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Sampling and the Estimation of Gold in a Placer Deposit

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SAMPLING AND THE ESTIMATION OF THE GOLD IN A PLACER DEPOSIT

BY GEO. R. FANSETT.

The sampling and the estimation of the gold present and recoverable play a very important part in the history and development of all placer deposits. For this reason everyone interested in placer mining should know the best methods of working this class of mineral deposit. The purpose of this bulletin is to indicate and describe to the miner and to the layman the best general methods used, so that they may understand and know how to do each and every part of the work, as well as to make the necessary calculations.

The work may be divided into three general subdivisions, namely: (1) The Sampling of the Deposit, (2) The Testing of the Samples, and (3) The Estimation of the Total Gold Present and the Gold Recoverable in the Deposit.

A placer is a deposit of mineral-bearing gravel, sand or soil. The commonest forms referred to are gold placers, tin placers, and platinum placers. The same method of procedure can be used in any kind of placer, but this bulletin particularly refers to gold placers, as they are the most common and of the most importance in the United States.

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. The act of collecting these pieces or fragments is called sampling.

The gold present is the amount of gold actually existing or present in the deposit. Gold is sold at the rate of $20.67 per ounce Troy, but results from assayers are calculated at the rate of $20 per ounce Troy. The ton used is the short ton of 2000 pounds avoirdupois. The value of silver fluctuates so that no definite value is given.

The gold recoverable is the amount of gold which can be extracted from the deposit by the use of any of the well known processes, such as a pan, sluice box, concentrator, centrifugal separator, dry washer, or any other process of ore dressing. There are always losses in this work, and for this reason the gold actually recovered is always less than is present in the deposit.

Sampling is slow work, and the greatest care is absolutely necessary and must be used in every detail of the work. Slipshod, careless work is absolutely out of the question, because if any one part of the work is not properly done, the collection of fragments obtained will not be a true sample of the deposit, and is not only valueless for the purpose intended, but will result in an incorrect estimate of the deposit.

RECORDS.

In the sampling of placers it is necessary to keep a good set of records, so that any questions which may arise can be correctly answered and definitely settled. For this purpose a topographical map, a sample book, and a diary are used to record all matters connected with the sampling of the deposit. These must be very carefully kept, as from one or all of them important points have to be decided.

If there arises a question in one's mind as to where to record a certain detail which seems to belong in two of the records, record it in both of them; and if it seems to apply to all of the records, record it in all of them, and do not consider it useless repetition—any matter worth recording is worth finding easily.

THE TOPOGRAPHICAL MAP.

A topographical map is made of the entire deposit as soon as a thorough preliminary examination has been completed. This map should be made to a scale large enough so that all details can be plainly marked.. All distances for this map are measured on the horizontal. All elevations are calculated from a permanently fixed benchmark or datum.

When the location of a test pit or hole is decided upon and work started, the location, together with the number given to it, is marked on the map. Likewise, when a test hole or pit has reached bedrock, the elevation of the bedrock is recorded. On the map is also recorded, by their numbers, the location of each of the samples, and, after they have been assayed, the values obtained. This map is used to record everything of this nature concerning the deposit, and should be so well kept that its records, together with those kept in the sample book and in the diary, will answer all inquiries which may come up.

THE SAMPLE BOOK.

Supplementary to the topographical map a sample book should be kept. In this book all records and details pertaining specifically to each sample are recorded, such as the name of the deposit, number of the sample, its location, the date when taken, kind of soil, assay returns, 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 or tag can be easily torn off. The number given the sample is written on the part of the page which remains in the book and also on the detachable part. The sample book should be kept so that the information in it, together with the information on the topographical map and in the diary, will answer all possible questions which may come up regarding the deposit.

The form on following page 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.

DIARY.

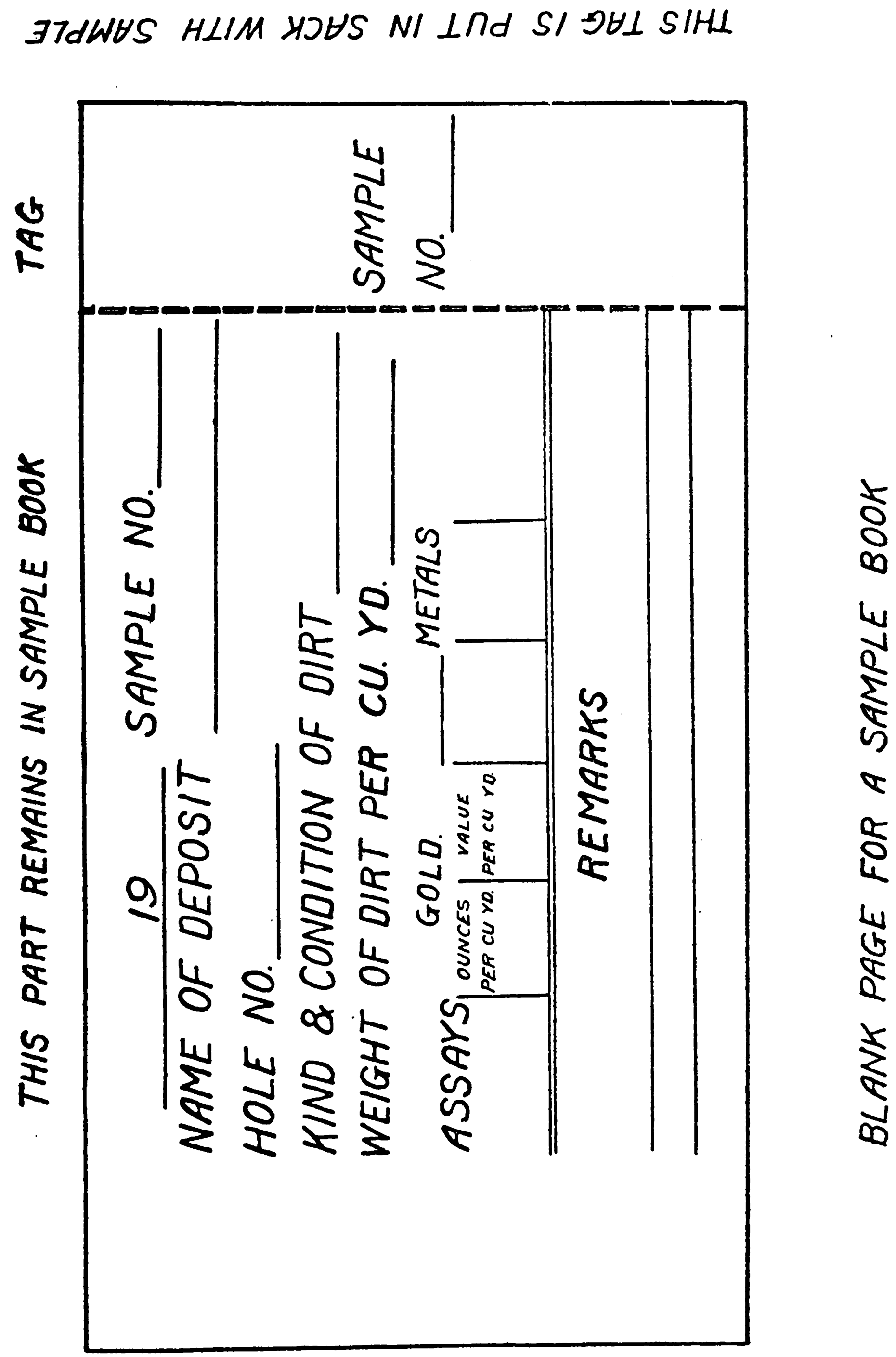
Together with above records a diary should be kept of the deposit. All matters of importance which are not naturally included among those recorded on the topographical map or in the sample book are taken care of in the diary. Such matters as the date when work started on a test pit, when and to what extent a certain pit caved, etc., should be recorded in the diary.

NUMBERING OF SAMPLES.

Each sample is given a different number, irrespective of its location, and by this number the sample is identified at all times. When the sample is taken the number is marked on the map at the proper location from which the sample was taken. The 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, if paper tags from the sample book are used. When the sample has been cut down to the desired size it is put into a sample sack or container, together with the tag bearing its number.

TAGS.

Only one tag is put into each sack with each sample. The tags used for this purpose are made either of paper, soft wood, or metal. Paper tags are usually used except when the samples are very wet. These are usually the detachable part of the page referred to in connection with the sample book, but can also be any piece of paper with the proper number written on it. These are rolled up tight in the form of a lead pencil and have their ends well crimped. This is



done so that they will not unroll and get soiled, thus keeping the writing legible.

Metallic tags having the number stamped on them are sometimes put into the sacks with the sample insttead of the paper tags. Soft wooden tags with the numbers written on them with a hard lead pencil are also convenient. A hard pencil is recommended for writing the numbers on the wooden tags because it will cut into the wood and even if the lead is rubbed off the indentation will be left. This kind of tag is very useful with wet samples.

Where any other tag is used instead of the detachable tag of the sample book, all the information in regard to the sample should be recorded in the sample book in the same manner as was explained above.

SAMPLE SACKS.

Only new sample sacks should be used. Used sacks may contain values from the former samples which they have held, which values may get mixed with the sample, thus enriching or salting it. It is poor business to spend a large sum of money on a collection of fragments from a deposit, in obtaining the sample, testing, shipping, and other charges, if the collection is not a true sample of the deposit. New sacks cost only a few cents each and should always be used. If tin containers are used they must be thoroughly washed and cleansed before the sample is put into them.

SAMPLING PLACERS BY THE USE OF TEST PITS.

One of the common methods used for sampling placers is in the use of test pits. The method of procedure is the same whether the hole is a shaft, pit, drift, raise, or other form of excavation. The one point to be kept in mind is that *all* of the material excavated from the hole decided upon is the sample.

Test pits can be used to advantage where the ground is stable enough to stand up well, where the deposit is not too deep or where water does not interfere too much.

The sample from a test pit is considered by many engineers to be better, in some respects, than the samples taken from drill holes. This is based on several assumptions;

(1) There is not the tendency for the values to concentrate in the lower level or bottom of the pit if the work is properly performed.

(2) Sectional samples or samples for any particular depth at a given point can easily be taken.

(3) The bulk of the sample from a test pit is much greater than that from a drill hole. For this reason, if small additions of values take place they will not affect the final result to so great an extent.

(4) In the test pit it is possible to see clearly the formations, and thus a better judgment of the deposit can be formed.

LOCATION AND NUMBER OF TEST PITS.

When test pits are used, great care and judgment should be exercised in locating the pits so as to get a fair final sample. Usually one pit for each two or three acres is sufficient. This is the number which was found ample in the sampling of several placers, but experience and judgment alone can decide this exceedingly important point for any particular placer deposit. As a general rule, the richer the deposit, the more pits are necessary. Also the greater number of pits are needed where the depth of the deposit is the greatest, as this represents the greater part of the tonnage. The sides or upper edges of the deposit should not be overlooked as these serve as indications as to whether the placer becomes richer or poorer as one works toward the higher benches.

FORM OF PIT.

The pits are usually rectangular in form, about three feet wide, and long enough so that a man can work to advantage. If the excavation is in the form of a drift, it must, of course, be high enough to work in comfortably. The sides should be as nearly perpendicular as possible. If the ground caves, it is necessary to timber it. If this happens, much care must be taken that none of the material outside of the section of the pit decided upon is included in the sample.

CAREFULNESS IN THE HANDLING OF THE SAMPLE.

The greatest care must be taken in handing the material. This is especially true after it has been taken out of the excavation. The safe way is to shovel or dump it directly onto a tight platform. If a platform is not available, a large sheet of steel or a large piece of thick canvas will answer the purpose. This is done so that no foreign material will get mixed with the sample. Since the bulk of the sample is usually much greater than is needed for the tests to be run (50 lbs. is usually more than is needed for panning and assaying), and too much to be handled conveniently, the next step is to cut or quarter it down to the size desired.

METHODS USED TO CUT DOWN THE SAMPLE.

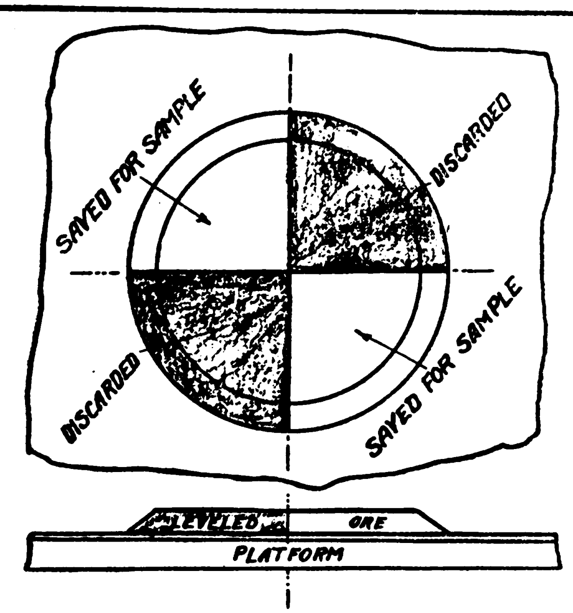
Where mechanical quartering machines are not available and the sample is over 800 pounds, all of the following methods can be used, in their order, to advantage in quartering down the sample. When the sample is less than 500 pounds and over 100 pounds, the Cornish method of quartering can be used. When the sample is less than 100 pound, the method using canvas or oilcloth is good.

CUTTING DOWN SAMPLE WHICH WEIGHS OVER 800 POUNDS. SHOVEL METHOD.

The first of the cutting down to about 500 pounds can be done by the use of shovels. In this method every second shovelful is passed to another platform or a different part of the same platform, which has been well cleansed. The odd ones are discarded. This operation cuts the sample in half. If it is still much too large (over 800 pounds) the above operation is repeated until the sample gets to between 300 pounds and 800 pounds. After it is cut down to this size (about 500 pounds) it is better practice to use the Cornish or Coning method down to about 100 pounds.

CORNISH OR CONING METHOD OF QUARTERING.

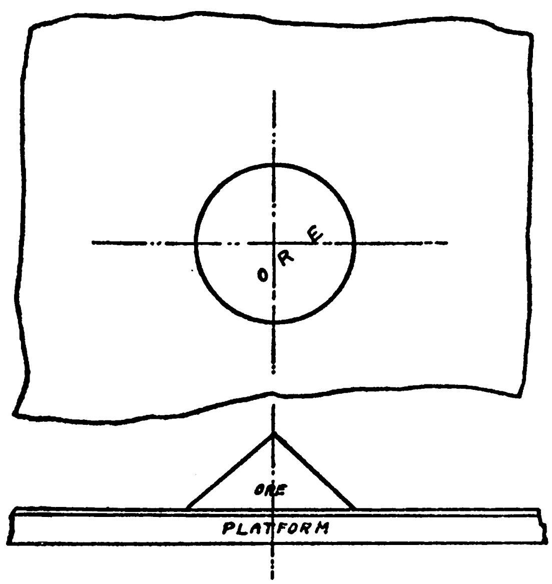
When the sample is not much over 700 pounds this method is used conveniently. The last heap of material from the preceding work of cutting down is leveled to a circular form not over four inches deep, by the use of a hoe, flat-nosed shovel, or a similar tool. The next step is to cone it, which is done in the following manner: From the outside of this leveled heap, 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 is passing once around it, thus making an even distribution of the values.



SKETCH SHOWING QUARTERING OF SAMPLE

After all of the material outside of the cone is piled up in this manner onto the cone, the material is removed to a different platform or a clean part of the same platform and leveled and coned again. This process is repeated until the material has been thoroughly mixed. When this has been accomplished it is then leveled again to a circular form not over four inches deep, and divided into equal quarters by cutting it along two diameters at right angles to each other. The two opposite quarters are discarded.

Much care must be taken in doing this work, as well as to clean thoroughly the parts of the platform where the discarded metal has been in order to prevent salting. If the sample is still too large, more than 200 lbs., the two quarters which were left from the preceding operation are removed to a clean part of the platform where it is leveled, coned, and leveled again to a circular form and divided as before, the two quarters being again discarded. This operation is repeated until the sample reaches about 100 pounds, when the following method should be used:



SKETCH SHOWING ORE CONED

QUARTERING BY USE OF CANVAS OR TABLE OILCLOTH.

The final sample from the preceding work is shoveled onto a square piece of table oilcloth or canvas about 6 feet by 6 feet. After this is done the two opposite corners of the oilcloth are taken, one in each hand. While one of the corners is slowly lowered, the other is raised at the same rate, the lower part of the oilcloth always resting on the ground or platform. This motion rolls and mixes the sample. After this is well performed the first two corners are allowed to fall flat, while the other two are taken in the same way. The sample is again rolled and mixed, but in the opposite direction to the first mixing. This is repeated several times until the sample is thoroughly mixed.

When this has been accomplished satisfactorily the canvas is spread out flat and the sample is leveled to a circular form as described before in the coning method. It is then divided into equal quarters by cutting it along two diameters at right angles to each other, as illustrated in figure (2). The two opposite quarters are discarded as in the coning method and the space where they were is thoroughly cleansed. If what remains is still too large the entire operation is repeated until the sample reaches the desired size. After thoroughly mixing it again the sample is put into a sack with the tag bearing its number for identifying it. It is then ready to be tested.

SECTIONAL SAMPLES.

These are samples taken at a given depth to indicate how the values run at that particular depth. They are usually taken from a section which has the same width completely around the pit or drift. When it is necessary to timber, these samples must be taken before the timber is put in place.

In the sample book record the number of the sample, the date when taken, the number of the pit, and all other data bearing on the sample. Measure down to the top of the section to be sampled from a fixed known elevation, such as the permanent ground level or a nail or stake solidly driven in at a definite elevation. Record this measurement in the sample book, together with the width of the section to be sampled.

The sample is the material which is picked off evenly from every part of this section. A sample pick, drill, or similar tool can be used. A box or other receptacle is held below so that all the material will be caught as it is broken off. A powder box answers this purpose very well. It is well to spread a piece of canvas on the ground below the place from which the sample is taken so as to catch any pieces that may not fall into the box. If the sample is too large it can be cut down, by one of the methods explained before, to the desired size. After being thoroughly mixed, the sample is put into the sack with the tag bearing the proper number, and is then ready to be tested.

DRILL SAMPLING.

Sampling by drilling is done either by the use of an augur drill, or by a churn drill outfit.

AUGUR DRILL METHOD.

The augur drill is a tool similar to that used in drilling post holes. The hole is made by the augur as it is turned, the material raised on the blades of the augur being the sample. It can only be used to advantage in soft ground which does not cave too badly, and only to a limited depth. The caving may be overcome by casing the hole.

Sampling by this method, where it can be used, is by far the cheapest and quickest of any method. It has the disadvantage, in some cases, of having the values concentrate at the bottom of the hole, from which it is next to impossible to extract them, thus tending to give an unfair sample.

The same care and experience in locating the holes to be drilled must be used in this method as in the location of the test pits. The records for sampling by this method are kept in the same manner as for test pits, and the same method for cutting down the samples can be used. After they have been cut down to the desired size they are well mixed, put into a sack with the tag bearing the proper number, and are ready to be tested. The testing of the samples and the method of calculation used will be treated later.

SAMPLING PLACERS BY THE USE OF A CHURN DRILL OUTFIT.

This is one of the very few methods which can be used to advantage when the deposit is deep, where the ground caves and where water interferes. For deep holes the cost per foot of hole drilled is low and the work usually progresses very rapidly.

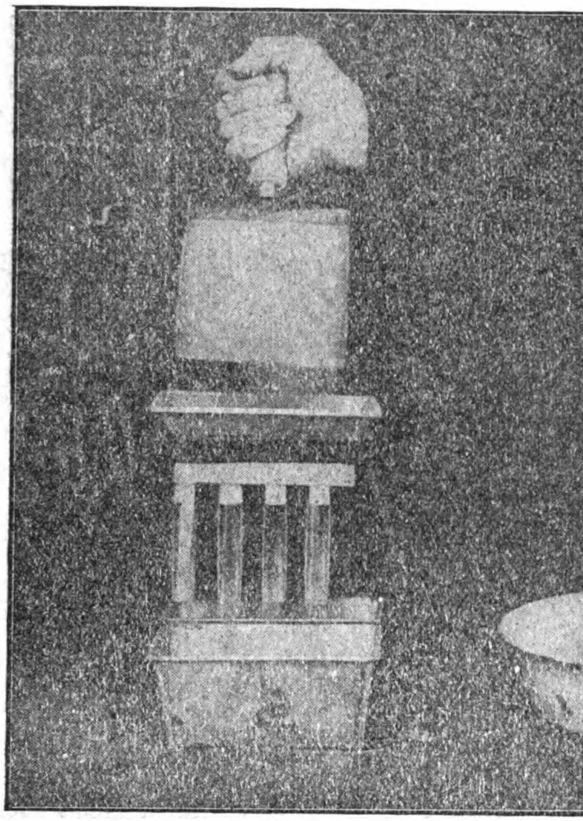
There is the disadvantage of the possible concentration of the values in the bottom of the hole, from which it is difficult to extract them. The values from around the sides of the hole may also be washed down into the sample and salt it. Sectional samples by this method are not considered to be very satisfactory. An expensive outfit is needed to do the work by this method, and unless much drilling is to be done it is found better to let the job to a reliable churn drill contractor who will furnish the rig, casing, and other supplies needed, as well as the skilled operators who are absolutely essential for doing the work satisfactorily. Where the ground caves or water interferes it is necessary to case the hole.

LOCATION OF THE HOLES TO BE DRILLED.

The same care and judgment should be taken in the locating of the points where the holes are to be drilled as is necessary in the location of test pits, and the same matters should be borne in mind when doing this work.

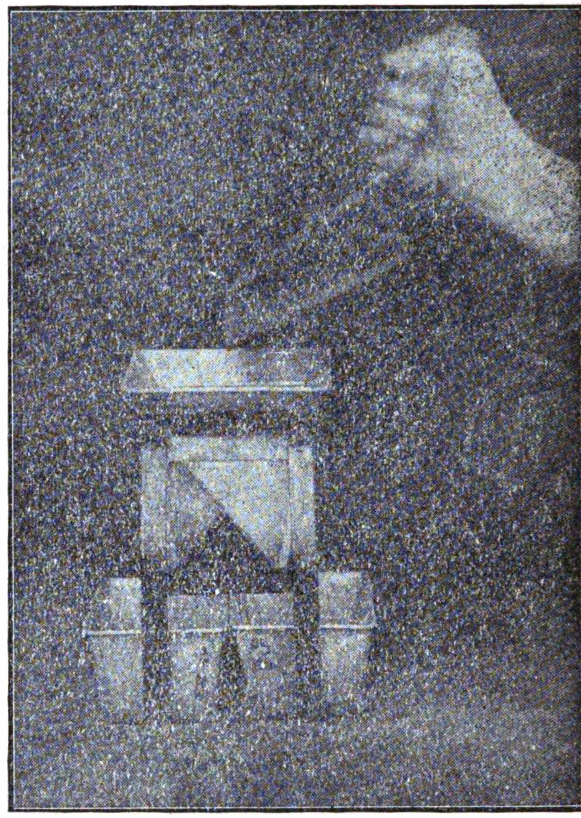
The same general method of procedure in mapping the deposit, taking and numbering the samples, and the care necessary in handling them, must be used for the churn drill work.

The material taken from the hole is usually crushed by the operation of the drill bit to a size smaller than a walnut. If, as in most cases, the sample is much larger than is needed for testing, it can be cut down to the desired size by using the methods heretofore described. The sample from the churn drill hole seldom contains pieces much larger than a walnut and can be cut down very rapidly and accurately by the use of a Jones Sampler. This is an inexpensive apparatus which stands rough handling and is not very bulky. If the work is properly done, the final cut down sample is absolutely accurate and for this reason this machine can be used to advantage, providing the pieces in the sampler are not over one-half as big as the width of the slot in the sampler which is used. It is sometimes advisable to use one large sized sampler in the first part of the cutting down work, cutting down to the final size by using a smaller sampler, the slots of which are narrower than than in the first.



JONES SAMPLER.

On top, the Jones 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 and slot is opposite to the outlet from the second chute and slot. The material is shoveled slowly from a flat-nosed shovel or scoop transversely onto these slots, much care being taken that they do not clog, the material distributed evenly by moving the shovel back and forth from one side to the other of the machine. 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. If the work is properly done, exactly one-half of the material will be caught in each of the pans, and each pan will contain the same values. One operation of the sampler cuts the sample in half. The material in one of the pans is saved for the sample, while that in the other is thrown away. If the sample is still too large, the above operation is repeated until it reaches the desired size. It is then put into its sack with the tag bearing the proper number, tied up, and is ready to be



tested.

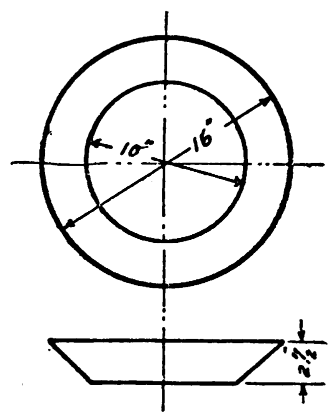
TESTING THE SAMPLES—PURPOSES OF THE TESTING.

The amounts of valuable mineral present and recoverable are the most important points to be decided from the test. Supplementary to this are several other important matters which should be taken into consideration, such as the form in which gold occurs, whether fine, coarse, or flaky; whether clay is present, and to what extent, and all other points which will determine whether or not the deposit can be worked at a profit.

METHODS OF TESTING.

Samples from gold placers are tested by panning or by the use of the dry washer or concentrator, or by both. Only those deposits where the dry washer can be used for working the deposit should be tested by the dry washer. These placers are only found in the deserts, where water for washing the ground is out of the question and where the ground is absolutely dry and free from clay. In all other placers the samples are usually tested by panning. After the panning tests prove satisfactory, tests on a large scale are usually made by using the method decided upon for doing the work.

For testing samples by panning the most important thing is a thoroughly experienced panner. The tools needed are good gold pans, a measuring box, small pans, glass vials, a good pair of balances, and tags. The pans used are the regulation gold pans made from sheet iron and must be absolutely free from grease and rust. They are usually 16 inches in diameter on top, 10 inches in diameter on the bottom, and 2½ inches high.



GOLD PAN

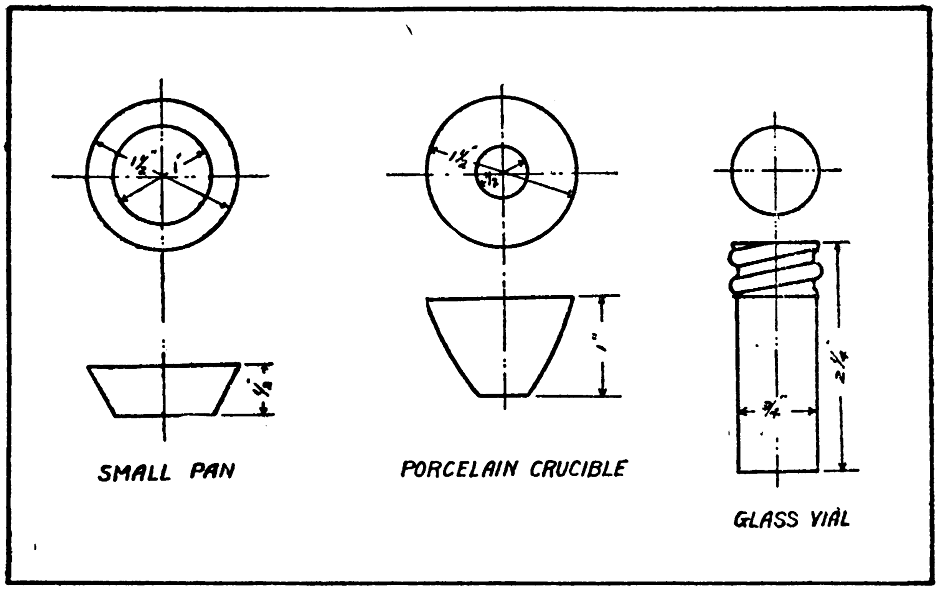
When the value of the gold obtained from the panning of one or more boxes of the dirt is known, it is an easy matter to calculate the value for a cubic foot or cubic yard of the dirt. The following example will illustrate this point:

Suppose four boxes of dirt were panned, and from them were recovered \$0.02 of gold. (Gold figured at \$20 per ounce Troy.) Since there are 8 of the 6"x6"x6" boxes in one cubic foot, and there are 27 cubic feet in one cubic yard, the calculation for this case is the following:

$\$0.02 \times 2 = \$0.04$, the value per cu. ft.
$\$0.04 \times 27 = \$1.08$, the value per cu. yd.

Small pressed steel pans of about one and one-half inches in diameter on top, and one inch in diameter on the bottom, and one-half inch deep, made in the same shape as the gold pans, are very convenient for holding and drying the values after they have been concentrated in the gold pans. Small porcelain crucibles are also used for this purpose. Small stoppered glass vials are sometimes used, especially if the samples are to be transported to a distant place to be assayed and weighed.

The box used for measuring the dirt to be panned can be of any convenient size, the cubical contents of which are known. A very convenient size is a box whose inside dimensions are exactly 6 inches long, 6 inches wide, and 6 inches deep. This box, when filled smooth to the top, holds exactly one-eighth of a cubic foot, or one-two hundred and sixteenth part of a cubic yard.



A good set of balances with a standarized set of weights should be used for the weighing of the values recovered. It would be poor business to do all of the work well and then use an inaccurate set of balances to do this very important part of the work.

For identification purposes a tag must accompany each sample, and the concentrate from it. This tag always bears the number of the original sample from which it was taken and all additional data which applies to this part of the sample only, such as the number of boxes of dirt washed to obtain the concentrate, the method used in the testing, to obtain the sample, the condition and kind of the dirt, etc., etc.

WEIGHING OF THE SAMPLE.

After the sample is brought to the place where the testing is to be done, the measuring box is filled and weighed. The weight of the sample is the total weight minus the weight of the empty box or receptacle. Since the cubical content of the box is known, the weight of a cubic yard of the dirt can be calculated. This is needed in order to make the calculations from the gold per ton to the gold per cubic yard.

FIRE ASSAY OF PART OF THE SAMPLE.

At this point in the work a part of the original sample should be taken to be assayed by the fire method. This will give the exact mineral content of the sample, and from the value obtained the mineral present in the deposit can be calculated. The assay values are only used for calculations for the gold present, and are always given by assayers in ounces Troy—per ton (2000 pounds avoirdupois) of dirt, so that from this it is necessary to calculate the value per cubic yard of dirt.

PANNING.

One or more boxes of the dirt, as desired, are then dumped into a gold pan and panned, the amount of dirt from each sample which is panned to get each concentrate being recorded on its tag and in the sample book. This operation needs no explanation as those connected with placer mining are usually expert at this class of work. After all of the dirt is washed out and only the concentrates remain, there are two common methods of procedure for separating and collecting the gold from the black sand and other impurities which are always found in placers. One of the methods is to assay the concentrates by the fire method and weigh the resulting gold bead. This gives the amount of gold recovered from the amount of dirt panned, and the gold recoverable from a cubic yard can be easily calculated. This method is perhaps the quickest, most accurate, and cheapest of any. The other method is to add mercury or quicksilver to the concentrates and amalgamate the gold. The amalgam is then retorted. This operation removes the quicksilver and leaves the gold in the retort, from which it can be removed and weighed.

The values in this operation are for the gold recoverable from a cubic yard of the dirt, and are only used in the calculations for the gold recoverable. The practice of washing the black sand and other impurities in a horn is not recommended, as much of the value may be washed away and lost, thus giving an unfair result.

TESTING WITH THE DRY WASHER.

The same general method of procedure can be followed as above outlined, if the sample is to be tested by the dry washer in the actual testing. A sample of at least 100 pounds is needed.

From the above operations the value of the gold present and recoverable per cubic yard is determined for each sample. It is then necessary to determine the gold present and recoverable from the entire deposit. This work requires the services of a man experienced in engineering calculations.

CALCULATIONS FOR THE VALUES OF THE DEPOSIT.

Two separate and distinct calculations should be made to determine these. One is for the gold actually present, and for this calculation the value as determined from the fire assay of the original sample before it was panned is used. The other calculation is for the gold recoverable, and in this calculation the values obtained after the samples have been panned are used.

GOLD PRESENT.

The gold present in a deposit is found in the following manner: The cubical volume of each section is calculated from the cross sections which are taken from the topographical map. The depths used are as found in the test pits, except they should be adjusted as determined by the contours of the bedrock.

The gold present for a section is the product of the cubical contents of the section multiplied by the gold value per cubic yard, as determined by the fire assay of the original sample taken from the test pit for that section before the sample was panned. The gold present in the entire deposit is the sum of gold present in all the sections.

GOLD RECOVERABLE.

The same method as described above is used for determining the cubical contents of each section. The gold recoverable for a section is the product of the cubical contents of the section multiplied by the gold value per cubic yard, as determined from teh results obtained from the panning or dry washer tests.

After the above results have been obtained it is usually desirable to make a valuation of the deposit.

VALUATION.

The purpose of the valuation of a placer deposit is to find out the net profit obtainable after all charges have been deducted.

As there are no two placer deposits exactly alike, and as all differ so much from each other, it is impossible to give anything but a few suggestions as to what has to be taken into consideration in this matter. In addition to the estimation of the gold recoverable by the process of extraction decided upon, management, climate, labor, power, fuel, water, transportation, equipment, food supplies, interest on investment, depreciation, government regulation, kind of government, etc., etc., are some of the many items which are important and must be taken into consideration in the calculations for making the valuation of any placer deposit. For the above reasons it seems advisable to have a thoroughly competent, reliable and experienced engineer supervise and be made responsible for the valuation of a placer deposit. The work will not only be correctly done, but the report on the deposit as submitted by the engineer will be accepted by everybody as authoritative.

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SAMPLING SERIES No. 2 SEPTEMBER 20, 1917

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 tp 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 proceedure 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 recovered 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.

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.

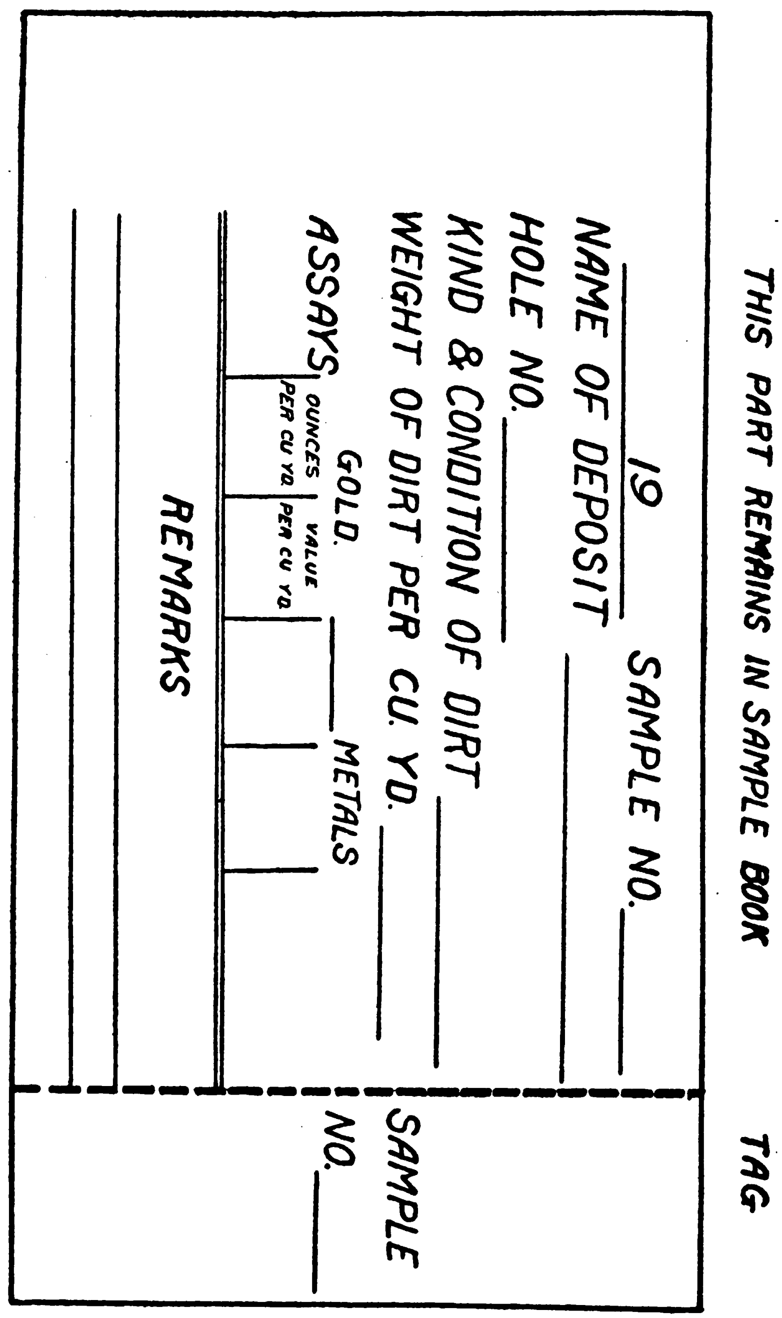
The form on Page 6 represents one of the pages used in a sample book, but this form should be changed, if necessary, to meet the requirements of any particular job.

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.



BLANK PAGE FOR A SAMPLE BOOK

THIS TAG IS PUT IN SACK WITH SAMPLE

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 proceedure 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 proceedure 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.

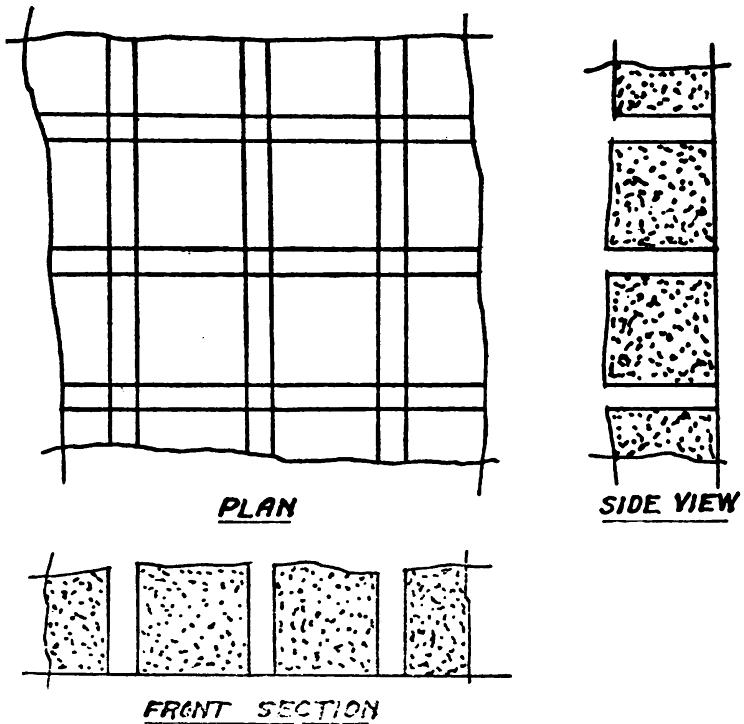
Crosscutting is usually impractical in tailings heaps, owing to the fact that the material usually caves easily, and if the crosscuts are broader at the top than at the bottom, there is more material taken for the sample from the top, and for this reason the sample is sure to be unfair unless all of 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.



SKETCH SHOWING
CROSSCUTS IN ORE DUMP

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.

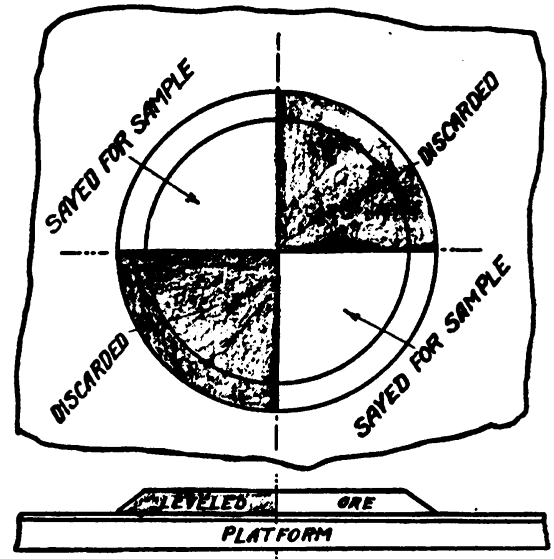
The leveling of the final cone to a circular form should be done very carefully, as usually the finest particles lie close to the apex of the cone, and as these usually carry the highest values, they should be distributed as evenly as possible in each of the four quarters.

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.

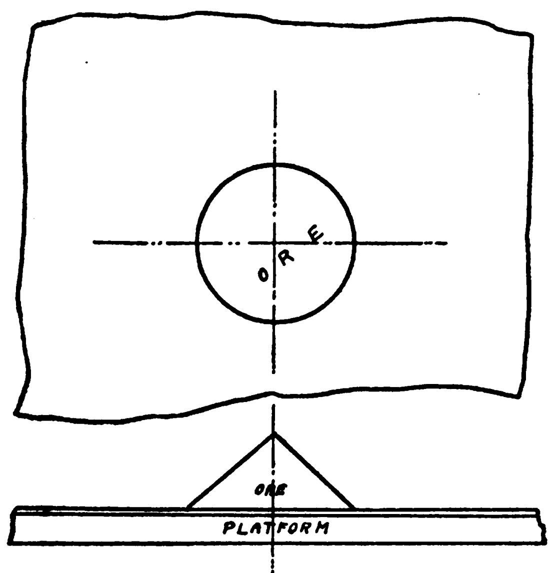
The sketches on Page 14 illustrate the above.

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

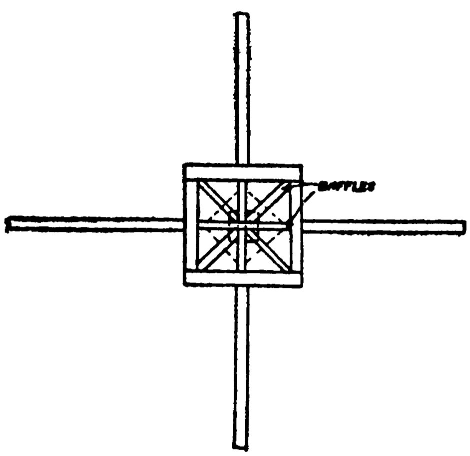


SKETCH SHOWING ORE CONED

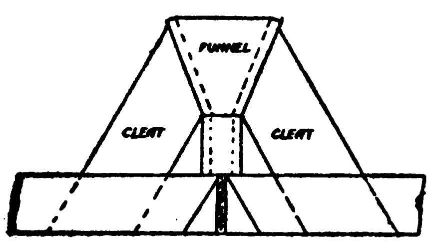
by cutting it along two diameters at right angles to each other, as illustrated above in Sketch No. 3.

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.



PLAN



ELEVATION

CROSS
FOR
QUARTERING DOWN SAMPLES

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 2-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.

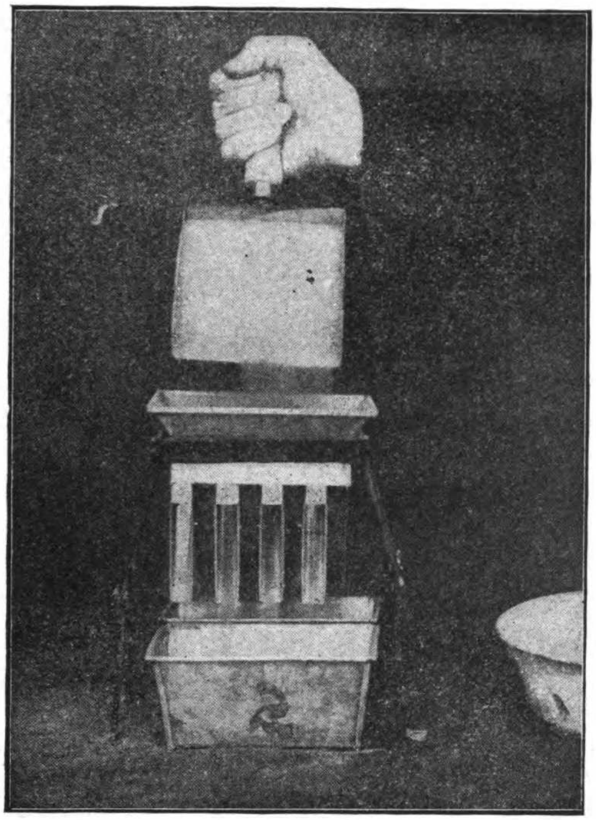
The material of the sample between the arms of the cross in the two opposite quarters, is saved for the sample, as was explained under the coning method. That in the other two quarters is discarded. The space between the arms of the cross where the rejected parts have been, is well brushed and cleaned 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.

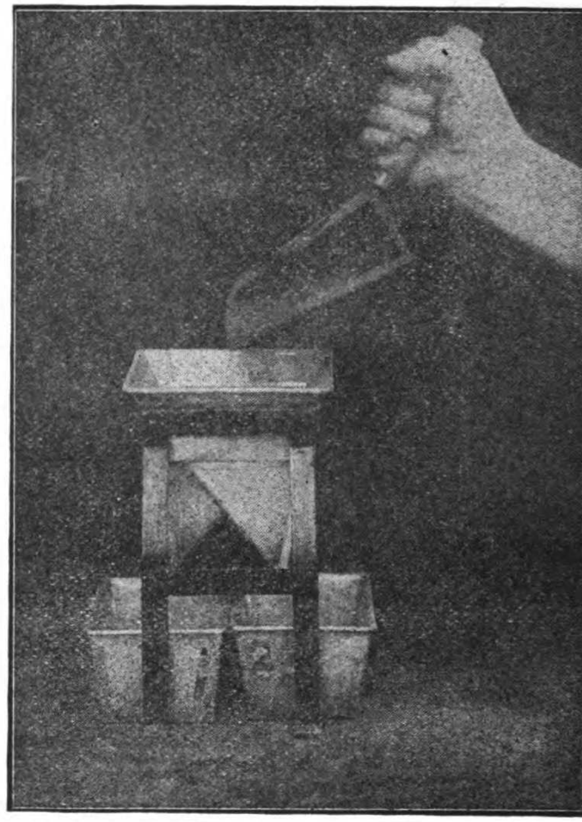
On top, the sampler has a row of horizontal slots, all of which have the same length and width. From each one of the slots runs a chute, every second chute running in the same direction; that is, the outlet from the first chute is opposite that of the second, and so on. The material is shoveled slowly 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 crosscut 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.

VALUATION 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.

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Sampling Mineralized Veins

BY

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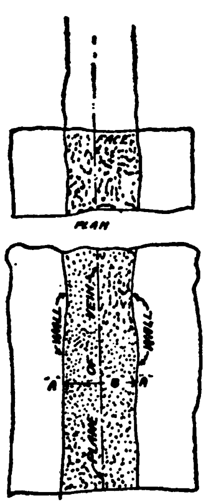
TAKING SAMPLES AND MEASURING THE WIDTH OF A MINERALIZED VEIN

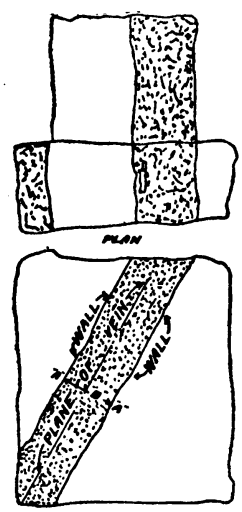
BY GEORGE R. FANSETT

Taking samples and measuring the width of an ore body are matters which everyone connected with the mining industry should be able to do properly. The purpose of this bulletin is to describe the methods generally used by many engineers, so that one may understand how to do this very important class of work correctly.

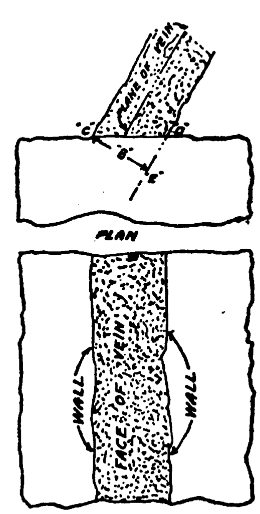
The width or thickness of a vein at any point is the distance between the walls of the vein, measured along a perpendicular or at right angles to the plane of the vein at that particular point. For this reason there is only one width or thickness of a vein for each point or location in it. The following sketches illustrate this:



FRONT VIEW
FIG. 1



FRONT VIEW
FIG. 2



FRONT VIEW
FIG. 3

Figures 1 and 2 illustrate veins the faces of which are at right angles to the plane of the vein. In cases of this kind it is a simple matter to make this measurement as "B". In a case like that shown in Fig. 3, where the exposed face of the vein is not perpendicular to the plane of the vein, it is often difficult to make this measurement correctly. In such instances there usually arises a great difference of opinion as to the width of the vein, unless the measurement is properly made.

One of the best methods for making the measurement is to hold the Zero (°′) end of the tape or rule at the contact of the wall of the vein as at "C", shown in Fig. 3. With the tape or rule held perpendicular to the plane of the vein, the reading on the tape where the other wall, if projected as at "E", would hit the tape, will give the true width, "B"—("C" to "E") for the vein at that particular point. "C" to "D" is not the width of the vein.

In mining terms a sample is usually considered to be a collection of fragments or pieces from a deposit which contains exactly the same minerals in the same proportion as they exist in the deposit from which they were taken. The act of collecting these pieces is called sampling. The material from a cross section or core, from a vein at any point in the vein represents a true sample of the vein at that particular point. Fig. 4 illustrates this.

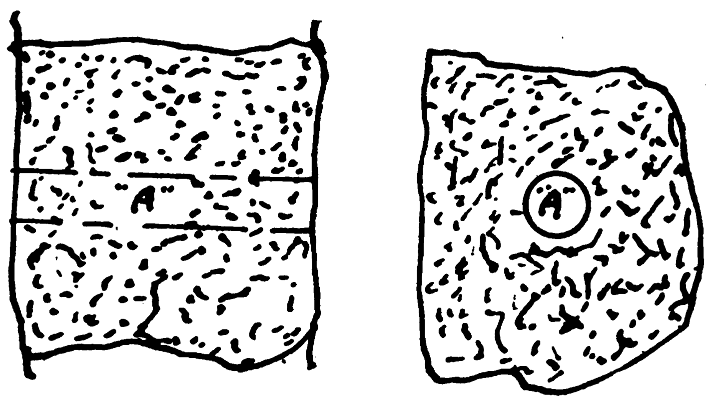


FIG #4.

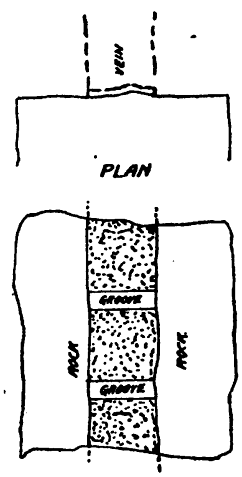
All of the material or core taken from the hole "A" represents a true sample from the vein at "A", but at no other point in the vein.

The above represents ideal sampling, and can sometimes be approached by the use of a diamond drill or other similar apparatus, but owing to the high cost and other considerations, it is seldom possible to sample a mine in this way. For these reasons, most engineers use methods which are quicker and cheaper, with the intention of approaching in accuracy the ideal case as closely as possible.

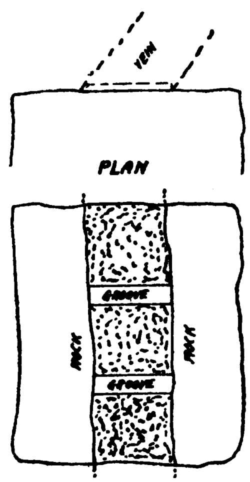
For this work many engineers sample veins by chiseling or hewing a channel shaped groove across the width of the vein, catching the material which is hewn out and using this material for the sample for that particular point of the vein.

The following sketch illustrates how these grooves appear on the face of a vein after being cut.

Figure 5 represents a vein whose face is perpendicular to the plane of the vein. In either case the sample taken from the groove will be a fair sample, since the same proportion of minerals present is maintained. The only difference in the two cases is that the samples from No. 6 will be larger than from No. 5. The width of the vein should be measured, as explained before.



FRONT VIEW
FIG #5



FRONT VIEW
FIG #6

The groove which is chiseled out should have as nearly as possible the same width throughout its entire length. In most cases, a fair sample can be taken from a groove from three to six inches in width. The point must be decided for each particular sample, and will depend upon the hardness of the rock, the kind of ore deposit, the size of the sample wanted, and many other factors, each one of which will help to decide this important point.

The groove should have the same depth throughout its entire length if the face is fairly straight. In cases as illustrated in Fig 7, the groove should be chiseled to a greater depth nearing the center than at the sides. This is for the purpose of keeping the same proportion in the sample as they exist in the vein.

A fair sample can usually be obtained from a groove one-half an inch to three inches in depth. This, like the width of the groove can only be decided on the ground.

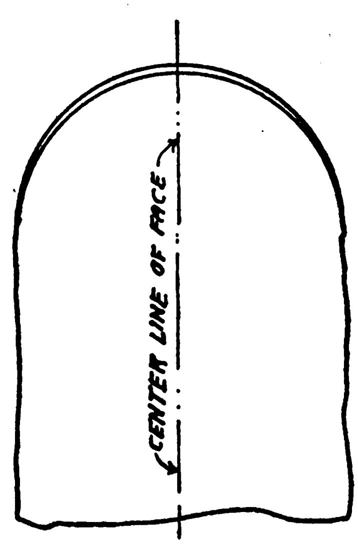


FIG. #7

Engineers usually use moils or gads for hewing out these grooves. For striking the moil, a single jack (four pound miners' hammer) is very serviceable. If the vein matter is particularly hard, a double jack (eight to ten pounds, two handed, miners' hammer) is better.

The sample pick is seldom, if ever, used where great accuracy is wanted, and is not favorably looked upon by most engineers for doing this class of work. The reason for this is that it tends to pick out the softer spots in a vein. Since the soft material is usually the richer material of the vein, and the hard the leaner, it is easily seen that the sample take in this manner may be worthless as a true sample for that vein. The sample pick can sometimes be used to advantage by a thoroughly experienced sample man, when great accuracy is not desired.

The geologist's hammer is likewise not used for this work, as it tends to hit the projecting parts of the vein, and as these hard parts are usually made up of the leaner material, the sample may be worthless.

The practice of putting in a pop shot to break out the sample in no manner represents sampling. Even if the rock which is broken out by the shot is carefully quartered down, it cannot be considered a sample of the vein. The reason for this is that the shot usually tends to break out a conical shaped cavity whose axis is the drill hole and whose apex is the inside end of the drill hole. For this reason, a greater amount of the rock around the outer end of the drill hole will be broken than around the inside end. This, of course, would give a collection of fragments or pieces of rock that does not contain the same minerals in the same proportion as they exist in the vein, and for this reason, if for no other, it is valueless as a sample from the vein.

The practice of gouging out a specimen from the heart of a vein and giving the entire vein the values which have been derived from this specimen, of course needs no comment.

The grab sample for accurate sampling is likewise looked upon unfavorably by engineers, as one is almost bound to take the bright high valued pieces from a dump or deposit, if his eyes are open, and if he closes them he will usually get either too much of the fines or the lean rock. In any case, it is likely to be of no value for accurate sampling.

A powder box or other convenient receptical is useful in catching the pieces of the sample as they are hewn from the groove. It should be held as close as convenient below the cutting tool so as to catch all that is hewn out. Great care should be taken that none of the material making up the sample is lost.

For doing this work, at least two men are needed, one to do the cutting and the other to hold the box, keep the records and superintend the work generally. They should take the greatest care in every detail of the work, for, if one part is poorly done it may make valueless all of the work connected with that particular sample.

In some cases, especially when taking samples from an ore body whose ore leaches readily, or when the exposed face is very rough, it is desirable to break down and smooth off the exposed face. This makes it not only easier to get a true section from the vein, but in the case of minerals which leach easily, one gets back into the ore body proper, and is not so likely to get a high grade or salted sample.

In cases where the vein only occupies a part of the face of the drift, it is often better to take for the sample of the vein the material hewn out from the vein. The material from the hanging wall can be put in a different sack and that from the foot in another. It will thus be possible to analyze each separately if desired. This matter can be settled for each particular sample.

In cases where the vein is so wide that the sample will be altogether too large, it is convenient to measure off certain distances on the vein and take samples from them, records being kept so as to identify each sample.

The samples taken in this way are usually much larger than is needed for the assays or analysis which are to be run on them. In these instances it is necessary to cut them down. Methods for cutting down samples to the desired size, and for keeping the records of the work, were described in Arizona State Bureau of Mines Bulletin No. 63, Sampling Ore Dumps and Tailings Heaps.