By Ralph Keeler

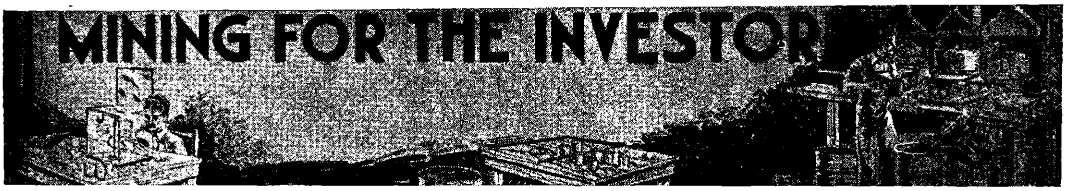
ASSAYING

One of the larger American manufacturers of mining and milling equipment calls the assayers the "Key Men" in the mining industry—and certainly no term could be better applied. To a great extent the whole success of a mining enterprise, from the discovery of the prospect through the various steps of development, construction, and operation, depends upon the skill, accuracy, and honesty of the assayer. The reason for this is obvious. Gold, silver, and other metals occur in nature in various quantities and with various associations; no two minerals are exactly alike in composition. There is only one way of learning exactly how much of each metal is contained, and that is by measuring carefully prepared samples.

The prospector takes the pieces of rock he finds in his travels to the assay office; if the results show the precious metal in sufficient quantity, he can show them to a financier and may obtain backing for the venture. As a mine is opened underground, methodical sampling and assaying enables the geologist and the miner to plan the work from day to day. After the assayer has determined the average composition of the ore, the metallurgist can start his test work preparatory to planning a flow sheet for a treatment plant. When the nature of the ore changes—which is common in gold mines as depth is attained—the assayer keeps the mill men informed and changes in the treatment plan can be devised. Ore reserves are estimated by the engineers after hundreds of assays are made of every section of the mine.

Before going into the details of assaying—and a little general information about this most important subject will help every investor in mining enterprises to read reports intelligently—it might be well to make one general statement:

If the assayer can't find it, it just isn't there commercially. A common way of misleading the public, particularly when assays show "Trace" or "Nil" is to issue a statement to the effect that "You see, the gold in this rock is so finely divided that the assayer couldn't detect it—but our extra-special Never-Miss Metallurgical Method, on which we have worked for years, will find at least $20 a ton." Such statements are, without exception, entirely unwarranted and, in many cases, a deliberate attempt to deceive the public. There was a good example of this type of fraud during the mining stock promotion boom in the Philippines in 1935 and 1936. Considerable ballyhoo had attended what was reported as the discovery of a virgin gold area in the vicinity of the Mayon volcano south of Manila. For several months glowing reports came in from the property—all



by the same engineer. Ore reserve estimates ran into the millions: milling plants of enormous capacity were discussed. Finally one of the seven companies formed went ahead and bought a small pilot plant. Unfortunately for the promoters and for the engineer who handled the whole deal, the man engaged to construct the mill went over the property and sampled it before starting construction. When his samples on assaying showed that there wasn't enough gold in the ore to warrant the erection of a one-ton milling plant, to say nothing of one large, the bubble burst. Immediately the engineer, and some of his Manila cohorts, spread the word to the gullible stock shareholders that the gold was there, but in such small particles that the assayer couldn t find it. For several weeks this ruse was kept up, until finally, after confirming reports had been received from Europe and from the United States, the disillusioned investors found that the gold in the Bicol area was indeed finely divided—so finely divided that it will just have to remain in the earth (what there is of it!) until very much better metallurgical plans can be made for extracting it. As a matter of fact, a similar proposition was brought to the attention of the public recently in Manila. A company which operated for some time has announced, over the signature of reliable engineers, that its ore reserves, amounting to a considerable tonnage, average around ₱5.00 per ton—which means, of course, that a large-scale operation is in order. The promoter of the company, however, has reported, in writing, to his stockholders that he can recover half an ounce, or ₱35, per ton from this ₱-5-per-ton ore. The mining engineers in the Philippines are waiting with considerable interest to hear of the outcome of this project; most of them are anxious to obtain the secret of the mysterious process, at any price to raise their own recoveries.

And now for a description of the process of assaying.

An "assay" is an examination of a mineral, an ore, an alloy, or any liquid or solid containing minerals, for the purpose of determining the exact amount of one or more metals contained in the substance. It differs from an "analysis" in that an assay determines only certain ingredients, whereas an analysis determines everything the material contains. In gold mining, for example, the assayer reports the amount of gold, and silver, sometimes per ton. In iron mining the percentage of iron, water, and sometimes manganese, chromium, or nickel, are desired.

There are two general types of assays: Fire Assays, and Wet Assays. Modern science has developed a new method of analysis, Spectrographic Analysis (for a description of this type of analysis see the Marsman Magazine, Vol. II, June 1938).

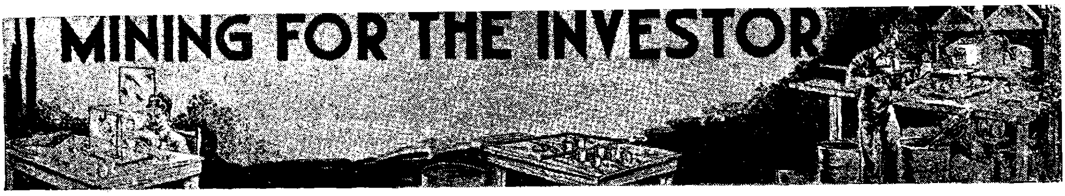
A Fire Assay is the determination of the amount of assaying of metallic ores, or products usually gold and silver, by methods requiring a furnace heat. In effect, it is smelting on a miniature scale, and involves the processes of scorification, cupellation, etcetera.

A Wet Assay is the assaying of metallic ores or products by chemical methods not requiring furnace heat. Lead, zinc, iron, manganese, copper, chromite, and many other metals are detected by wet assays.

*Fire Assaying.** A record is made of each sample, giving name and address of owner, date, owner's mark, *elements to be assayed for,* amount of charges, and other special instructions. The sample is then dried, in a small oven or over an open hearth. The entire sample is then put through a fine crusher, which reduces it to about 70 mesh (about the size of grains of sugar). The crushed sample is then thoroughly mixed and quartered (divided into four parts) until only 8 or 10 ounces remain; this portion is a true representative of the whole sample.

The unused portion, known as "rejects" is then filed with duplicate markings of the original tag. This is done for two reasons: to provide a duplicate sample should the original be lost; to

* Description of fire assaying from "Mining Directory-Catalog and Engineers' *Handbook* published by Mining Committee, Los Angeles Chamber of Commerce.



return to the owner should he desire to have a duplicate test made.

The sample of 8 to 10 ounces is now ground to around 120 mesh (about the fineness of flour) in a pulverizer or on a bucking board. It might be explained here that the most scrupulous care is taken that two samples are not mixed: every grinder and container is carefully brushed and cleaned after each sample goes through it, and a blank sample (known to obtain no precious metals) is often run through the machine for further safety.

The pulverized sample, with its identifying tag, is now taken to the weighing and fluxing room where charges are weighed carefully and put into fire clay crucibles along with the proper fluxes. The fluxes and ore are thoroughly mixed and covered.

The size of the charge for an assay is based on a system of weights known as Assay Ton Weights; made up from a comparison of the Avoirdupois, Troy, and Gram Weights. It saves a vast amount of calculation and labour.

one pound avoirdupois	—7,000 troy grains
2,000 pounds	—one ton
2,000 x 7,000	—14,000,000 Troy grains, in one ton Avoirdupois
480 Troy grains	—one ounce Troy
14,000,000 ÷ 480	—29,166 Troy ounces in one ton Avoirdupois
29,166	—milligrams — one Assay Ton

2,000 pounds is to one assay ton as one ounce Troy is to one milligram

Therefore, if one assay ton of ore assays one milligram of gold or silver the whole ton contains one ounce Troy.

American practise is to report assays in dollars (pesos in the Philippines per ton). That is, if the ore assays one ounce per ton, it is reported as ₱70 per ton. English practise, used in Africa, Australia, etcetera, is to report ounces per ton, or pennyweights per ton (twenty pennyweights in one ounce Troy).

To return to our assaying: the prepared sample is fused (melted) in the assay furnace. Today assay furnaces use fuel oil or gasoline for fuel; formerly coal and wood were used. After about 30 minutes the molten charges are poured into moulds. This step is smelting on a small scale with much more refined fluxes than can be used in large plants.

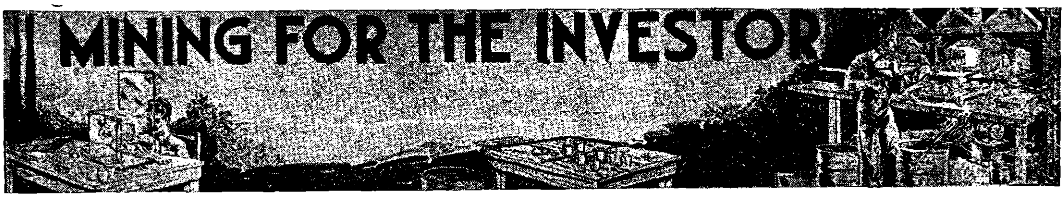
Upon cooling the worthless slag is freed from the base bullion which has settled to the bottom of the mold. This bullion, consisting mainly of lead, which was added with the fluxes in oxide form, contains the gold and silver in the ore.

The lead bullion is carefully freed from all adhering particles of clay by pounding and shaping into a cube-like form. It is now ready for refining, and is subjected to a treatment in the muffle furnace known as cupelling. Here the lead in the base bullion is changed to lead oxide and is absorbed into the cupel, leaving the gold and silver in a refined state as a "bead" which is round and silvery in appearance. This is metal refining on a small scale.

The beads are removed from the cupels and are carefully cleaned, to detach any small particles that might adhere to them. They are then weighed on delicate balances and the weight recorded. This is the combined weight of both gold and silver.

The beads are now treated with acid to remove the silver; this process is called "parting". The acid dissolves the silver, leaving the gold untouched in the form of a sponge. This gold sponge is carefully washed and dried, and is weighed on even more delicate scales than that used for the combined beads. When the weight of the gold is determined, it is deducted from the weight of the combined button, leaving the weight of the silver.

After the weighings are made the calculations are made and a certificate made out, showing the gold and silver in ounces and the value in dollars (or pesos). This certificate is checked with



the original record and delivered to the owner of the sample.

The unused portion of the ground sample known as "pulp" is filed for reference so that anytime within 60 days the pulp may be called for. At the end of 60 days (this period varies, of course, in different laboratories) it is thrown away.

This describes the ordinary fire assay for gold. Different ores require somewhat different manipulations, but the fire assay remains the preeminent method for all classes of gold and silver ores and their products. This applies equally to platinum, palladium, iridium, rhodium, ruthenium, whether oxided ores, sulphides, tellurides, or base ores of all kinds or colloids from photographic work, or gold or silver or platinum in any form.

Every conceivable interference has deliberately been added to weighed amounts of gold and silver, the proper assay performed, and without a single exception a satisfactory check has been obtained between the amount of gold weighed in and the amount of gold recovered. Likewise, but with somewhat more variation, the silver has also been recovered; the losses are known.

The U. S. Bureau of Mines has made extensive tests of claims conflicting with the above and has invariably proved them either mistaken or fraudulent. All other competent investigators have reached the same conclusion.

A chemical method for gold determinations has been devised for field use. An iodine solution for dissolving the gold is used and the gold precipitated by re-distilled mercury which is later parted with nitric acid. The method, when properly performed, in every detail checks the fire assay closely. It is a slow and tedious method, however, and requires skilful operation.

THERE IS NO ORE, METAL, MINERAL OR METALLURGICAL PRODUCT WHICH CANNOT BE ANALYZED OR RECOVERED BY STANDARD METHODS OR PROCESSES, ALL CLAIMS TO THE CONTRARY NOTWITHSTANDING. Beware of anyone having special methods or secret processes for chemical analysis, assay, or recovery. NONE OF SUCH METHODS HAVE EVER AT ANY TIME MADE ANY SUCCESS. High sounding technical terms should always be a warning. Beware of mysteries: "Colloidal, Subatomic, Allotropic, Amorphous" and many other terms have been used by frauds who have been exposed by the U. S. Bureau of Mines, notably in their Bulletin 2496, of 1922.

Wet Assay. The exact percentages of the base metals—iron, copper, lead, zinc—can be determined by a chemical quantitative analysis. There are many such methods, depending upon the metal to be reported and the various impurities. In each case the sample is ground fine, as for fire assaying, and is prepared for treatment in practically the same way. Instead of being fused, however, various chemicals are introduced to dissolve the ore, and others added from time to time to take care of impurities. By means of chemical manipulation it is possible to determine the amount of any element present in the ore; reports are made in percentages, as 47% Fe, etc.

Every mining operation of any size has its own assay laboratory, since the mining engineers must know the values of their ore as they work underground, and the millmen must be able to check their results from shift to shift. At a large mining project, such as Itogon, dozens of samples are taken hourly in the mine, and as many more in the mill. The Itogon assay office handles around 350 assays a day; during November 1938, it ran 10,592 assays—at a cost of ₱.291 per assay.

A small assay laboratory, which can be run by one man, costs around ₱2,800 while a large unit, such as the bigger companies operates, runs into real money. Microscopic examinations are conducted, spectographic analyses made, and in general scientific research is undertaken in the modern large assay office.