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Sampling of Dumps and Tailings

BY

GEORGE R. FANSETT

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THE SAMPLING AND ESTIMATION OF THE METAL PRESENT IN A DUMP OR TAILINGS HEAP

by GEORGE R. FANSETT

The sampling and estimation of the metal present in an ore dump or a tailings heap are matters which are of considerable importance to most men connected with the mining industry, as they are often called upon to handle this class of work, either for themselves or for others.

There are several important points which can be settled concerning the material in an ore dump or tailings heap before any work is started in the shipping or in the treatment of the material, and most of these points can be decided from the results obtained from the analyses, the testing of the samples or the reports from the smelters on the samples.

A few of the important points which can be decided are the following:

1. The amount and kinds of valuable minerals present and their values.

2. The net profit, if any, which can be derived from the dump. This is the amount of money left over after all charges which may be levied against the material in the dump have been deducted. Some of these charges are the following: Treatment charges, freight, labor, tools, etc. As the profit to be derived is the most important matter concerning every dump, every possible precaution to include every charge which might be levied against the material should be taken into consideration in the calculations which will settle this point.

3. The process of treatment. The results from the samples should decide if the material making up the dump should be treated or dressed first, or if it is better to have it smelted as it exists in the dump.

Under the above headings are many subdivisions, which enter into the calculations, a few of which follow:

(a.) 1. For Tailings. The best ore dressing process of treatment for the extraction of the values from the tailings. 2. The kind and cost of the necessary equipment.

(b.) For ores where it is desirable to concentrate the values before
smelting. A great part of the mine-run falls in this class. Among these are ores which will not pay the charges levied against them unless their values are concentrated before they are shipped or smelted. There are others where the net profit is much increased by this preliminary treatment.

(c.) For ores which are high grade enough to smelt as they exist. Under this heading several important points can be settled. (1) Whether it is better to smelt the ore locally, or (2) to ship it to a custom smelter, and if it is better to ship to a smelter, (3) which smelter will give the best financial returns.

The above points are mentioned only to illustrate the nature of a few of the important matters that can be settled from the results obtained from the samples taken from an ore dump or a tailings heap, and will serve to emphasize the importance of the proper sampling of an ore dump or a tailings heap, and the points that can be settled from the results obtained in the analyzing and testing of the samples before the work is started on the shipping or on the treatment of the material making up the dump or heap.

It is far better to spend a few dollars in the sampling and testing of the samples than to ship the material to a smelter and discover that the money received will not pay the freight and other charges levied against it, or for one to install expensive machinery and find later that the expected values are not present or that the process of extraction is not adapted to that particular ore, or that a different process would have been better. In other words, it is better to be sure than sorry.

For reasons such as these, it would seem to be to the advantage of all those interested in the mining industry to understand the methods generally used in the sampling and in the estimation of the metals present in ore dumps and tailings heaps so that they will know how to do the work if called upon to do it. The purpose of this Bulletin is to indicate and describe the methods which are used by many of the large mining companies and many engineers for getting this preliminary information and doing this kind of work, in cases where a large expenditure of cash and expensive machinery is out of the question, and where the value of the dump is to be estimated within reasonable limits.

Before describing the methods of procedure for doing the work, it may be advantageous to define several terms which are used in this Bulletin.

Definition of an Ore.—Richards. An ore is a natural aggregation of minerals from which a metal or metallic compound can be recov-
erred with profit on a large scale. When the per cent of metal is too low for profitable extraction, the rock ceases to be an ore. The rock has to be tested to determine this point.

Definition of an ore dump. An ore dump is a pile or heap of ore. The ore making up a dump is usually selected roughly for each particular dump,—that is, high grade ore is usually dumped in one pile, medium in another, and waste discarded.

Definition of a tailings heap. A tailings heap is a dump which is made up of the detritus or rejected crushed material from a metal extraction or a reduction plant.

Definition of a sample and sampling. A sample is a collection of fragments or pieces from a deposit which contains exactly the same minerals in exactly the same proportions as they exist in the deposit from which the sample was taken. In this bulletin the material saved from each cutting down operation is referred to as the sample. The act of collecting these pieces is called sampling.

Definition of the minerals present. The minerals present are those actually existing in the sample and the amount of each present is determined by a quantitative analysis of the sample.

Definition of the metal recoverable. The metal recoverable is that which can be actually recovered from the ore by the use of the processes of ore dressing or reduction utilized, or both, and as there are always losses in these processes, the metal recoverable is always less than the metal actually present in the deposit.

Definition of “values.” Gold, silver or other valuable minerals which are present.

Testing. This term as used in this article may mean assaying, analyzing, tests for a process or, in fact, any or all of the various tests for which a sample may be used.

Carefulness.

Sampling is slow, hard, caretaking work, and the greatest care is absolutely necessary and must be taken in every part and detail of the work. It would be poor business to spend a large sum of money and labor in the taking of samples and then find out that, owing to some part of the work being carelessly and incorrectly performed, the samples are worthless. In a case like this the results may be considered dangerous, as they may lead to heavy unmerited expenditures, and much money would be wasted. In order that the estimate of an ore deposit shall be correct, the figures which are used in making the estimate
certainly must be correct. For the above reasons, careless, slipshod work is absolutely out of the question in taking samples and sampling.

RECORDS.

In the sampling of ore dumps and tailings heaps, it is necessary to keep a good set of records so that if any questions arise, at the time or after the work has been finished, they can be immediately settled and answered correctly and definitely. For doing this, it is well to use a topographical map of the deposit, a sample book and a diary. All matters and information pertaining to the deposit should be recorded in one or all of the above mentioned records. If any point to be recorded seems to belong to more than one of the above mentioned records, record it in all the records where it seems to belong. If it seems to belong to all, record it in all, and do not consider it useless repetition, as any matter worth recording is worth finding easily and quickly. These records represent the work done, and for this reason should be most carefully and accurately kept.

THE TOPOGRAPHICAL MAP.

As soon as a thorough preliminary examination of the dump or heap has been completed, a topographical map is made of it. It should be made to a scale large enough so that any and all details can be plainly marked on it. All distances for this map are measured on the horizontal; all elevations are calculated from a known and permanently fixed bench mark or datum. The map is used for locating the points where samples are to be taken, furnishing the data for making the calculations for the cubical yardage of each section of the deposit and for the whole deposit. When a test pit or a crosscut or other work is decided upon, and work started on it, the location of the pit or excavation, together with the number given to it, should be marked on this map at its proper location. Also when a test pit reaches the bottom of the dump, the elevation of the bottom is marked at the proper location. The depth of the dump at that point can then be found by subtracting the elevation of the bottom from the elevation of the top at that place.

On this map is also recorded by the numbers given to them the location of each of the samples. After these samples have been assayed, the values obtained are also marked. In fact, this map is used to record everything of this nature concerning the deposit.
Sampling Series No. 2

THE SAMPLE BOOK.

Supplementary to the topographical map and diary, a sample book should be kept. In this book all details and records pertaining specifically to each sample are recorded. The following will illustrate some of the matters which are taken care of in the sample book: (1) Number given to the sample; (2) Date when the sample is taken; (3) Name of the deposit from which the sample is taken; (4) The location at which the sample was taken; (5) Assay returns from the sample, etc., etc.

A convenient form of sample book is one which has a page which is perforated near the far end so that this end part of the page or tag can be easily torn off and put into the sack with the sample to identify it. The number which is given to the sample is all that is usually written on the tag. This number, together with all other matters concerning the sample, is written on the part of the page which is fixed in the book and these pages form a complete record of the samples.

The form on Page 6 represents one of the pages used in a sample book, but this form should be changed, if necessary, to meet the requirements of any particular job.

THE DIARY.

Together with the aforementioned records, a diary should be kept. All other matters of importance which are not naturally included among those recorded on the topographical map or in the sample book are taken care of in the diary. Such matters as when the work is started on a certain pit, when and to what extent a pit caved, etc., etc., should be taken care of in the diary. As before stated, any inquiries which may come up in regard to the deposit, the sampling, or the samples from a deposit should find a satisfactory answer either in the diary, the sample book or on the topographical map, or all of them.

NUMBERING OF THE EXCAVATIONS.

Each excavation is given a different number and in most cases they are numbered consecutively. This serves to make it easier to remember where each particular excavation lies. The one important point is that no two excavations have the same number, thus avoiding any confusion.
NUMBERING OF THE SAMPLES.

Each sample is given a different number, irrespective of its location, and by this number the sample is identified at all times with the aid of the notes kept in the sample book. No two samples should have the same number or mark. If a sample is concentrated, the concentrate or tailing should be given either an entirely different number, and notes made in the sample book as for any other sample, or if the same number is given to it, a note should be put on the tag stating just what it is. For example, “Wilfley concentrate, from sample No. 276.”

When the sample is taken, the number given to it is marked on the topographical map at the proper location. This number is also marked on a page in the sample book and on the detachable part of the page or tag of the sample book. After the sample has been cut down to the desired size, the sample, together with the tag bearing its number, is put into a sack or other container.

TAGS.

Only one tag is put into each sample sack with each sample, and the number on the tag, together with the notes kept in the sample book, serve to identify the sample at all times. The tags used for this work are made either of paper, soft wood or metal. Paper tags are commonly used except with samples which are very wet. These tags are usually the detachable part of the page of the sample book referred to, but can also be any piece of paper with the proper number written on it. These paper tags are rolled up tightly in the form of a lead pencil, and have their ends well crimped. This is done so that they will not unroll easily and get soiled, thus keeping the writing legible.

Metallic tags, having the number stamped thereon, are sometimes put into the sample sack with the sample instead of the paper tag. These are very serviceable with samples that are wet.

Soft wooden tags with the number written thereon with a hard lead pencil are also serviceable, especially with wet samples. A hard pencil is recommended for writing the numbers on the wooden tags, because the lead will cut into the wood and the indentation will remain even if the lead is rubbed or washed off.

SACKS AND CONTAINERS.

Only new sample sacks should be used. If tin or other containers are used, they should be thoroughly cleaned out before the sample is
put into them. Sacks which have been previously used for holding samples or dirty containers may contain values from the former samples which they have held, and these values will get mixed with the sample and enrich or salt it, thus spoiling the sample. It would be poor business to spend a large sum of money on a collection of fragments from a deposit in the collecting or taking of it, testing, freight, and other charges, if the collection is not a true sample, having been spoiled by the enrichment or salting from an old sack, when new sacks cost but a few cents each.

Size of Sample.

The final size of the sample depends on what is to be done with it. If it is only to be assayed or analyzed, only a few pounds are needed. The size of the sample sent to a commercial assayer or chemist for the common analyses does not have to be more than a pound. If the sample is to have a complete analysis made of it, a few pounds is usually sufficient. If it is to be tested for an ore dressing process and a process of reduction, from 500 pounds to several tons may be needed. In other words, the needs will determine the size of the sample saved. When sending a sample for analysis, it is well to keep a part of the sample sent, so that check analyses can be run on it if it is desired.

Limits of Sampling.

Most dumps which are to be sampled will not stand a big outlay of cash for doing this work. Expensive machinery and power are usually out of the question. In many cases shovels are the only tools available. For this reason it is the practice of engineers to use methods for doing the work that will give approximate results in the shortest time, and in the cheapest manner possible. The estimates which are made from the results thus obtained should be correct within reasonable limits of each particular case.

The work which has to be done on most dumps before the shipping or treatment of the material should be started, to obtain this preliminary information, can be divided into several parts, the most important of which are the following:

1. Taking the sample.
2. Testing of the sample.
3. The estimation of the values present and recoverable.
4. The valuation of the dump.

These matters will be handled in this bulletin in the above order.
APPLICATION OF METHODS USED.

The methods of procedure in the sampling of ore dumps is practically the same as that used in tailing heaps, and unless some part of the work is mentioned as applying particularly to one or the other of these classes of dumps, the methods described will be understood to apply to the two classes of dumps.

In cases where it is questionable whether the dump is of value or not, the usual course of procedure is first, to take grab or pipe samples. These are assayed and the results from them are used only to indicate whether or not a more thorough sampling of the dump is merited. To take grab samples, the dump is laid off in squares. Handfuls or shovelfuls of the material are taken, as fairly as possible, at each intersection of the lines forming the squares. This is usually all mixed together and assayed. The results from the assay are rough, and indicate only whether or not the dump is worth bothering with at that particular time.

In tailings heaps, pipe samples are sometimes used for this purpose instead of grab samples. This method can only be used in finely crushed material, and is done by driving a short length of pipe (1½-inch pipe answers) into the heap at points from which the samples are wanted. The pipe, with the sample in it, is withdrawn and the sample is knocked out of the pipe and assayed. These samples, as in the case of the grab samples, are rough. If the results from these rough samples indicate that it is worth while more thoroughly to sample the dump, there are many methods of procedure for so doing, among which the following are often used:

- Ore dumps: from 500 lbs. to about 5 tons. Fraction sampling or crosscuts.
- Above 5 tons—crosscuts, test pits, or drill hole sampling.
- Tailings heaps: Above 5 tons—test pits or drill hole sampling.

METHODS OF PROCEEDURE.

A topographical map of the dump should first be made. From this map the cubical contents in the dump can be calculated. The tonnage or weight of the material in tons can be found by multiplying the weight in tons per cubic yard by the number of cubic yards. The weight can be found by weighing a known quantity as a cubic foot.

Small dumps, or those containing not over 5 tons, can be sampled either by using what is commonly known as the fractional method or by crosscuts.

The fractional method is one commonly used when the ore is to be shipped to a smelter or to a reduction plant. By this method all the
material in the dump is shoveled from where it lies to a different place. Every second, third, fifth or tenth, or any other numbered shovelful decided upon in advance, is shoveled into a separate heap on a clean, tight platform or other clean, smooth surface, and the heap thus made up is kept for the sample. The most important points to be taken care of are: (1) If every fourth shovelful is to be saved for the sample, be sure and save only every fourth and no others, or if it is decided to save every tenth, be sure and save only every tenth shovelful of the material. (2) Do not pick the material which is to be saved for the sample. The shovelful saved for the sample should contain as near as possible the same amount of material and the same kind of material as that previous and following. This work separates the dump into two lots: one is to be used for the sample and the other is to await the results obtained from the testing of the sample.

Where the material in the dump does not cave, sampling is sometimes done by the crosscutting method. The width of all of the crosscuts must be the same throughout their entire lengths, and from top to bottom. The material taken from the crosscuts is all mixed together and is used for the sample. This method is rough, but in cases where a quick, cheap and fairly accurate estimate is desired, it can be used to advantage. The sketch on Page 11 illustrates this method.

Crosscutting is usually impractical in tailings heaps, owing to the fact that the material usually caves easily, and if the crosscuts are broader at the top than at the bottom, there is more material taken for the sample from the top, and for this reason the sample is sure to be unfair unless all of the material in the dump is absolutely uniform. Tailings heaps not larger than 5 tons are seldom of any commercial value.

For a small dump the only tests usually desired are the assays and smelter reports. For these tests 20 pounds is usually more than is needed. When the amount saved for the sample from the first operation is more than 800 pounds, and the amount desired for the final sample is about 20 pounds, one of the following methods can be used in cutting down the sample to the desired size.

**Methods of Cutting Down Sample from Ore Dumps When Quartering Machinery Is Not Available.**

- Down to about 500 pounds. Fractional method of cutting.
- From about 500 pounds to 100 pounds. Coning, quartering by use of a cross or the Jones sampler.
From 100 pounds to the size desired. By use of canvas or table oilcloth, or the Jones sampler.

Tailings Heap Sample.

Down to 500 pounds. Fractional method of cutting down or by use of the Jones sampler.

From 500 to about 100 pounds. Coning; quartering by the use of a cross, or the Jones sampler.

From about 100 pounds to the size desired. Method using canvas or table oilcloth, or the Jones sampler.

The reject from each cutting down operation is usually added to the pile left from the first cutting down operation.

There are many cases where no machinery is available and shovels are the only tools to be had for cutting down samples to the desired size. In such cases it is necessary to use a method for cutting down the sample which will give results which will be, within reasonable limits, as accurate as possible. In these it is a common practice to
use the fractional method repeatedly, as was described under "The Fractional Method of Sampling," for cutting the sample down to about 500 pounds. From 500 pounds to about 100 pounds the coning method is often used.

When the coning method is used, the pieces of material making up the sample must not be larger than will pass through a 2-inch screen when the sample weighs over 300 pounds. When the weight is less than 300 pounds, all of the pieces in it must pass through a 1 inch screen. It is therefore necessary to crush or break up all pieces which are larger than indicated above. A cobbing hammer and anvil are convenient for breaking these pieces up if a crusher is not available. If a crusher is to be had, it is better to crush all pieces to less than one inch.

The main advantages of the coning method are: (1) No expensive machinery is needed; (2) Any kind of mineral can be cut down by this method.

The main disadvantages of this method are that the material has to be handled so many times that the cost of the work is very high, and it is next to impossible to get an absolutely even distribution of the values.

The last heap of material saved for the sample from the preceding cutting down work is leveled to a circular form by use of a hoe, flat-nosed shovel or similar tool, so that it is not over four inches deep. The next step is to cone the material, which is done in the following manner. From the outside part of the leveled heap of material, at points equally distant from each other, equal amounts are shoveled up and allowed to fall onto the center of the leveled heap in such a manner that the material is evenly distributed on all sides of the cone which is formed. In this way, only a portion of the heap is shoveled up in passing once around the heap, the metal is mixed, and a fair distribution of the values is accomplished. When all of the material outside of the cone, which is formed at the center of the heap, has been shoveled up to the cone, all of the fine material left outside of the cone on the platform is swept into a shovel and shoveled onto the top of the heap. The cone is then shoveled to a different platform, or to another part of the same platform which has been thoroughly cleaned. It is then leveled again to a circular form and coned again as was described above. This process is repeated until the material has been thoroughly mixed. When this has been accomplished, the last cone formed is leveled again to a circular form, the depth of the material being about four inches.
The leveling of the final cone to a circular form should be done very carefully, as usually the finest particles lie close to the apex of the cone, and as these usually carry the highest values, they should be distributed as evenly as possible in each of the four quarters.

The leveling is ordinarily done by the use of a shovel, the back part of which is held vertically toward the apex of the cone. It is the common practice to start at about one-half of the distance from the outside of the cone and its apex, and work around, always working toward the apex, the material being dragged out over the outside edge of the cone. After the material is leveled evenly, it is divided into equal quarters by cutting along two diameters which are at right angles to each other. The two opposite quarters are kept for the sample; the other two are discarded and are added to the balance of the material which made up the original dump.

The sketches on Page 14 illustrate the above.

One operation of this method thus cuts the sample down one-half. If the sample is still too large (over 100 pounds) this entire operation is repeated on the portion saved for the sample until it reaches about 100 pounds, when the method using table oilcloth or canvas is more convenient. Much care must be taken in doing this work, as well as to clean thoroughly the parts of the platform where the discarded material has been, in order to prevent salting from the values which may have been left there. Table oilcloth is considered one of the best materials for this purpose, as it has a perfectly smooth surface, and for this reason no values can get into the fibres or cracks and thus detract from one sample or salt another.

When this method is used, all pieces of the sample must be small enough to pass through a one inch screen. The final sample saved from the former cutting work is shoveled onto a piece of the oilcloth about six feet square. Then taking the two opposite corners of the cloth, one in each hand, one corner is lowered at the same time and the same rate that the other is raised, the bottom of the cloth always resting on the platform. This motion rolls and mixes the sample. When this has been carefully done, the two opposite corners are taken in the same way, the sample is again rolled and mixed, but in the opposite direction to the first operation. This is all repeated several times, until the sample has been thoroughly mixed. The canvas is then spread out flat on the platform and the sample leveled to a circular form not over three inches deep, as was described before in connection with the coning method. It is then divided into equal quarters.
SKETCH SHOWING QUARTERING OF SAMPLE

SKETCH SHOWING ORE CONEO
by cutting it along two diameters at right angles to each other, as illustrated above in Sketch No. 3.

The opposite quarters are kept for the sample and the other two discarded. The place where the discarded material has been should be thoroughly cleaned, so that none of it will be added to the sample. The final sample is then thoroughly mixed, put into a sack with the tag bearing its number and is ready to be analyzed.

There are several other methods than those explained above which can be used to advantage in all or in parts of the work of cutting the sample down to the desired size. Some of these methods are considered by many engineers to give more accurate results, and in some cases the work can be done more rapidly and cheaply. The main drawback is that special apparatus is required, but when this can be procured they will give more accurate results.

One of these methods is the use of a cross for quartering the material. This is used after the sample has been cut down to about 800 pounds by the fractional method. When the sample weighs over 300 pounds, the pieces should be small enough to pass through a 24-inch screen; when it weighs less than 300 pounds, they should pass through a 1 inch screen.

The cutting down by this method is done with the aid of an apparatus, a sketch of which is shown here. It consists of four arms which are built at right angles to each other in the form of a cross, with a funnel located above the cross, the center of the funnel and the spout from it being exactly over the intersection of the arms. The spout should be long enough
and small enough so that the mineral will fall vertically, or straight down, thus accomplishing an even distribution.

This apparatus is placed on a clean, tight, level platform; the sample saved from fractional sampling, after being thoroughly mixed by coning, as explained above, is then shoveled into the hopper of the funnel, care being taken that none of the sample falls over the side of the funnel into any one of the quarters. It is a good precaution to cover the arms of the apparatus to prevent this, and after each run has been completed, to collect the material which has fallen over the side of the funnel, and shovel it into the funnel, thus adding it to the sample to which it belongs.

The material of the sample between the arms of the cross in the two opposite quarters, is saved for the sample, as was explained under the coning method. That in the other two quarters is discarded. The space between the arms of the cross where the rejected parts have been, is well brushed and cleaned off, so that any values which may be there will not salt the next sample. One operation thus cuts the sample in half. After this is well done, the apparatus is lifted and placed at another clean part of the platform and is ready to have the above operation repeated if the sample is still too large.

When the sample reaches about 100 pounds, it is well to use the oilcloth method, or a Jones sampler, if such is available. At this stage there should be no pieces of the sample which will not pass through a one inch screen.

**The Jones Sampler.**

The cutting down of a sample from any size can be accomplished rapidly and accurately by the use of a Jones sampler, providing the size of the pieces in the material is not more than three-quarters of the width of the slots in the sampler, a picture of which is shown below. This is an inexpensive apparatus which stands rough handling, and gives good results providing it is properly used.

On top, the sampler has a row of horizontal slots, all of which have the same length and width. From each one of the slots runs a chute, every second chute running in the same direction; that is, the outlet from the first chute is opposite that of the second, and so on. The material is shoveled slowly from a flat-nosed shovel or scoop transversely onto these slots, much care being taken that the chutes do not clog, and to distribute the material evenly by moving the shovel back and forth from one side to the other of the apparatus. The end of the shovel should be held about one inch above the slots.
of the sampler, and in this way equal amounts of the sample will fall into each slot and run down and out of the chute under it. A pan is placed under each row of chutes, to catch the material and if the work is properly done, one-half of the sample will be caught in each of the pans. That in one pan is saved for the sample, and the other discarded. The operation is repeated until the desired size is obtained. It is then sacked with the tag bearing its number, and is ready to be tested.

In some cases it is advantageous to bank up several samplers, one above the other, so that the sample from the first falls into the second automatically, and in this way the work is done much more rapidly and with less handling. When used in this way, care must be taken to have the samplers arranged in such a way that the material entering one sampler from the one above it is evenly distributed.

The Jones sampler is particularly adaptable for cutting down samples from tailing heaps, as these are usually crushed to sands. When the material has to be crushed, it is usually advisable, for the sake of economy, to use the fractional method to cut it down to about 500 pounds. The large pieces are then broken up and thoroughly mixed with the rest before it is put through the sampler. This can be cut down by using a large sized sampler, one having slots 1 to 1½ inches wide. When it has been cut down to about 100 pounds, it is advisable to use one with slots not over ½ inch in width. It is therefore necessary to break up all of the pieces larger than this size,
so that they will pass through the slots. They should be thoroughly mixed either by coning or by use of the oilcloth or canvas, and shoveled into the sampler.

The sampling of ore dumps from 5 tons to about 100 tons can be done cheaply and conveniently by the cross-cut method described above. When this method is used, great care and judgment are needed in locating the crosscuts, so that as fair a sample as possible will be taken from the dump. The material taken from the crosscuts is the sample, and it can be cut down to the desired size by using the methods which were described above.

Dumps of this size can also be sampled by using test pits. These are pits which are sunk in the dump, the material taken from them being the sample, which can be cut down to the desired size by methods previously described. The location of these pits is a most important matter, requiring much care and judgment so that as fair a sample as possible will be taken. This method is described very fully in the Arizona State Bureau of Mines Bulletin No. 51.

Another method often used where the material is not coarse is that of the augur drill. This method is also described in Bulletin No. 51 of the Arizona State Bureau of Mines.

Churn drills can be used if necessary, but as this is very uncommon practice, reference only is made to it here.

**Sampling Dumps of Over 100 Tons.**

The sampling of dumps of over 100 tons is usually done either by using test pits, augur drill or churn drills, as described above.
From the above it is evident that more or less judgment is needed in the selection of the process best suited for the sampling of any particular dump. In some cases a combination of the above methods is cheaper and better, but these points should be decided before the work of sampling begins.

**Analysis of the Sample.**

The next step after the samples have been cut down to the desired size is to have it assayed or analyzed. This part of the work should be done by a thoroughly competent and reliable man, since the results from these analyses will decide many important matters regarding the dump, a few of which are the following:

1. The amounts of the valuable minerals present per ton of the material in the dump. This is the weight and value of the gold and silver present, and the per cent of the copper, tin, zinc, lead, or any other minerals which may be present.
2. The amount of the various fluxes present. This is the per cent of lime, iron, silica, and other fluxes present.

The results from the analyses are used in the calculations which are made to determine an estimation of the minerals present and the valuation of the dump.

**Estimation of the Total Valuable Minerals in the Dump.**

This is the total weight of each valuable mineral which is in the dump, and is determined by multiplying the weight of each mineral present per ton of material by the number of tons of material in the dump.

The tonnage of the dump is calculated by multiplying the number of cubic yards in the dump by the weight in tons of the material per cubic yard. The number of cubic yards is calculated by using the cross sections of the dump which are taken from the topographical map of the dump. The weight of a cubic yard of material is found by using the weight of a known volume of the material as, for example, a cubic foot of it, and making the necessary calculations for a cubic yard. This part of the work should be done by a man who is familiar with engineering calculations as a wrong estimate would lead to serious consequences.

**Testing for a Process of Extraction or Concentration.**

Where the assay returns and the estimate of the minerals present indicate that the dump is of commercial value at that particular
time, in many cases, especially in very large dumps, it is desirable to have the material tested for an ore dressing process, or process of extraction. This is the process which is best suited for recovering the valuable minerals and rejecting the gangue.

It is the usual practice to send the sample to a competent and reliable man or company, who make a business of testing ore. These men know how to do the work and have the available machines and equipment for testing the sample thoroughly after the preliminary tests have been made.

Value of the Dump.

After the above points have been decided, the next matter of importance is the valuation of the dump. The principal point to be decided from this is the ultimate net profit which can be made from the dump. This is the amount of money which will be left over after all the charges which may be levied against the dump have been deducted. As this is the most important point to be decided, and will determine whether the dump is of commercial value or not, and to what extent it is of value, these calculations should be made by an experienced, capable and reliable man.

The following will serve to indicate a few of the matters which should be taken into consideration in making these calculations:

1. Amount of valuable minerals which are present, and the amount of money that will be paid for them.
2. Handling charges—Labor, freight, and all other charges of this nature.
3. Equipment—Tools, machinery and other necessary articles.

In addition to these, a few other items affecting the valuation calculations are management, climate, water, power, fuel, food supplies, interest on the capital invested, etc., any of which, if neglected, will give incorrect valuation.

If the valuation should determine that it would not pay to ship the material at that particular time, it is well to keep all the data and results obtained from the sampling, estimating and valuation, as they may be of use at some future date, when, for some unexpected reason, such as higher prices paid for the minerals, the discovery, perfecting or development of a process of extraction or other reason, it may be possible to handle profitably the material in the dump.