a scorifying dish and exposed in the open muffle. The hot air oxidizes and slags off the lead, and on pouring and cooling this may be separated from the reduced button by pounding as before; in many cases it separates itself.

*All assays should be made in duplicate to check any error.