

BRITISH COLUMBIA DEPARTMENT OF MINES  
HON. W. K. KIERNAN, *Minister*      JOHN F. WALKER, *Deputy Minister*

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BULLETIN No. 18

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SPECIMENS AND  
SAMPLES  
THEIR TREATMENT AND USE

*by*

OFFICERS OF THE DEPARTMENT OF MINES  
VICTORIA, B.C.



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Printed by DON McDIARMID, Printer to the Queen's Most Excellent Majesty  
1956

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## PREFACE

This bulletin, written for the prospector, deals with the specimens and samples he takes in the field and the treatment they receive in the Department of Mines laboratories in Victoria. Specimens and samples are taken for different purposes and accordingly are different in character. Specimens are taken largely to permit identification of minerals, and samples are taken to permit assays or chemical analyses that determine how much of various metals or other constituents are contained in the sample.

This bulletin brings out the differences between specimens and samples; the usefulness of each; how they should be taken, labelled, and shipped; and how specimens and some samples can be studied in the field. Amongst other things, it stresses the need for proper care in taking specimens and samples, in making records concerning them, in packaging and shipping them, and in sending instructions to the laboratory. These items are important whether material is sent to the laboratory of the Department of Mines or to any other laboratory. A later part of the bulletin describes how specimens and samples are examined and assayed in the Department's laboratory in Victoria.

In reprinting this bulletin in 1956, some changes in the arrangement of the subject-matter have been made and changes have been made in the text.

# Specimens and Samples, Their Treatment and Use

## FREE ASSAYS AND MINERAL DETERMINATIONS

In the Department of Mines laboratories, rock and mineral specimens found in British Columbia are identified without charge.

An independent prospector whose occupation during the summer months is prospecting may complete and file the Department of Mines Application for Free Assays. On acceptance of the application, the Department will perform a reasonable number of assays for him that year without charge. Application blanks are obtainable from the office of any Mining Recorder. Assays will not be performed on samples that are obviously not representative (*see p. 9*).

Those not eligible to have free assays performed in the Department laboratory and prospectors desiring more assays than the Department will perform without charge may send their samples to a firm of assayers and analysts, of which there are several in British Columbia.

When he submits a sample for assay, the prospector must attend to the items dealt with in the next section.

## INSTRUCTIONS FOR LABELLING, RECORDING, PACKAGING, AND ADDRESSING OF SPECIMENS AND SAMPLES FOR SHIPMENT TO THE DEPARTMENT OF MINES

The shipper should make sure that every sample or specimen that he sends in is identified by an individual number or other symbol on a tag or slip of paper accompanying the specimen or sample, and that the tag or slip of paper has on it clear instructions that he wants the rock or certain minerals determined, or a sample assayed for certain metals, or that he wishes to know whether or not it contains anything of value.

The practice of ringing, with crayon, the parts of a specimen containing a mineral to be determined, and of actually selecting loose grains of mineral or of material from pan concentrates, will remove any doubt that it is the desired mineral which is being determined.

To avoid confusion and in order that essential information shall not be forgotten, the prospector should keep a precise written record of each specimen or sample for his own use. The record should include the number or other symbol used to identify the specimen or sample and should include most of the following information:—

The date; the place; the nature of the material represented; its relation to other rock near by; the purpose for which a specimen is taken; and, for samples, the width sampled, the position from which each sample is taken, and the metals for which it is to be assayed.

If several specimens or samples are taken, it may be advantageous to make a sketch showing the position of each relative to the others, to the workings, and to the boundaries of the mineralized body from which each was taken. If several people are working together, the name of the person who took each sample or specimen should also be recorded. As the best possible record of the nature of a specimen, it is well, in addition to the written record, to keep a duplicate specimen, properly labelled.

For the convenience of prospectors the Department of Mines now issues specimen or sample tags, stapled together in booklets of ten sheets, with a cover giving directions for their use. Each sheet is printed on special strong water-proof paper. Bona fide prospectors may obtain these booklets, free of charge, from any Gold Commissioner, Mining Recorder, or Sub-Mining Recorder.

Each sheet of the booklet consists of two identically printed halves, separated by a line of perforations. The sheets are numbered serially; both halves of a sheet bear the same serial number. One sheet should be used for *each specimen or sample*. When taking a specimen or sample, both the upper and the lower halves of the sheet should be filled in. The upper half is retained by the prospector as his own record, to refer to when he receives the laboratory report; the lower half, properly filled in, is torn off at the perforations, folded so as to protect the writing and enclosed with the sample or specimen being sent to the laboratory.

The number on the tag serves to identify the specimen or sample, since no two tags issued by the Department of Mines bear the same number. If the tag is properly filled out, no covering letter need be sent to the laboratory for that particular specimen or sample.

The tag should be filled out in the following way. Whether for a specimen or a sample, fill in the sender's name, address, submitter's mark (if any), date, district, property, and locality. If the specimen or sample was obtained on a mineral claim, the claim or the property name should be given, otherwise the locality only is stated. The remaining information required on the tag depends on whether the material is a specimen or a sample. *If a specimen*, ignore the "Width sampled" space and the "Assay for" space. In the "Remarks" space state that the material is a specimen, and state the purpose of sending the specimen; e.g., describe the minerals you want identified. *If a sample*, state the "Width sampled" if the sample is taken across a measurable width, but if the sample is not representative of the measurable width, state what it is; e.g., grab sample from pile of ore, grab sample at intervals along 60 feet of outcrop, etc. State what metals to assay for, and use the "Remarks" space if necessary to describe further what sort of laboratory examination is wanted. A sheet properly filled out for a sample is illustrated on page 6, and one properly filled out for a specimen is illustrated on page 7.

If any prospector does not use these specimen and sample tags, he should be sure that he keeps an equivalent record in a note-book, and that each specimen or sample sent to the laboratory is accompanied by a slip of paper or thin cardboard on which he has written the identifying number or other symbol, the mineral determination or the assay desired, and the other information mentioned in the preceding paragraph, not forgetting his name and address. If he wishes to write a letter about the desired work, the letter must be sent separately, as inclusion of a letter in a parcel is contrary to postal regulations.

Samples and specimens, each properly labelled, each specimen individually wrapped, and each sample enclosed in a clean strong cotton or paper sack, should be sent to the laboratory, *strongly wrapped in paper or enclosed in a sack or box, and sent prepaid to The Chief Assayer, Department of Mines, Victoria, B.C.* The Department supplies printed shipping tags with the proper address printed on them. These tags can be obtained free by bona fide prospectors from the Department of Mines at Victoria, or from any Gold Commissioner, Mining Recorder, or Sub-Mining Recorder in the Province.

On request made to the Department of Mines, Victoria, a limited number of sample sacks will be loaned to bona fide prospectors free of charge.

## DEPARTMENT OF MINES.

Nº 2482

## SPECIMEN OR SAMPLE TAG.

Taken by John Doe  
Address Kelly Lake P.O.  
Submitter's mark (if any) \_\_\_\_\_  
Date Aug. 17, 1943  
District Upper French Bar Creek.  
Property and locality Bonanza Claim, 3 mi. N.W. Swan  
Lake; north end of cut, 100 yd. W of cabin  
Width sampled 3 ft. full width of vein  
Assay for Gold & silver  
Remarks Quartz mineralized with  
pyrite

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## DEPARTMENT OF MINES.

Nº 2482

## SPECIMEN OR SAMPLE TAG.

Taken by John Doe  
Address Kelly Lake P.O.  
Submitter's mark (if any) \_\_\_\_\_  
Date Aug. 17, 1943  
District Upper French Bar Creek  
Property and locality Bonanza Claim, 3 mi. N.W. Swan  
Lake; north end of cut, 100 yd. W of cabin  
Width sampled 3 ft. full width of vein  
Assay for Gold & silver  
Remarks Quartz mineralized with  
pyrite

## DEPARTMENT OF MINES.

Nº 2483

## SPECIMEN OR SAMPLE TAG.

Taken by John Doe  
Address Kelly Lake P.O.  
Submitter's mark (if any) \_\_\_\_\_  
Date Aug. 18, 1943  
District Upper French Bar Creek  
Property and locality Bonanza claim, 3 mi NW Swan Lake; south end of outcrop, 200 yd. W. of cabin  
Width sampled \_\_\_\_\_  
Assay for \_\_\_\_\_  
Remarks Specimen, from quartz vein, determine dark mineral ringed with blue crayon.

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## DEPARTMENT OF MINES.

Nº 2483

## SPECIMEN OR SAMPLE TAG.

Taken by John Doe  
Address Kelly Lake P.O.  
Submitter's mark (if any) \_\_\_\_\_  
Date Aug. 18 1943  
District Upper French Bar Creek  
Property and locality Bonanza claim, 3 mi NW Swan Lake; south end of outcrop, 200 yd. W. of cabin  
Width sampled \_\_\_\_\_  
Assay for \_\_\_\_\_  
Remarks Specimen, from quartz vein, determine dark mineral ringed with blue crayon

## TAKING SPECIMENS AND SAMPLES AND THEIR TREATMENT IN THE FIELD\*

### SPECIMENS

A good specimen consists of one or more pieces typical of ore, mineral, or rock, large enough to show the character of the material. Specimens are especially useful for close study, either in the field or in the laboratory, thus permitting exact identification of rocks or minerals. They are also useful as records, to assist the memory, and permit comparison with specimens from different points or with rock in place.

A specimen may be studied in the field with the aid of a hand-lens, pocket-knife, and other simple equipment, thus obtaining immediately information of great value in prospecting; or the specimen may be studied more elaborately in a laboratory, where microscopic examination may be made of a polished surface—if it contains sulphides, or of a thin section or powder for determination of translucent minerals, or chemical tests may be used to determine minerals. It should be noted that these are distinctly different procedures from quantitative analysis (assaying) applied to samples.

Care, patience, and, at times, hard work are required in selecting and breaking proper material for specimens, and in trimming rock specimens to suitable size. Identifying weathered material may be difficult and unsatisfactory, and as weathering rarely goes deep in British Columbia, we are usually interested in fresh, unweathered rocks and minerals. For these reasons a specimen should consist of unweathered material, and several sides of an ore or rock specimen should be freshly broken. As a specimen of an ore or rock, a piece 1 by 2 by 3 inches is usually large enough. A few grains or even a single crystal may be enough to permit identification of a mineral; however, it is better to have too much than too little.

Concentrates, or grains selected from concentrates, obtained in panning unconsolidated material or vein matter that has been properly prepared, may be used as specimens. Further reference to concentrates will be found later under the headings "Study of Specimens and Samples in the Field," page 14, and "Sampling Unconsolidated (Placer) Deposits," page 13.

If the prospector is interested in a particular mineral in a specimen, it is a good idea for him to use a crayon to mark a ring around the part of the specimen in which that mineral is found. If interested in the identification of grains of some particular material or mineral in gravel or in a placer concentrate, it is best to separate that material or mineral. Marking or separating the material of interest will be of use when studying the material later; and if the material is sent to a laboratory for study, there will then be no room for doubt concerning the particular mineral or grains of material in which the submitter is interested.

Each specimen should be identified by marking it with an appropriate number or other symbol, lettered with india ink or with crayon on an unimportant part of the specimen, or the symbol may be lettered on a piece of adhesive tape and stuck to the specimen. Another method is to wrap with the specimen a sample or specimen tag or a piece of paper or thin cardboard on which the symbol is written or printed. A suitable record should be made at the time each specimen is collected; suggestions for the record are given on pages 4 to 7.

Bruises, scratches, or other damage reduce the usefulness of specimens. Therefore, each specimen should be protected by being wrapped carefully in several thicknesses of paper—say, half a sheet of newspaper to an average specimen. It is particularly necessary to have specimens individually wrapped and labelled if several of them are to be carried in a pack-sack or shipped in one package.

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\* By H. Sargent, Chief of the Mineralogical Branch.



## SAMPLES

A sample consists of a relatively small quantity of material (usually a few pounds) taken to represent part of a mineral deposit or a quantity of broken material. Samples may be taken from lode deposits (veins or other mineralized bodies of rock) or from unconsolidated material (placer). To be of use, a sample must be taken in such a way that the assay\* of the sample will correspond closely with the grade of the section sampled. A well-taken sample from a lode deposit consists of many small pieces of rock taken in a systematic, uniform, and impartial manner. Only such a sample can be considered representative.

The assaying (quantitative analysis) of a sample, done in the chemical laboratory or assay office, is an elaborate process which calls for the use of valuable materials and of the assayer's time. Therefore, assays are warranted only on samples which were well taken. The Department of Mines laboratory will not perform assays on samples that obviously cannot be representative and, therefore, do not warrant the cost of assaying.

At this point it is in order to say that the compositions of most minerals are well known, and that one has only to turn to one of many books on mineralogy to learn that pure galena, for example, contains 86.6 per cent lead, or pure chalcopyrite 34.5 per cent copper. Therefore, there can be little point in sending in one or two lumps consisting essentially of one well-known mineral to be assayed for its principal metallic constituent. However, there may be very good reason for having assays made to determine the higher-priced metals that may be present in small but important quantity intimately associated with, or in some cases actual minor constituents of, pure minerals. Thus we might well need to have determined the gold and silver content of samples consisting essentially of galena or chalcopyrite or the cadmium or indium content of a sample consisting essentially of sphalerite.

In the following general discussion reference will be made to lode deposits, but the principles also apply in sampling placer deposits. Procedure followed in taking samples is outlined at a later point under the heading "Sampling Lode Deposits." The intervening paragraphs outline uses of samples and principles of sampling.

PRECISE SAMPLES, properly spaced, permit outlining closely whatever parts of a mineralized body are of commercial grade, and make it possible to calculate precisely the average grade of each part sampled. If the workings, other exposures, or drill intersections, demonstrate the continuity of profitable mineralization vertically as well as horizontally, it is possible to calculate the volume and average grade of the orebody.

Precise samples are usually taken by or under the supervision of an engineer. Each sample is taken with elaborate care and each measurement is made closely and recorded accurately. If a property is being considered for purchase, any orebody that has been indicated will be sampled in this manner. The sampling will cover the full width of the orebody and sample sections will be spaced at intervals of a few feet along the strike.

INDICATOR SAMPLES are taken as a preliminary step in examining a mineral deposit, or to assist prospecting for and exploration of mineral deposits by giving indications of the distribution of values and the kind of mineralization with which values are associated. Indicator samples are taken in the same manner as are precise samples, but as they are not to form the basis for close estimates of the grade of an orebody, some of the refinements used in taking precise samples can be omitted. In general, prospectors take indicator rather than precise samples.

The person taking indicator samples should keep clearly in mind the fact that he requires reliable information, which is only obtained if reasonable care is used. A sample consisting of one or two pieces knocked from an outcrop or picked from a pile of broken material cannot be depended upon to represent fairly the mineralized body or pile of broken ore.

\* Assays are expressed as "troy ounces per ton" for precious metals (gold, silver, platinum, etc.), and as percentages for base metals or minerals.

**PRINCIPLES OF SAMPLING.**—Mineral deposits are usually much smaller in one dimension than in the others, and this smaller dimension—width or thickness—is usually at right angles to any banding or layering of the deposit. As values are apt to be different in adjoining bands or layers, a sample taken at right angles to them will give most information about the average grade of the deposit. For this reason, samples should be cut across the mineral deposit and not along it. The most favourable section for sampling is at right angles to the walls of the deposit, but in steeply dipping veins samples are frequently cut in horizontal sections that are not quite at right angles to the walls unless the vein stands vertically. The important dimension for any sample is the width which it represents. A sample width of 5 feet means that the sample was cut across a width of 5 feet, which may be the full width of the mineral deposit or may be part of the width. In the latter case such other samples as are necessary are cut so that the full width of the deposit is represented.

A sample must be typical of the material it is to represent, and also must represent quantitatively all the constituents of the material sampled. That is, a sample should contain all the minerals in the same proportion as they exist in the material sampled, and should contain the same volume of material from each inch of width sampled. Thus in sampling a banded vein, if one band is twice as wide as another, the sample must contain twice as much material from the wider band as it does from the narrower one.

Usually metallic minerals, and especially the precious metals, are irregularly distributed through the gangue (quartz or other rock-forming minerals). The gangue is usually harder, more difficult to break, and less apt to break into fine grains than are the metallic minerals, and brittle material is apt to fly off and be lost when it is broken. To be truly representative the sample must contain the proper proportion of all parts of the material sampled, regardless of the ease or difficulty in breaking. It is worth noting that a sample containing an excessive proportion of either coarse or fine material usually will not truly represent the section sampled.

A sample must be large enough to represent fairly the various kinds of material in the rock sampled. In general, the more uniform the material sampled, the smaller the sample may be. Provided samples are taken fairly, the larger the sample, the better will be its chance of being truly representative. But merely taking a large sample is not enough. *Good sampling requires taking an equal quantity of rock from each unit of width in a section, usually at right angles to the walls of the mineralized body.* From 1 to 2 pounds of material is usually taken per foot of width sampled. If the values are distributed very irregularly, a quantity greater than 2 pounds per foot of width may be required. Because mineralization is rarely uniformly distributed, several and often many samples will be needed if the grade is to be estimated accurately for an entire mineral deposit even of moderate size.

If the differences in hardness of the various bands or parts of a mineralized body are not great, a fair sample can usually be cut, provided a conscientious effort is made to include a uniform quantity from each inch of width across the mineralized body, regardless of the hardness or of the amount of mineralization. If there are marked differences of hardness or of mineralization, more dependable results will be obtained if the total width to be sampled is divided into parts, each of which consists of material of about the same hardness and degree of mineralization, and a separate sample is taken from each part. Let us suppose that a vein 4 feet wide includes 6 inches at the hangingwall heavily mineralized with sulphides, that the adjoining 2 feet 3 inches consists of quartz with scattered grains of sulphides and that the remaining 1 foot 3 inches to the footwall consists of vein matter that has been crushed to small fragments. In this case three samples should be taken to represent the full width of the vein (Fig. 1).

Because failure to take an entirely uniform quantity of material for each unit of width sampled is less serious if the sample width is not too great, and because the distribution of values is indicated more clearly by samples of moderate rather than large width, the maximum width from which a single sample is taken is usually not more than 3 to 5 feet.

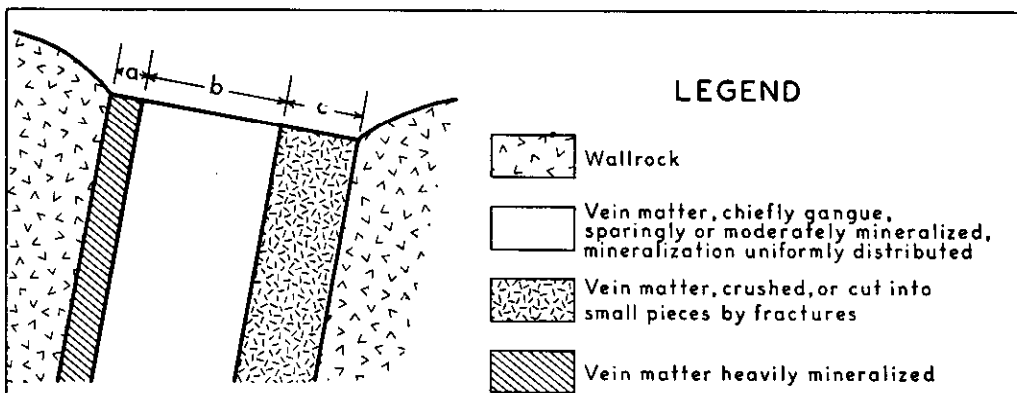


Figure 1

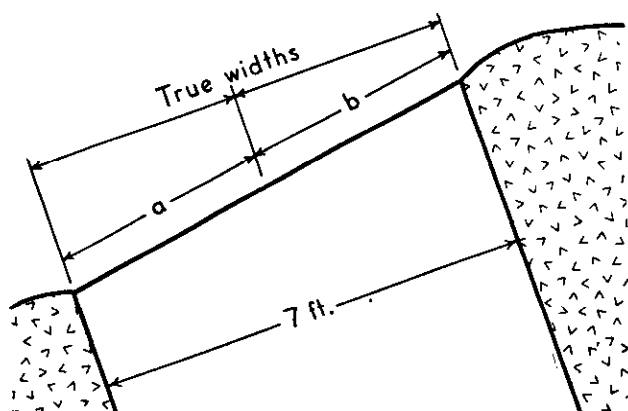


Figure 2

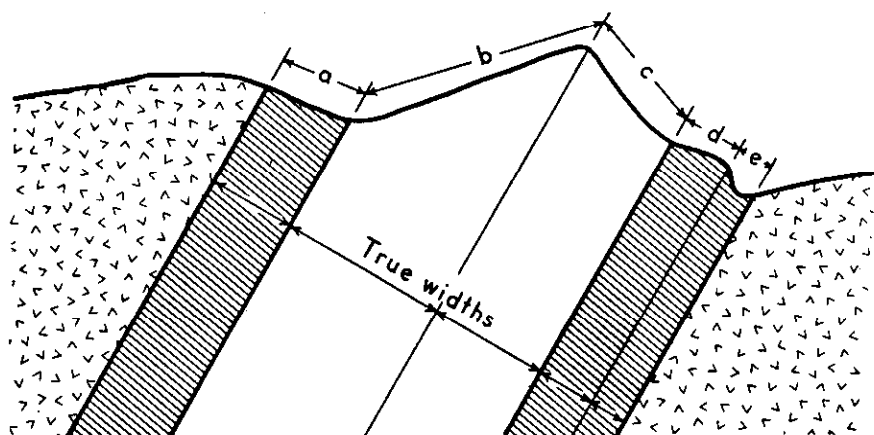


Figure 3

The surfaces along which samples are cut are indicated by letters (a, b, c, d, e). Where these do not represent true widths, the equivalent true widths are indicated.

If the lode is more than 5 feet wide (3 feet in the case of high-grade deposits), even though the mineralization seems evenly distributed, two or more samples should be taken, each representing part of the width and together representing the full width of the lode. Figure 2 shows a wide vein from which two samples are taken to represent the full width.

If the exposed surface of a vein is irregular—that is, if parts of the surface are of markedly different slope—it is best to divide the width into parts, each one of which is essentially of uniform slope, and from each such part to take whatever number of samples the differences of hardness or of mineralization require (Fig. 3).

**SAMPLING LODGE DEPOSITS.**—Samples can be cut with a prospector's pick or with moils and a hammer. All the pieces of rock broken off for the sample should be caught in a sample sack or box, or on a sampling sheet of canvas or oilcloth. To prevent salting with material from some previous sample, the sacks, box, or sheet used should be shaken or brushed free of all adhering material before beginning to cut a sample. Sacks are cleaned best by shaking thoroughly and then turning them inside out. If caught in a box or on a sampling sheet, the sample must be transferred at once to a clean sample sack. The sampler must make sure that no foreign material is allowed to contaminate his sample sack, canvas, or box, or to fall into the sample he is taking. As soon as a sample has been cut, the essential details should be recorded, the identifying tag or slip of paper should be made out, folded so as to protect the writing, and enclosed with the sample in the sack, which should be tied securely at once.

Two types of samples are commonly taken:—

- (a) Chip sample, consisting of chips taken from points uniformly distributed in a band or grid extending across the width sampled.
- (b) Channel sample, containing all the material from a channel of uniform width and depth, cut straight across the width sampled.

Each type has advantages; experience has shown that for some types of mineralization chip samples are superior, while for other types channel samples are better.

In taking a chip sample, it is a good plan to draw two parallel lines about 6 inches apart at right angles to the strike of the vein and extending from one wall to the other; and to divide the space between these lines into 3-inch squares. In some types of mineralization a grid with wider spaces is used. The lines can be drawn with a crayon or scratched with the point of a pick. A chip of approximately the same size is then broken from about the centre of each square. The chips should be caught in a bag or box or on a canvas as they are broken from the rock. If too much breaks off at any point, the material should be broken into smaller pieces and the excess discarded. Chip samples can usually be cut with a prospector's pick.

In taking a channel sample, two parallel lines, 2 to 4 inches apart, are drawn straight across the vein. All the material between the lines to a uniform depth, say half an inch, is then cut out for the sample and all the pieces are caught carefully. If material breaks from outside the lines, or too deep, the excess should be discarded. In some cases it may be possible to cut a fair channel with a pick, but using moils and a hammer gives better control and permits cutting a uniform channel where that cannot be done with a pick. A prospector rarely takes a channel sample. In precise sampling of many deposits, moiled channel samples must be taken.

#### SUMMARY OF PROCEDURE IN SAMPLING LODGE DEPOSITS

1. The sampling sheet, box, or sack to be used is cleaned carefully.
2. The surface to be sampled is cleaned of loose material and projecting pieces of rock are trimmed off.
3. Two properly spaced parallel straight lines to guide the sampler are drawn from one wall to the other on the surface to be sampled.
4. The number of samples to be taken along the section is decided upon and the part to be included in each is marked.

5. The sample is cut, the fragments being caught on a sample sheet, in a box, or directly in a sample sack.

6. A record is made of the details of the sample, and the assays required are noted on a sample tag which is put in the sample sack.

7. The sack is securely tied ready for shipment to the laboratory for assay.

**SAMPLING UNCONSOLIDATED (PLACER) DEPOSITS.**—Sampling unconsolidated deposits and concentrating the heavier materials of the sample, by panning or other means, is useful in the search for economic placer deposits. It may also be useful in prospecting for lode deposits, for if gold or other mineral is found in significant amount the prospector will then look farther up-stream or up the side-hill for the lode deposit from which the valuable mineral came.

Deposits of gravel, sand, or other unconsolidated material may contain gold or other valuable minerals. Mining such material in British Columbia has been almost exclusively for gold, but prospectors should bear in mind that platinum, tin, tungsten, and certain gem stones are recovered from deposits of unconsolidated material in various parts of the world, and that interest has been shown in gravels containing uranium.

Precise sampling, to determine if unconsolidated material can be worked profitably by placer-mining, generally calls for the systematic sinking of test-pits, shafts, or bore-holes through the unconsolidated material and for a short distance into the underlying bedrock, or drifting on bedrock. Prospectors are usually concerned with discovery and preliminary sampling; accordingly they take samples of gravel, sand, or soil from creek-beds, the sides of streams, and from hillsides. *It may be necessary to do a moderate amount of digging at any such point, and it may be necessary to sink test-pits from time to time.*

If all the unconsolidated material, from the grass roots to bedrock, must be handled, it will be useful to know whether or not the upper part contains recoverable values. In general, the values are found concentrated in cracks and depressions in the upper part of the bedrock and in a few inches of gravel lying immediately on bedrock. The overlying gravel usually is poor or barren, although such is not always the case. If values are found to be concentrated in a "paystreak" on bedrock or on false bedrock, the prospector can dispense with the labour of testing the much larger quantity of overlying gravel. Where possible the testing should extend down to bedrock. Care should be taken that for the area of the particular sample all the material on bedrock or contained in crevices is gathered up and included in the sample.

The valuable minerals in placer deposits are heavy. Concentrating a sample by using a gold-pan, rocker, or sluice retains the heavy minerals and gets rid of the lighter material. In testing gold placers the gold contained in each pan is weighed or estimated. If the gold in each pan is too little to weigh on scales which are available, the weight should be estimated and the gold from a number of pans should be combined for weighing to check the estimates.

Fire assays of gold in placer samples include gold locked up in sulphides or quartz and also flour gold as well as the gold recoverable by placer-mining methods. For this reason, fire assays on placer material cannot be interpreted in terms of gold recoverable by placer-mining; therefore, separating the gold from the other materials in the concentrates and weighing or estimating the weight closely is preferable to sending the concentrates to the laboratory for fire assay. The same can be said, to a degree, for tin or tungsten placers; but, as the tin and tungsten minerals are more difficult to detect than is gold, it is desirable, particularly in the prospecting stage, that from time to time samples be sent in for laboratory determination or assay.

Careful reconcentration of concentrates in a smaller gold-pan, removal of magnetic black sands with a magnet, and blowing lighter material from the dried concentrates, help in separating the gold from the other material. Amalgamation with mercury (quicksilver) also assists in separating gold from other material. The gold from several pans can be

amalgamated in the same two or three drops of mercury, thus giving a bead large enough to weigh. The amalgam must be heated in a retort\* or in an open container to drive off the mercury and leave the gold behind.† The mercury recovered from retorted amalgam almost always contains some gold, and therefore should not be used in testing samples. Only clean gold can be amalgamated. Gold coated with tarnish or rust will not combine with mercury unless the coating is removed. Gold can be amalgamated in an ordinary pan if a little mercury is poured in and the contents of the pan are stirred vigorously. If concentrates are being amalgamated in a small pan, two or three drops of mercury should be enough. The mercury will become changed to pasty amalgam if it takes up enough gold. The amalgam can be readily separated from the remainder of the concentrates by panning.

If a balance suitable for weighing the gold is not available, the weight of gold must be estimated. It is important that the weight and value per pan be determined accurately, as an error of 1 cent per pan would be equivalent to about \$1.75 per cubic yard of gravel. A single pan does not provide a safe basis for estimating the gold content of any yardage of gravel.

Almost invariably some silver, copper, iron, or other metal is alloyed with gold found in placer or lode deposits. The purity or fineness of gold is expressed in parts per thousand; thus gold "1,000 fine" is 100 per cent pure gold, gold "800 fine" contains 800 parts of gold and 200 parts of other metal per 1,000 parts. At the present time for a troy ounce of gold 1,000 fine the mint pays about \$35, less a small handling charge. For an ounce of gold 800 fine the mint settlement would be about \$28, less the handling charge.

The metals alloyed with it influence the colour of gold. Usually all gold from one creek has about the same colour and fineness. The fineness, in addition to determining the value per ounce, has an important bearing on the weight of a piece of gold of any particular size.

If the weight of grains or nuggets of gold is to be estimated, it will help greatly if the estimator can compare the grains of which he wishes to estimate the weight with grains that have been weighed accurately. This can be done conveniently if weighed grains from small to large are glued to a card on which the weight of each grain is written. The grains should be weighed on a sensitive balance. The card should be protected from wear and can be carried conveniently in a note-book. It is worth remembering that a porous nugget, or a spongy bead obtained by driving the mercury from amalgam, will weigh much less than a compact nugget of the same size, and that a single small compact grain of gold will weigh as much as a large number of flaky colours.

A spherical grain of gold with a diameter of one sixty-fourth of an inch would be worth about one-twentieth of a cent. It could readily be hammered out into a thin flake, one-thousandth of an inch thick, which could be cut up into many smaller flakes comparable with the fine colours found in some placer deposits. "Colours" may weigh so little that a thousand or more are required to contain gold worth 1 cent. Fine colours, unless extremely abundant, will not yield enough gold to be of interest to the individual placer-miner. If the gold on a creek were entirely in fine colours, averaging 500 to a cent, a man panning fifty pans per day would have to recover 5,000 colours per pan in order to make \$5 per day. It is obviously impossible to count such numbers of colours; however, an experienced man is able to form a fair idea of the combined value of the fine colours by noting the length of the "tail" or string of colours when gravel is panned down so that only the heaviest material remains.

## STUDY OF SPECIMENS AND SAMPLES IN THE FIELD

In prospecting for, or exploring, mineral deposits the identification of rocks and minerals is of great use. If the information can be obtained on the spot, it is much more

\* A small quantity of amalgam can be put in a hollow in half of a potato. The other half is then wired to the first and the potato is roasted in the fire.

† To avoid mercurial poisoning, such work should be done in a well-ventilated place, preferably out-of-doors; care must be taken not to transfer mercury from the hands to the mouth, nor to breathe the fumes.

helpful than if one has to wait while specimens are sent to the laboratory and the results of the laboratory study are sent back by mail. In addition to identifying rocks and minerals, it is often possible, by careful examination of a deposit and by testing samples in the field, to form a reasonably close estimate of the grade of a deposit. The following paragraphs deal with studying samples and specimens in the field in order to gain information which will guide prospecting.

Minerals can usually be distinguished from each other by differences in their characteristics, such as colour, streak, transparency, hardness, specific gravity, fracture, cleavage, magnetism, and crystal habit. The use of a pocket magnifying-glass, a streak plate (an unglazed porcelain insulator, cost 2 or 3 cents, will serve), a steel knife, a magnet or compass, and good judgment will make it possible to determine most of these characteristics in the field.

Handbooks on mineralogy or prospecting, and tables for determining minerals, list the characteristics of minerals. Such a book\* or tables should be carried in the field. With this information and simple equipment a good prospector can identify most of the minerals he comes upon, and needs only to send in for laboratory determination occasional specimens about which he is uncertain.

Chemical tests, made with a blow-pipe and certain chemicals, are not described in this bulletin. They are described in books on mineralogy and in some handbooks for prospectors.

An ultra-violet lamp may be used by a prospector in testing for scheelite, an ore mineral of tungsten. The lamp may be used on rock in place or in examining specimens or pan concentrates. An ultra-violet lamp may also be used in making a bead test† for uranium.

In addition to their use in prospecting outcrops, portable Geiger-Mueller counters or scintillation counters may be used in testing specimens for uranium. However, it should be realized that radiation detected by a counter may be from uranium, thorium, potassium, or the background, and that a specimen of low-grade uranium ore might have no noticeable effect on a counter. Since radiation counters need care in handling and the results are not always dependable indications of uranium, publications‡ dealing with the use of such instruments should be studied carefully. Reference will be found on page 20 to the use of the Geiger-Mueller counter in the laboratory.

The ore minerals of copper, lead, and zinc can usually be identified with little difficulty. To contain enough metal to be an ore, mineralized rock usually must contain at least 2 or 3 per cent of copper mineral or 5 to 10 per cent of lead and zinc minerals; however, very large deposits containing lower percentages might be mined profitably. These minerals are generally conspicuous, and as they form a considerable part of the volume of a base-metal ore, it is usually possible without chemical analysis, to form a fair idea as to whether or not a mineralized material contains ore mineral in quantity that approaches or exceeds the minimum required for ore.

The presence of silver minerals (as grey copper, ruby silver, argentite) is usually recognizable if the silver content approaches or exceeds commercial grade.

Gold may or may not be visible to the naked eye. However, in material that does not consist of massive sulphides, some gold is often recognizable if the gold content approaches commercial grade. If the mineralization contains a substantial percentage

\* "Elementary Geology Applied to Prospecting," by John F. Walker, is obtainable from the Department of Mines, Victoria, B.C., for a small price. Other handbooks are obtainable from booksellers.

† To make the bead test for uranium, a loop about one-twelfth of an inch across is made at the end of a length of wire. Chromel or iron wire is satisfactory for the uranium bead test, and is relatively cheap so the loop can be cut off and discarded after use. The loop is heated in a blow-pipe flame and dipped into powdered sodium fluoride and then fused, and the process repeated until a more or less spherical bead is formed. The heated bead is dipped into the powdered mineral, and, with the mineral adhering to it, is fused in the flame for about two minutes. When cool, the bead is tested for fluorescence. A bead containing uranium will fluoresce a bright lemon yellow. Other elements may give a bead that fluoresces yellow, although duller. It is a good idea to prepare a uranium bead to be kept for comparison.

‡ The British Columbia Department of Mines usually has mimeographed notes available, and the Geological Survey, Department of Mines and Technical Surveys, has issued several handbooks and bulletins giving information on radioactivity and the use of counters in prospecting for uranium. The United States Atomic Energy Commission has issued several handbooks on this subject.

of sulphides, gold is apt to be at the margins of sulphide grains or enclosed in them and therefore may be inconspicuous. Whether sulphides are scanty or abundant, only assaying will give accurately the gold content of samples, but less precise information obtainable in the field may be of great value to the prospector, particularly as it can be obtained in remote localities and with very little delay.

If the gold particles can be freed from the other material by breaking up or grinding the sample, it is possible to wash away most of the other material, using a gold-pan, a large spoon, or a frying-pan. Whatever is used must be entirely free from grease, and should be heated to redness in the fire to burn off grease if any is present.

An experienced man can form a fair idea of the gold content of ore by estimating closely the amount of ore with which he starts, and equally closely estimating the amount of gold which he is able to separate.

To be of commercial interest for its gold content alone, ore must contain several dollars' worth of gold per ton. If free gold in grains of some size can be seen in the ore, or in concentrates panned from a crushed sample, the deposit warrants careful study. If from half a pound of ore careful panning recovers a few tiny colours, the prospects are less attractive. One-half pound is one four-thousandth of a ton, and for ore to run \$5 per ton, one-half pound would contain one-eighth of a cent. This would be 12 colours if they ran 100 to the cent, or 125 colours running 1,000 to the cent. A single small grain might well weigh more than the considerable number of fine colours. In estimating the quantity of gold it is found useful to count the colours and to compare their size with those obtained in other pannings.

Estimation of gold in test-panning placer deposits has been discussed on pages 13 and 14. A similar procedure may be used in estimating the value of gold recovered by treating a sample or specimen of ore. It is unlikely that panning crushed samples will permit close estimation of the grade of ore, but it can indicate whether mineralization contains enough gold to be of interest. The results obtained in this way should not be regarded as final; samples of promising mineralization should be sent in for assay even if testing in the field fails to indicate gold in important quantity.

The quantity of ore to be tested for gold must be broken into small pieces and then ground to a fine powder. Roasting the small pieces, spread thinly in a can or other container over a fire, before grinding will make the grinding easier if the ore contains a fair amount of sulphides. If the gold is closely associated with sulphides, it will be best to carry on the roasting in such a manner that the sulphides are oxidized as completely as possible. Alternate roasting and crushing or grinding may be easier and will give more complete oxidation. Roasting fine sulphides mixed with soda may be necessary to break down some material completely. The last stage before the actual washing should be grinding. For this purpose a mortar and a pestle are required, cast-iron ones can be bought, or a 2-inch pipe cap and the hammer-end of a prospector's pick can be used as a substitute.

Panning gravel or soil from creeks or side-hills, or the decomposed material from outcrops, is a well-established and extremely useful procedure in prospecting, often making it possible to trace gold colours or other heavy minerals to their source in a lode deposit. In much of the country five or more small colours in a pan warrant careful search for the deposit which is the source of the colours. Concentrating the heavy minerals by panning makes it possible to detect a few small particles of gold or of other heavy minerals which could not possibly be detected when mixed with a large quantity of gravel, sand, or soil.

In general, the small heavy particles will be most easily found if the panning is carried to the point where only the heaviest material remains in the concentrate, but in order to obtain the maximum information it is desirable that minerals of intermediate specific gravity be retained in pan concentrates which are sent to the laboratory for study. With these thoughts in mind, it is suggested that when a prospector wishes to send in concentrates, he should divide them into two parts when he has panned to the point where



material of intermediate specific gravity (grey sands) begin to be washed out of the pan. The one part should be allowed to dry, packaged, and sent in for laboratory examination. The other part can be studied by the prospector and then panned down to black sand for final study.

In studying the pan concentrates the prospector will find a magnifying-glass useful. Study under ultra-violet light\* will reveal scheelite or zircon if present in important quantity. A Geiger or scintillation counter may be used to test for radioactivity as an indication of uranium, but such a test will probably require at least a quarter of a pound of concentrate. A bead test (*see* p. 15) may be used on a grain of mineral thought to contain uranium. Study of pan concentrates may give very useful information in prospecting for lode deposits. Angular gold, particularly if still attached to quartz, has probably not travelled far from the vein where it originated, while rounded grains of gold have probably travelled a long way from their source.

Cassiterite (tinstone), wolframite (an ore of tungsten), tantalite, and certain other dark minerals are difficult to identify in pan concentrates. Their presence would become apparent if the concentrates were tested in the laboratory. Further, there is a possibility that in the laboratory study other facts may become apparent and may be of use in prospecting. For these reasons it is recommended that from time to time a quantity of pan concentrates, including material of intermediate specific gravity, be sent to the laboratory to be sure that no important information is being overlooked.

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\* Many minerals show characteristic colours (fluoresce) when exposed to the ultra-violet lamp. Some common minerals with their fluorescent colours are as follows: Scheelite, bluish-white to pale yellow; zircon, orange-yellow; some calcite, reddish; white encrustations of lime, pink; secondary zinc carbonate, white.

## THE LABORATORY TREATMENT OF SPECIMENS AND SAMPLES\*

### RECEIPT OF SPECIMENS AND SAMPLES AT LABORATORY, AND LABORATORY RECORDS

When a package of samples or specimens is received at the Department of Mines laboratory in Victoria, it is opened (*see* Plate 1A) and each sample or specimen is put in a separate tray and given a serial number. The receipt of each sample or specimen is promptly acknowledged by postcard. If the material is a specimen, on which the identification of certain minerals or the classification of the rock is requested, then the specimen is referred to the Mineralogical Branch of the Department for the sort of study described in the next section. The Mineralogical Branch then issues the laboratory report. However, if the material is a sample on which assays are requested, it is examined by the Analytical and Assay Branch, which also issues the laboratory report.

### STUDY OF SPECIMENS

Specimens are examined by a mineralogist with sufficient care to answer questions asked by the sender in his accompanying letter or sample tag. The first step is study of the non-fluorescent minerals present with a hand-lens, followed by a study under an ultra-violet lamp to see whether any fluorescent minerals (such as scheelite) are present. This is often sufficient in the case of common rocks and minerals, but in the case of some rocks and minerals a thorough microscopic examination is necessary.

Use of the microscope makes possible the identification of the less common minerals and also makes the association of minerals clear. In this microscopic examination a rock-forming mineral is ground to a powder and the fragments examined, or a very thin slice of rock is cut to study not only the individual minerals but the relationship between them; such a slice is known as a "thin section" (Plate 1B).

In the case of ore minerals which are not transparent, a surface of the sample is ground and polished on a special polishing-machine; this is the treatment given to sulphide minerals when particularly careful study is called for. Plate 1c shows such a polished surface mounted in bakelite.

Plate 2A shows what a thin section of rock may look like under the microscope when magnified thirty times. Notice how the crystal structure is clearly shown. Plate 2B shows what a polished surface of metallic minerals may look like under a microscope when magnified nineteen times. Plates 2c and 3 show some of the microscopic equipment used in examining samples and specimens.

The sender usually wants his specimen classified; that is, he wants it named. He may also want all the information he can get concerning the nature of the deposit from which it was obtained. The mineralogist identifies the specimen, and from experience in the field and knowledge of the geology of the district from which the specimen came can usually supply information about the deposit or formation from which the specimen came. This is one of the reasons why the laboratory requires information on the locality and district from which the specimen or sample came.

The laboratory report sheet, sent to the submitter of a specimen, lists the minerals determined or gives the name of the rock.

### PREPARATION AND ANALYSIS OF SAMPLES

(a) MINERALOGICAL EXAMINATION.—Each sample, before crushing, is examined to determine the character of the mineralization and to indicate the valuable minerals present. The sample is examined with a hand-lens and is also studied under ultra-violet

\* By G. Cave-Browne-Cave, Chief Analyst and Assayer.

light. This particular examination is made solely as a guide to the subsequent analysis of the sample, and the findings are not stated in the laboratory report.

(b) ANALYST'S EXAMINATION.—Following the mineralogical examination, the Chief Analyst examines the sample. Taking into account the specific requests the prospector makes in his covering letter or sample tag, and the results of the mineralogical examination, he decides what laboratory work should be done on the sample. Assays are usually made only on reasonably large (at least 1 pound) representative samples. On inadequate samples a semi-quantitative analysis may be made, to guide the prospector. The sample is then handed to the crusherman to prepare.

(c) CRUSHING THE SAMPLE.—After drying, if necessary, the entire sample is crushed in a jaw crusher to particles about the size of dried peas or smaller (Plate 4A). This crushed sample is thoroughly mixed and then divided by riffing, to decrease its bulk, using a Jones riffle (Plate 4B). The smaller sample so obtained is then ground to a very fine powder in a disk pulverizer (Plate 5). This powder is divided into four parts. One part is kept on file for three months. One part goes to the fire-assay laboratory for precious-metal assays, and the unused portion goes to the radioactivity laboratory for radioactivity measurements. One part goes to the spectrographic laboratory for a complete analysis of base metals, and the fourth part goes to the wet-assay laboratory for base-metal assays.

(d) SPECTROCHEMICAL ANALYSIS.—With the installation in 1941 of a modern grating spectrograph and accessories, the laboratory increased greatly the service it could render to prospectors. With this instrument it is possible to make a rapid and complete analysis of a sample for all the base metals. Despite the apparent complexity of the apparatus, there is no uncertainty about the results of such an analysis. Plate 6 shows the main spectrographic installation.

A detailed discussion of the principles of spectrochemical analysis lies outside the scope of this bulletin, but a brief discussion of how an analysis is performed is appropriate. A weighed portion of the powdered sample is placed in a pure carbon cup (Plate 7A). This cup is then inserted into a vertical carbon rod, forming one pole of an electric arc (Plate 7B). Another pure carbon rod forms the other pole of the arc and is clamped so that a  $\frac{1}{2}$ -inch air-gap separates it from the carbon cup holding the sample. Both carbon rods are connected to an appropriate source of electricity. When the arc is "struck," electricity flows continuously across the  $\frac{1}{2}$ -inch air-gap from one carbon rod to the other. A temperature of over 4,000 degrees Fahrenheit is created thereby and the tips of the carbon rods become white hot (Plate 7C). The heat is so intense that it not only melts, but actually vaporizes all the powdered sample contained in the carbon cup, no matter what elements the sample may contain. Depending on various factors, it takes between one and three minutes for the entire rock sample to vaporize in the electric arc. While in the arc-gap, the vaporized metals of the sample emit light of various colours or, to be exact, of various wave-lengths. Each metal emits its own characteristic group of colours, or wave-lengths, and no other metal ever duplicates this group exactly. The light enters the spectrograph, is there analysed, and exposes a photographic film, forming a series of lines corresponding with the colours emitted. When developed, this film is called a spectrogram, and shows many thin vertical black lines along its length (Plate 8A).

Spectrochemical analysis is possible because each metal always produces a certain group of black lines on the photographic film, at certain fixed positions, and no two metals produce the same group of lines. The analyst knows where the lines of each metal occur on the film, and by studying the proper part of the film can tell whether a certain metal is present or not. Examine Plate 8B. It shows portions of three spectrograms. The upper one is of pure zinc. The lower one is of pure cadmium. The middle one is of a prospector's ore sample. Notice how the zinc lines in the uppermost spectrogram coincide exactly with lines in the middle spectrogram. That tells us that zinc is present in the prospector's sample. Likewise the cadmium lines in the lowest spectrogram coin-

cide exactly with lines in the middle spectrogram. Hence cadmium is also present. Actually such comparisons are made by magnifying and projecting the spectrogram onto a screen. Plate 8c is a close-up of part of the actual screen with part of a spectrogram of a rock shown in the upper half of the picture and with part of a "master plate" projected and shown in the lower half. This master plate has marked on it the sensitive lines of all the metals in their correct places. The part shown has a molybdenum (Mo), a tin (Sn), and three vanadium (V) lines. The upper half of the picture has lines coinciding exactly with these molybdenum, tin, and vanadium lines on the master plate. Hence these metals are present in the prospector's sample. Other molybdenum, tin, and vanadium lines exist in other parts of the spectrogram but are not shown here. The instrument used to magnify and project spectrograms is shown in Plate 9.

The positions of the black lines in a spectrogram tell what metals are present (qualitative analysis). By measurement of the exact blackness of the lines the percentage of a metal in a sample can be determined (quantitative analysis). The instrument shown in Plate 9 is also used to measure this blackness. It contains a photo-electric device which permits exact measurement of the blackness of any line. Alternatively, visual estimates of the blackness of the lines can be made, from which approximate values of the percentages of the metals can be obtained. This method is called semi-quantitative analysis, and is usually used except on special problems. Then if this semi-quantitative analysis shows that the sample contains certain base metals in percentages of possible economic importance, the sample is sent to the wet-assay laboratory, where the percentages of these metals are accurately determined.

An important feature of the spectrographic method is its extreme sensitivity. It will detect metals present down to between 0.01 per cent and 0.0001 per cent (between one one-hundredth and one ten-thousandth of 1 per cent) of a metal in a sample, depending on the metal. It is only in work such as geological studies and the analysis of smelter products that the detection of such minute percentages is of value, and to the prospector and field engineer they are of no significance whatever in the present state of our knowledge of geology. Such low percentages, even when measurable, are considered as "traces" when reporting on samples from the field.

In addition to metals present in higher percentages, most samples sent in by prospectors contain ten to fifteen metals as spectrographic traces; that is, in quantities so small that they can be of no possible commercial value. It would merely be confusing if a report were issued listing all these trace metals. Consequently they are not given in the usual laboratory report. Instead the report on the spectrochemical analysis may read: "A spectrochemical analysis for all the base metals was made. The only metals found, and their percentages, were those occurring normally in rocks." If such a report is received, the prospector can be assured that there are no base metals of possible economic interest in his sample. There is no possibility that the spectrograph has failed to show an important amount.

The spectrograph is not generally used to detect the precious metals in a rock sample. One important reason is that although base-metal minerals can readily be crushed to fine powders, and consequently a representative sample taken for spectrochemical analysis, the precious metals, such as gold, will not grind into a fine powder but will merely roll up into a ball. Hence a large weight of powdered sample is needed for analysis to represent the sample accurately. Such a weight (about one-half ounce) is too large for the spectrograph. Consequently precious-metal detection and assaying is done by the fire-assay method.

(e) EXAMINATION OF A SAMPLE FOR RADIOACTIVITY. — The laboratory is well equipped to measure radioactivity in samples. There is a laboratory-model Geiger counter to measure the beta radiation from radioactive elements in samples, and a high-pressure ionization chamber to measure the gamma radiation. Both instruments have been carefully calibrated with standard samples of unanium and of thorium ores.

In practice, prospectors' samples are first tested for radioactivity with the Geiger counter. Most minerals and rocks are very slightly radioactive, and cause the Geiger counter to respond to the same degree as it would for a sample containing a few thousandths of a per cent of uranium. If the prospector's sample contains such a low level of radioactivity, the laboratory report will read: "The degree of radioactivity was found to be no greater than that occurring normally in rocks."

For some samples the degree of radioactivity is above the normal level for rocks. In such a case the laboratory report may read: "Radioactivity equivalent to . . . per cent uranium oxide ( $U_3O_8$ ) was found by Geiger counter." This statement does not necessarily mean that the element uranium is present, because a Geiger counter responds not only to uranium, but also to thorium, and to a much lesser degree to less radioactive elements in nature, notably potassium. The laboratory statement means that the radiation from the sample has exactly the same intensity as that from a sample containing the stated percentage of uranium oxide. The sample may contain uranium, or thorium, or a mixture of the two, possibly with some potassium. However, where the sample is very small and not representative, such as a single small piece of rock, or where a preliminary measurement of radioactivity is all that is needed at the time, this form of laboratory statement is used.

For radioactive samples that are also representative, further measurements are usually made by using the ionization chamber. Then from the combined measurements on the Geiger counter and the ionization chamber, the percentages of uranium and of thorium are calculated. These percentages are then usually checked by making chemical assays for uranium and for thorium, and it is the results of these assays that are given in the laboratory report.

(f) WET-ASSAY LABORATORY.—This laboratory is equipped to determine accurately the percentage of any element in a sample. The term "wet" assay is used to indicate that the percentage of metal in a sample is determined by using acids and solutions of other chemicals.

It is not appropriate to describe the methods of analysis in detail, but the method used for determining the percentage of zinc in a sample is outlined below. This outline involves some of the more usual operations an assayer performs in wet assaying.

A precise amount of the pulverized rock sample is weighed on a balance (Plate 10A). This weighed sample is placed in a glass beaker and acids are added. On heating, most of the metallic minerals, including the zinc minerals, decompose and are dissolved by the acids (Plate 10B), and a solution containing zinc and other metals results. The next step is to separate these other metals, such as iron, manganese, copper, etc., from the zinc. To accomplish this the assayer adds to the solution certain chemicals which precipitate the unwanted metals as solids but leave the zinc in solution. The next step is to separate these solids from the clear zinc solution, by filtration. Plate 11 shows the mixture of solids and zinc solution being filtered. In this step the mixture is poured into a cone-shaped filter-paper which retains the solids but allows the solution, containing all the zinc, to pass through and be collected in a beaker.

Thus purified, the zinc solution is then brought to a definite acidity and temperature, and is then ready for the final step—that of "titration." Plate 12A shows this operation. A solution of known concentration of a chemical called potassium ferrocyanide is added slowly to the zinc solution, and combines with the zinc to form a solid which is precipitated. The potassium ferrocyanide is added until all the zinc has been precipitated, and a change in colour of an "indicator" solution tells accurately when this point has been reached. The exact volume of potassium ferrocyanide added is measured, and from this measurement the assayer can at once calculate how much zinc was in the solution. Then he can readily calculate the percentage of zinc in the rock sample. In similar ways the percentages of copper, lead, iron, tungsten, or other metals in the sample are determined. However, each determination is a separate undertaking, and starts with its own weighed

quantity from the pulverized sample. Plates 12B and 13 show other operations in wet assaying and analysis.

(g) FIRE-ASSAY LABORATORY.—The fire-assay method is used to determine the number of troy ounces of precious metals (gold, silver, platinum, iridium, osmium, palladium, rhodium, and ruthenium) per ton of ore. The methods used differ radically from those in the wet-assay laboratory.

A precise amount of pulverized sample is weighed out and mixed with certain dry chemicals called fluxes. Lead oxide is added, and if the ore has not a sufficient reducing power of its own, flour is also added as a source of carbon. The entire mixture is then placed in a fireclay crucible (Plate 14), put in a furnace, and brought to a temperature of about 1,800 degrees Fahrenheit for about one-half hour (Plate 15). On heating, the fluxes combine with the rock and form substances that melt readily; the entire mixture is a liquid after about thirty minutes in the furnace.

During this half-hour heating period, the lead oxide and carbon react to form metallic lead. The molten lead, being heavy, falls through the liquid mixture of sample and flux like a shower of rain, and as it falls it amalgamates with (dissolves) all the precious-metal particles in the sample. When time has been allowed for all the lead to collect as a liquid on the bottom of the crucible, the crucible is taken from the furnace and the molten contents poured into an iron mould to cool, as in Plate 16. The lead sinks to the bottom of the mould, beneath the lighter rock-flux liquid which is called "slag." When solidified the lead exists as a cone-shaped button attached to the slag, as in Plate 17A. The lead button is broken away, hammered into a cube, and brushed well to remove adhering particles of slag, and the slag is thrown away, for all the precious metals have now been extracted from it.

The lead button (Plate 17B), which contains all the precious metals that were in the sample, is then put in a hot "cupel" in a furnace at about 1,200 degrees Fahrenheit (Plate 18A). The lead melts, and on the upper surface combines gradually with the oxygen in the air to form liquid lead oxide. This liquid lead oxide rolls off the molten lead and is absorbed by the cupel until all the lead has been oxidized and absorbed. The precious metals on the other hand do not oxidize, and are not absorbed by the cupel. They remain on the surface of the cupel as a round, shining bead (Plate 18B), which contains all the precious metals present in the sample.

The bead is carefully removed from the cupel, after cooling, and is brushed and then weighed. The bead is next treated with hot acid to dissolve the silver and leave the gold, which is not affected by the acid. The gold is well washed, dried, and weighed on a very accurate balance (Plate 19) which is sensitive to 1/15,000,000 ounce. Then a simple calculation gives the amount of both gold and silver present in the sample, in terms of troy ounces per ton. Usually about one-half ounce of ore is taken for assay; from this a gold bead about the size of a pin-head represents about 10 ounces of gold per ton.

The presence of members of the platinum group is indicated by the appearance of the bead and by its behaviour with hot acid. Special methods are needed for the separation of metals of the platinum group from each other.

## THE LABORATORY REPORT

DESCRIPTION OF THE REPORT.—The results of examination and analysis are entered on a laboratory report and sent to the person who submitted the sample. This report is worthy of discussion here so that there need be no misrepresentation.

A typical example of a laboratory report is given on page 23. In the first column is the laboratory serial number assigned to the sample when it is received in the laboratory. In the second column is the identifying number the prospector gave to his sample; where a Department of Mines sample tag has been used, its serial number will be quoted here. In the third column is the laboratory report.

OFFICE OF THE CHIEF ANALYST  
AND ASSAYER



DEPARTMENT OF MINES  
VICTORIA

SAMPLE RECEIVED FROM..... John Doe, Esq.,

ADDRESS..... Green's Corner P.O., B.C.

LABORATORY No.	SUBMITTER'S MARK	LABORATORY REPORT										
1012 A	# 1	<p>A spectrochemical analysis for all the base metals was made. Lead, zinc, and a fraction of one per cent of cadmium were found; the other metals found, and their percentages, were those occurring normally in rocks.</p> <p><u>Assays:</u></p> <table><tr><td>Gold</td><td>0.63 oz. per ton</td></tr><tr><td>Silver</td><td>5.1 oz. per ton</td></tr><tr><td>Lead</td><td>1.6%</td></tr><tr><td>Zinc</td><td>9.3%</td></tr><tr><td>Cadmium</td><td>0.2%</td></tr></table> <p>The degree of radioactivity was found to be no greater than that occurring normally in rocks.</p>	Gold	0.63 oz. per ton	Silver	5.1 oz. per ton	Lead	1.6%	Zinc	9.3%	Cadmium	0.2%
Gold	0.63 oz. per ton											
Silver	5.1 oz. per ton											
Lead	1.6%											
Zinc	9.3%											
Cadmium	0.2%											

THIS DOCUMENT, OR ANY PART THEREOF, MAY NOT BE REPRODUCED  
FOR PROMOTIONAL OR ADVERTISING PURPOSES.

DATE..... January 27th, 1956.

CHIEF ANALYST AND ASSAYER.

The spectrochemical analysis shows lead, zinc, and cadmium to be the only base metals of interest. This means that although there were probably between ten and fifteen trace metals, in addition to the usual rock-forming constituents such as silicon, only lead, zinc, and cadmium could conceivably be of economic interest. Analyses for the precious metals are not made spectrographically, and consequently these are not listed.

The "Assays" give the precise percentages of lead, zinc, and cadmium as reported by the wet-assay laboratory after the analysts there had been informed that the spectrochemical analysis showed that these metals were present in percentages sufficiently high to warrant accurate assays. The results of the fire assay indicate the presence of 0.63 ounce ( $\frac{63}{100}$  ounce) of gold per ton, and 5.1 ounces of silver per ton.

The radioactivity report, and particularly the wording used, are discussed in section (e) on page 20.

Base-metal deposits cannot be evaluated solely on the value of the chief base metals. Minor amounts of certain metals may add to the value of the ore. On the other hand, some impurities may be detrimental, and if they are present above certain percentages, a smelter may refuse to handle the ore. All base metals present in significant quantity will be stated in the spectrochemical analysis quoted in the laboratory report. Non-metals, such as sulphur, phosphorus, and selenium, are not listed there because the spectrograph does not detect most non-metals. On request, the Department of Mines will provide the prospector with additional information on the harmful impurities in his ore, and may undertake to do further assaying of his samples to determine the percentages of these impurities.

**CALCULATION OF MONEY VALUE OF ORE FROM LABORATORY REPORT.**—The percentage of each metal is given in the report, but the money value of the metals is never given, because the gross value of contained metals is not the real value of any ore, to the man who mines it or to anyone else. Whether an ore is shipped to a smelter or milled on the property, or both, a percentage of each metal is lost in the treatment process, the amount varying with the method of treatment and the type of ore. Further, one metal in the ore of another may not only be lost in the process but may make smelting more difficult. For this reason, little or no payment may be made for zinc in a lead ore and the treatment charge may be increased if zinc is present. The case of zinc or arsenic in a copper ore is similar. There are also freight and treatment charges, which reduce the gross value of the ore.

The following example will give an idea of what a ton of lead-silver ore containing a little gold will net the prospector, under the terms of the schedule effective March 1st, 1953, of The Consolidated Mining and Smelting Company of Canada, Limited, at Trail:—

#### *Analysis*

(Assays on dry weight. Moisture, 6.5 per cent.)

Gold .....	0.021 oz. per ton
Silver .....	20.0 oz. per ton
Lead .....	42.0%
Zinc .....	7.2%
Silica .....	28.0%
Lime .....	3.0%

(NOTE.—Assays for silica and lime are not usually made on indicator samples such as are usually submitted by prospectors because this information is not important during the earlier stages of developing a property.)

#### *Metal Content (per Ton, Dry Weight)*

Silver .....	20 oz.
Lead .....	840 lb.
Zinc .....	144 lb.

(NOTE.—In order to convert the percentage of a metal into the number of pounds of metal per ton of ore, use is made of the fact that 1 per cent of a metal represents 20



pounds of metal per ton of ore. Thus 42 per cent of lead represents  $42 \times 20 = 840$  pounds of lead per ton of ore, and 7.2 per cent of zinc represents  $7.2 \times 20 = 144$  pounds of zinc per ton of ore.)

#### Prices

Silver.....	85¢ per oz.
Lead.....	15¢ per lb.
Zinc.....	13¢ per lb.

#### Payments

Gold (less than 0.03 oz. per ton).....	Nil
Silver: 95% of 20 oz. @ (85¢—1¢) per oz.=19 oz. $\times 84¢$ .....	\$15.96
Lead: $92\frac{1}{2}\%$ of 840 lb. @ (15¢—3.5¢)=777 lb. $\times 11.5¢$ .....	89.36
Zinc: 41% of 144 lb. @ (13¢—7¢)=59 lb. $\times 6¢$ .....	3.54
	<hr/> \$108.86

#### Charges

Base charge.....	\$15.00
Add debit for deficiency in "free lead" <sup>1</sup> below 40%: $40 - (42.0 - 7.2 \times 3)$ @ 20¢=19.6 $\times 20¢$ .....	3.92
	<hr/> \$18.92
Subtract credit for silica and lime: (28.0+3.0) @ 14¢=31 $\times 14¢$ .....	4.34
	<hr/> \$14.58
Add debit for moisture in excess of 5%: (6.5—5.0) @ 20¢=1.5 $\times 20¢$ .....	.30
	<hr/> Total treatment charges.....14.88
Net, per ton.....	<hr/> \$93.98

<sup>1</sup> "Free lead" is defined as the percentage of lead less three times the percentage of zinc. Deficiency in "free lead" is 40 per cent less the percentage of "free lead."

Out of the net amount payable by the smelter, all costs of mining and shipping must be paid. Freight on such a shipment would be expected to cost between \$5 and \$35 per ton, depending on the location of the property.

The gross value per ton of the above ore would be:—

Gold: 0.021 oz. $\times \$35$ .....	\$0.73
Silver: 20 oz. $\times 85¢$ .....	17.00
Lead: 840 lb. $\times 15¢$ .....	126.00
Zinc: 144 lb. $\times 13¢$ .....	18.72
Total.....	<hr/> \$162.45

On comparing this gross value of \$162.45 with the net value of \$93.98, from which mining and shipping costs have still to be subtracted, it is clear that the gross value does not give even approximately the real value of the ore.

## CONCLUSION

It will be seen that as a matter of course a sample from a bona fide prospector receives a complete examination in the Victoria laboratory. There is no chance that a metal is overlooked. A complete examination takes a longer time than does a single assay for any one metal. For this reason, laboratory reports of complete examinations may take a longer time (several days) than if assays for one or two specified metals were made.

If a prospector is not interested in a complete examination but merely wants his sample assayed for one or two or three metals, he should state this in his covering letter or on his sample tag, mentioning specifically the metals in which he is interested. In this way time and money are saved, and the laboratory report may then be made out within two or three days after the sample is received. Assays on certain rarer metals, however, may require more time, and during the height of the busy summer season laboratory reports on samples may not be forthcoming as rapidly as when there is no rush of work in the laboratory.

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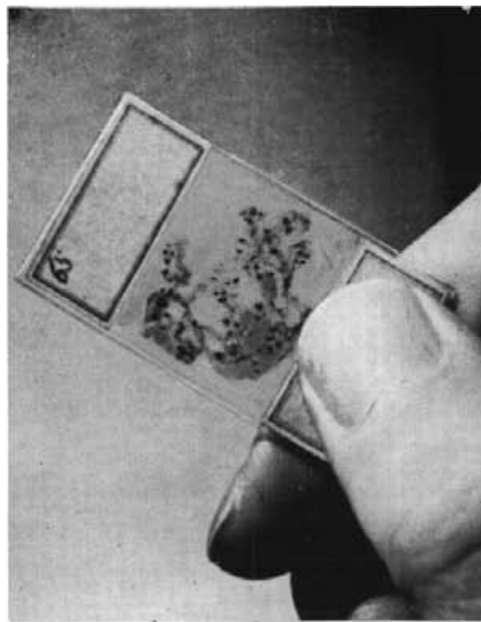
VICTORIA, B.C.

Printed by DON McDIARMID, Printer to the Queen's Most Excellent Majesty  
1956

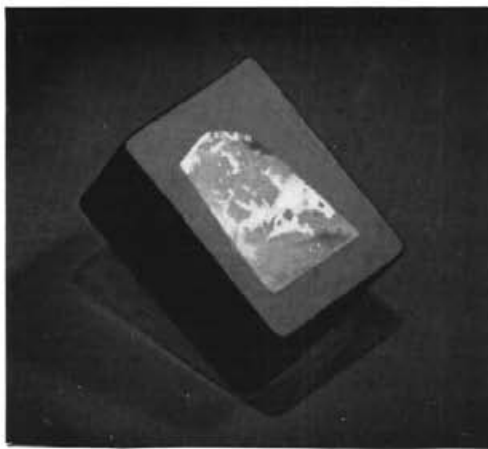
**PLATE 1.**



**A.—A typical sample, properly packaged and labelled.**

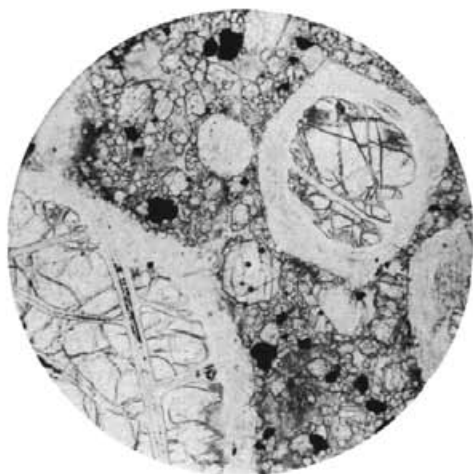


**B.—A thin section of rock, ground to a thickness of about one one-thousandth of an inch and mounted on a glass slide for microscopic study.**

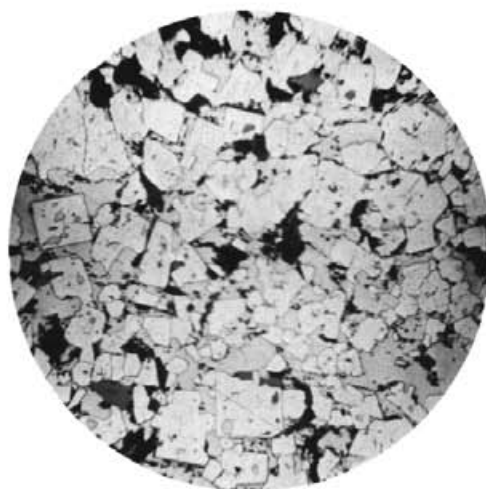


**C.—A polished section of ore. The rock is mounted in a Bakelite cast, one surface of the rock given a high polish and examined microscopically to identify the ore minerals.**

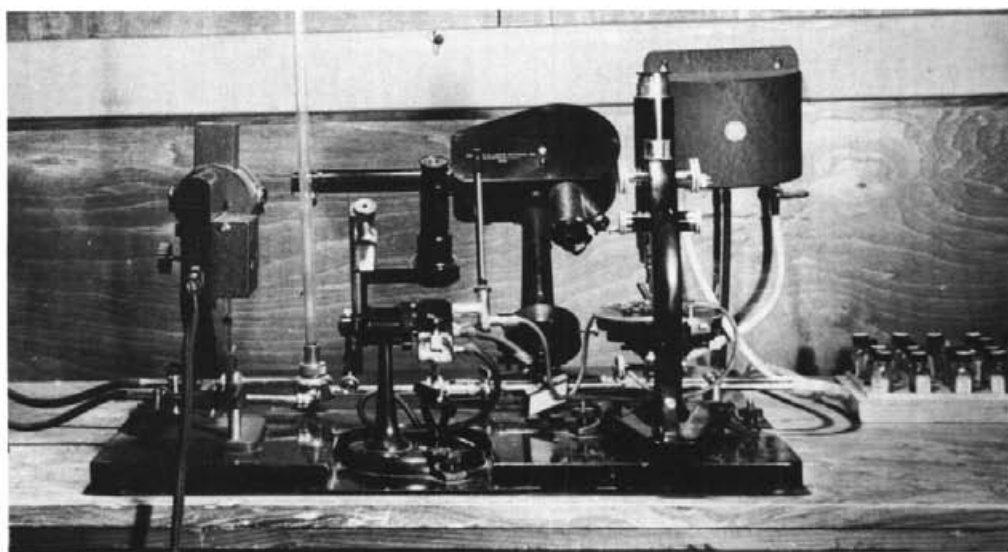
**PLATE 2.**



**A.**—A thin section of rock as seen through a microscope. Large grains are olivine, now altered around their rims and along fractures to serpentine (clear), and some magnetite (fine, black grains). The intervening material is a mixture of pyroxene (grains), serpentine (clear), and magnetite (black). Magnified thirty times.

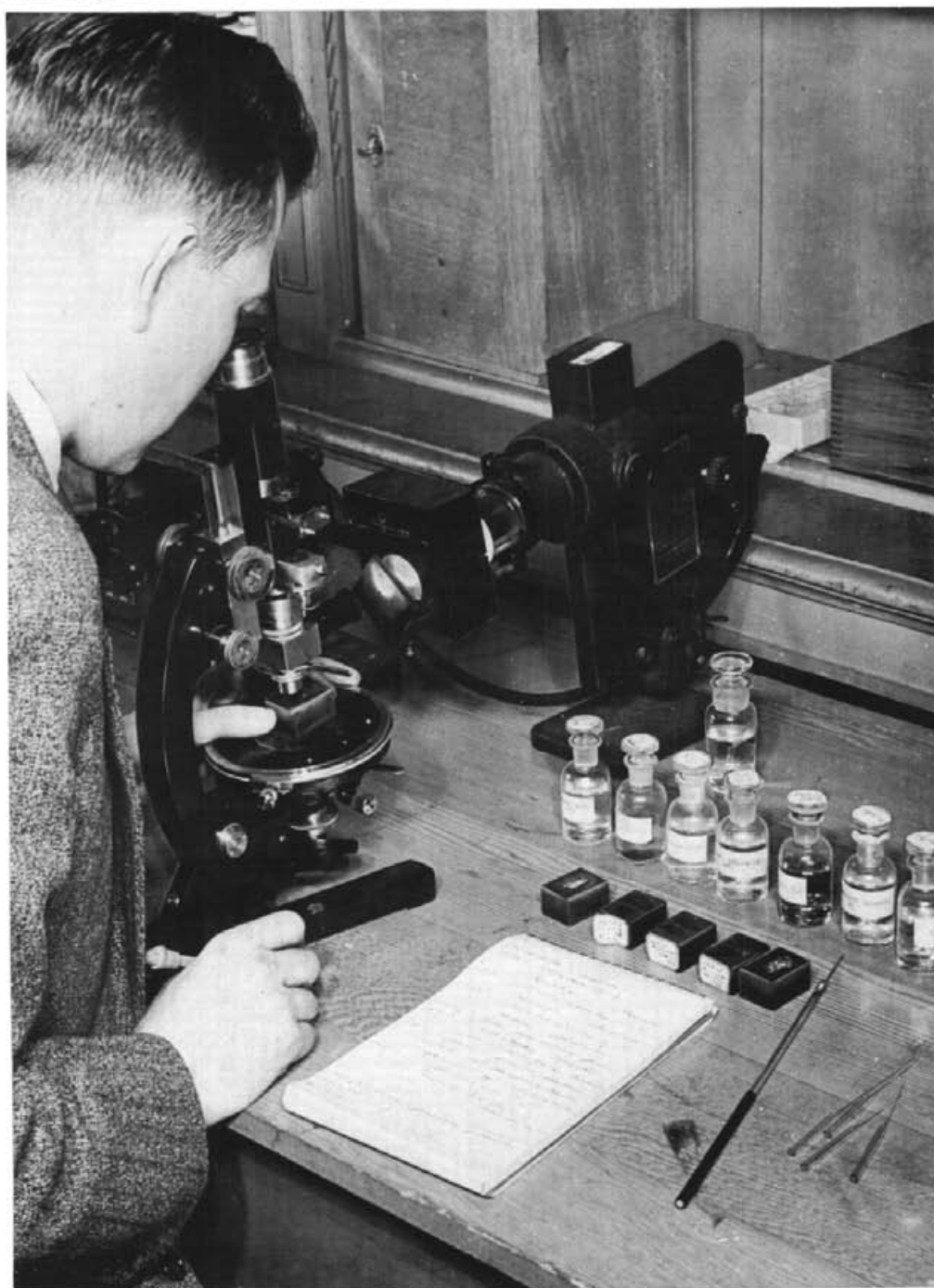


**B.**—A polished section as seen through a microscope. An intimate mixture of cubic pyrite (light grey grains), chalcopyrite (dark grey grains), and quartz (black areas). Magnified nineteen times.

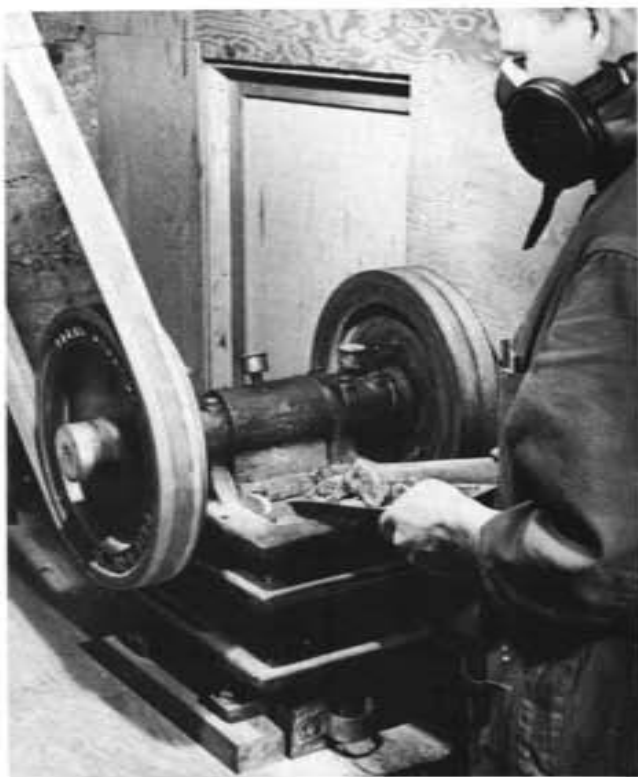


**C.**—The Emmons double variation equipment. Used in the most precise work for identifying mineral grains microscopically.

**PLATE 3.**



Examining a polished section (Plate 2B) under a microscope, using reflected light. The bottles on the right hold chemicals, a drop of which, when placed on the surface of a particular mineral on the polished section, gives a characteristic reaction by which the mineral can be determined.

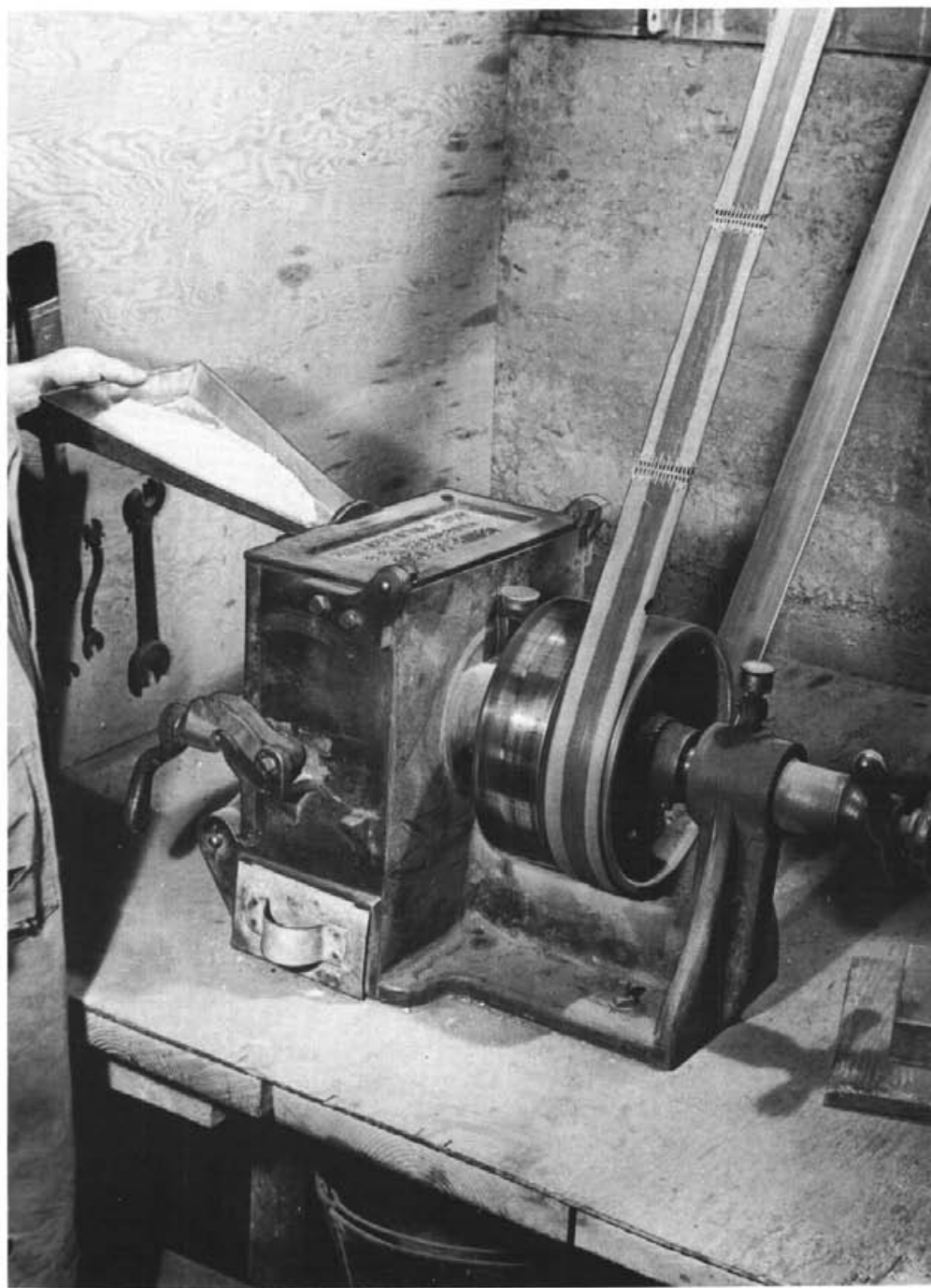


A.—Preliminary crushing of a sample in a jaw-crusher.



B.—After crushing the sample it is sampled in this Jones riffle, the falling ore being split into two streams by the metal partitions shown. One-half of the sample goes to the left-hand pan, the other half to the right-hand pan. The contents of either pan may be taken for further grinding and sampling.

**PLATE 5.**



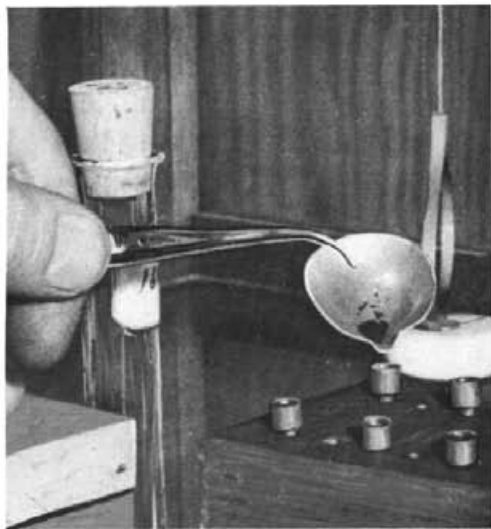
**Grinding the crushed and sampled ore into a fine powder. The ore is fed in between two circular steel disks enclosed in the steel box. One of the disks revolves rapidly, thereby grinding the rock between the disks.**



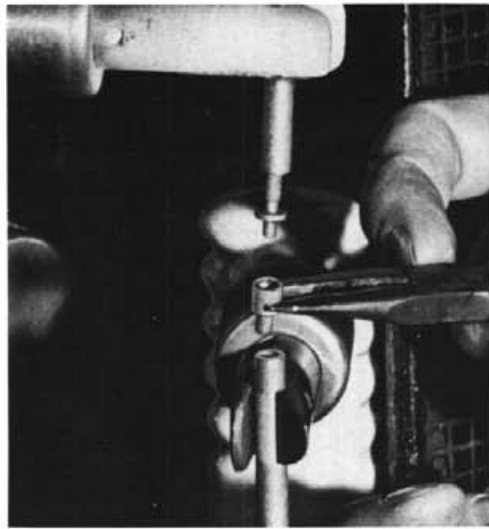
The spectrograph, an instrument to analyse and photograph the light emitted by incandescent metallic vapours. An electric arc produces these vapours from the powdered rock. The arc is enclosed in a wire cage shown on the right. The camera is on the left. The instrument is about 5 feet long.



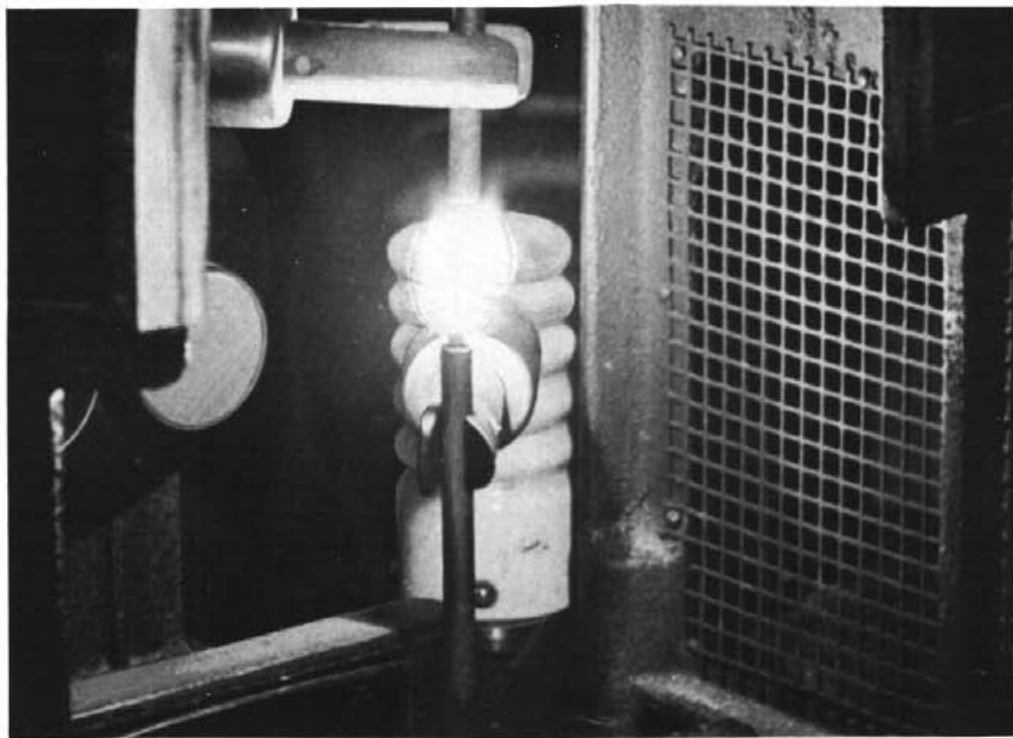
**PLATE 7.**



**A.—**Transferring weighed rock powder to a carbon cup for spectrographic analysis.

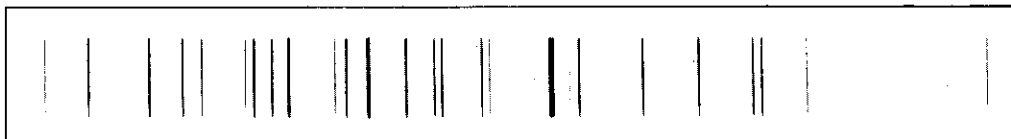


**B.—**Placing the carbon cup containing the rock sample in a carbon rod holder, which forms one electrode of an electric arc. The upper carbon rod shown is the other electrode.

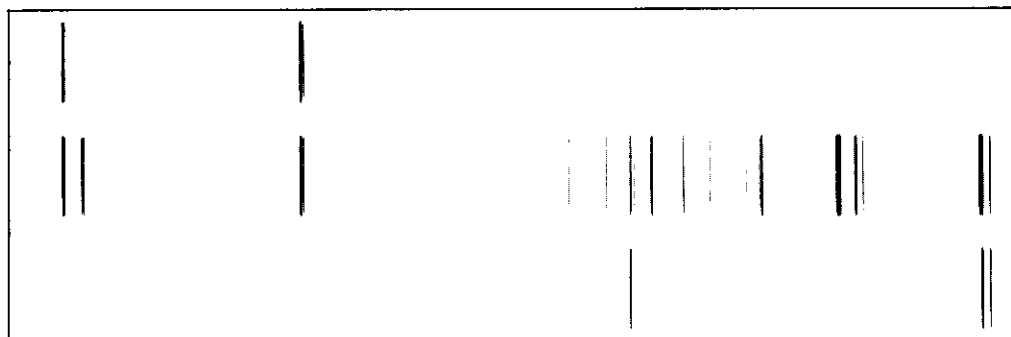


**C.—**The carbon rods have been touched together, then separated one-half inch. Electricity is flowing across the gap, producing intense heat which is vaporizing the rock sample. Notice the light the arc emits. The spectrograph analyses this light.

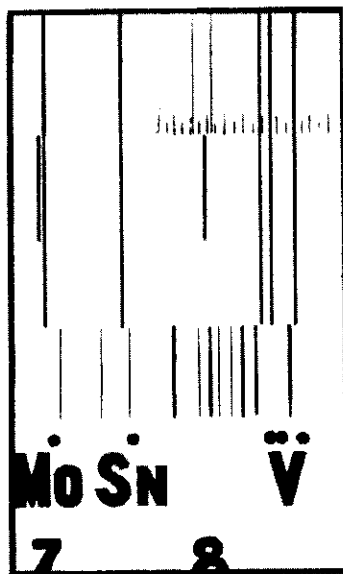
**PLATE 8.**



**A.—Part of a typical spectrogram. The light emitted by the arc (Plate 7C) has travelled through the spectrograph, thereby being dispersed into very narrow beams which produce fine black lines on the film.**



**B.—Parts of three spectrograms. The upper one is of zinc, the lowest is of cadmium, and the middle one is of a prospector's sample. Both cadmium and zinc are present in his sample. The additional lines in the centre spectrogram are due to the presence of other metals in the prospector's sample.**



← **C.—Lines on a spectrogram of an ore containing molybdenum, tin, and vanadium.**

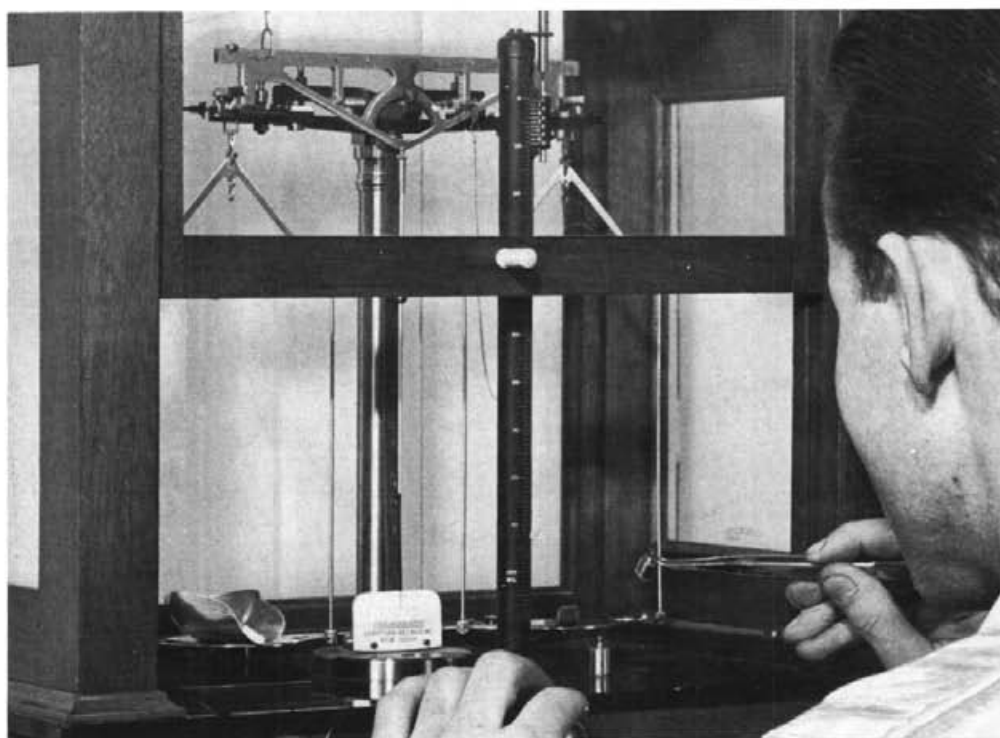
Below the horizontal dividing line is a projected image of a master plate, on which occur sensitive lines of all metals. Here the molybdenum (Mo), tin (Sn), and vanadium (V) lines of the master plate are shown. Notice they coincide exactly with those of the ore.

← An iron spectrum on the master plate, used for alignment purposes.

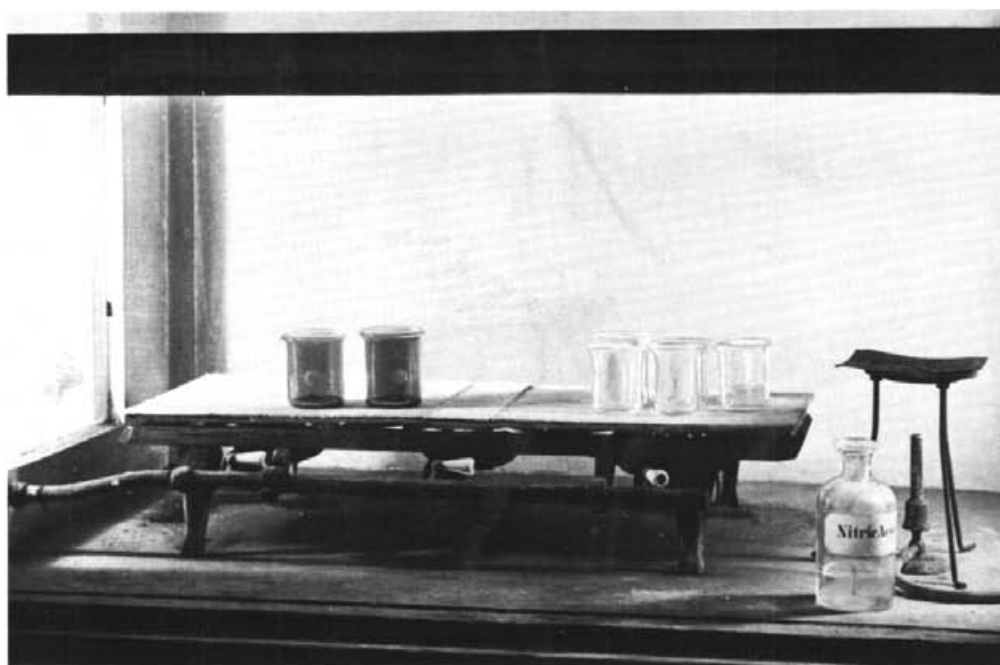


A comparator used for reading spectrograms, and a densitometer used for measuring the blackness of the lines.

**PLATE 10.**

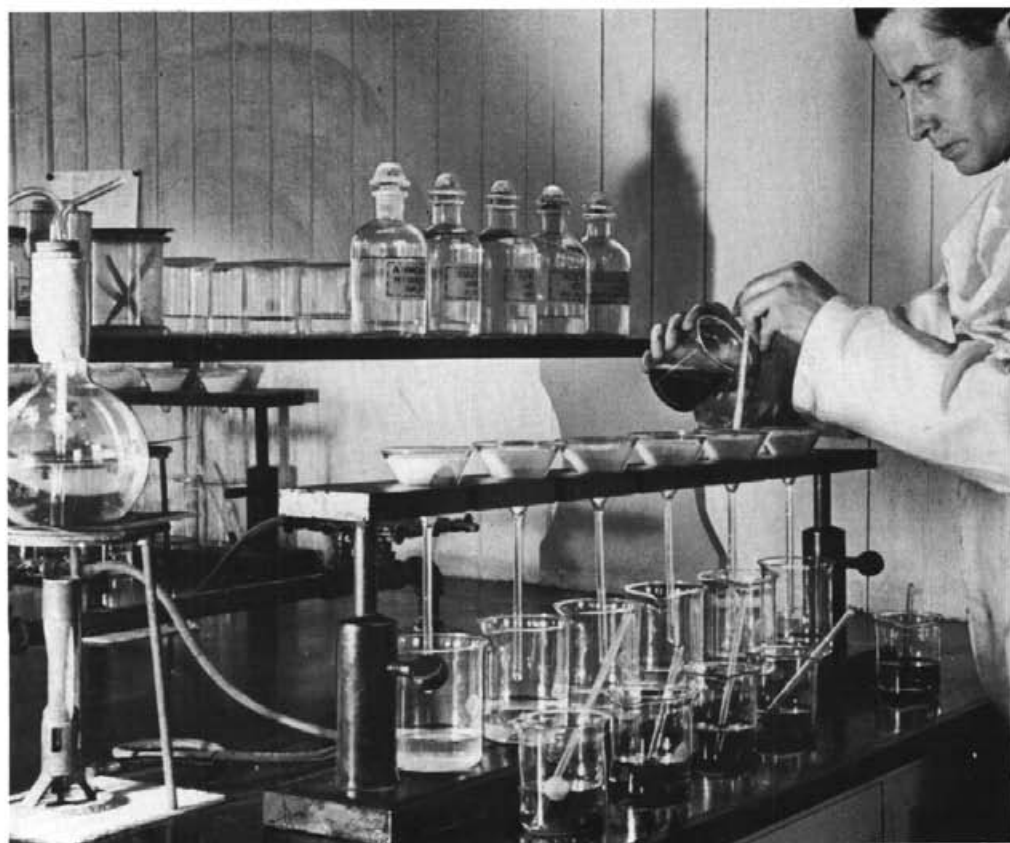


**A.—Weighing a sample of powdered ore for analysis in the wet laboratory.  
This particular sample is to be assayed for zinc.**



**B.—Dissolving the zinc ore sample in acids.**

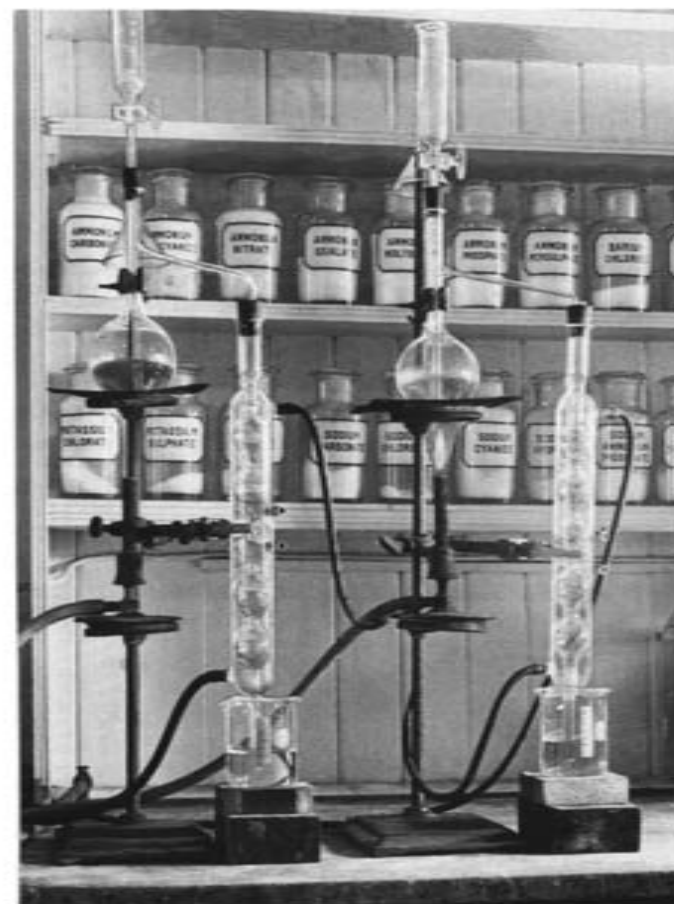
**PLATE 11.**



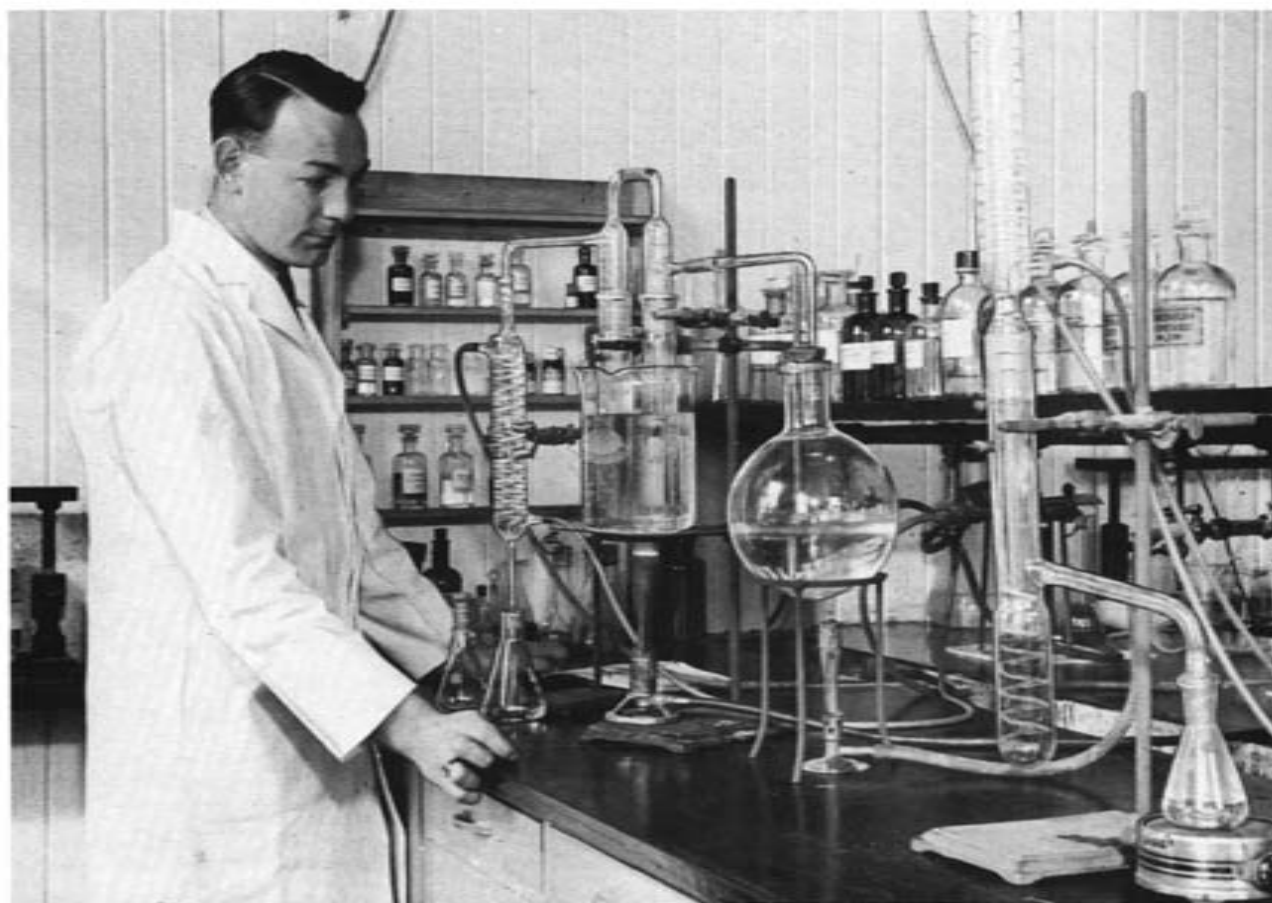
**Interfering metals have been precipitated as solids, but the zinc has remained in solution. The picture shows these solids being separated mechanically from the zinc solution by filtration through special paper cones.**



A.—Titration of the zinc solution.



B.—Distillation apparatus used in determination of arsenic in ores.



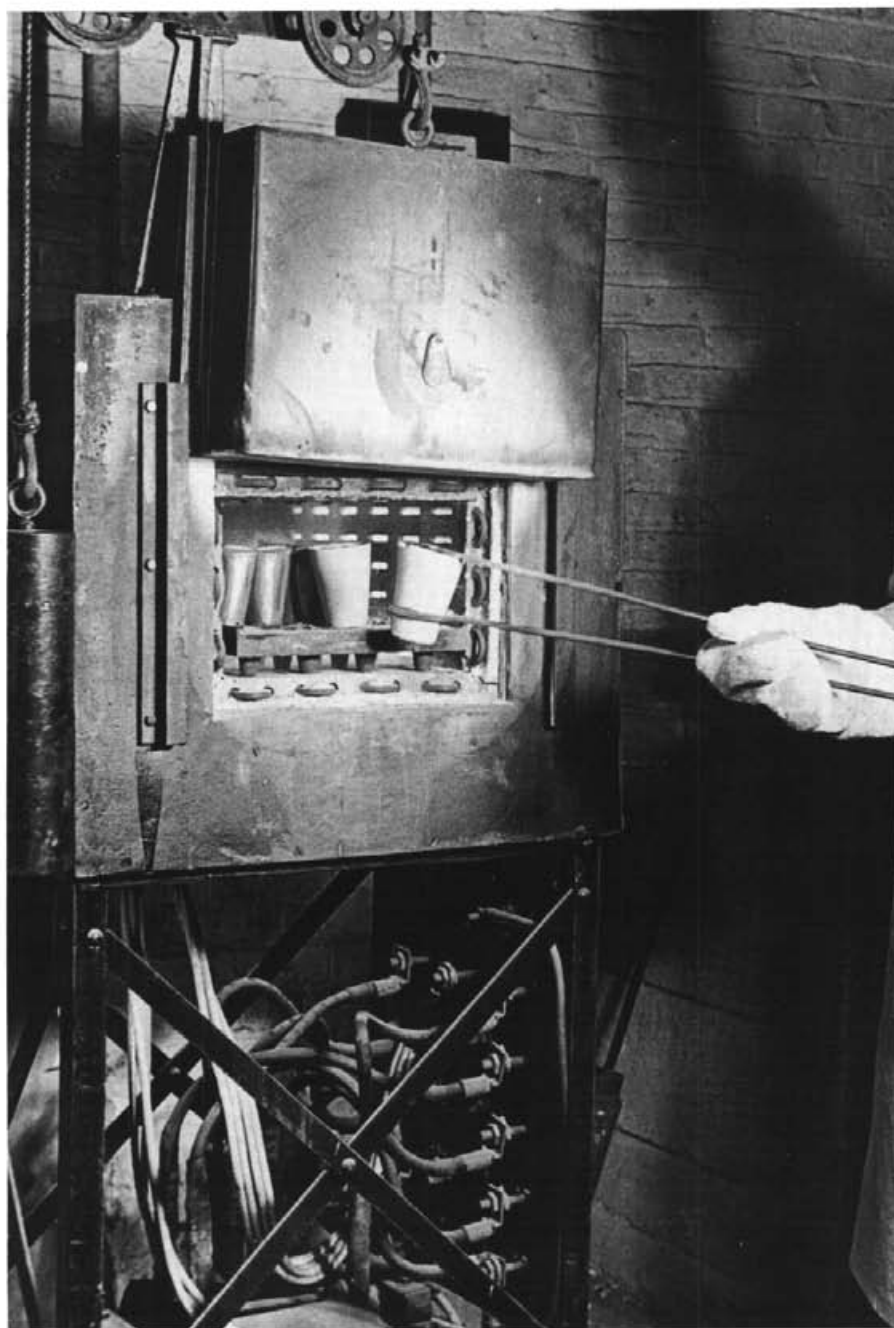
A complex operation in special analytical work.



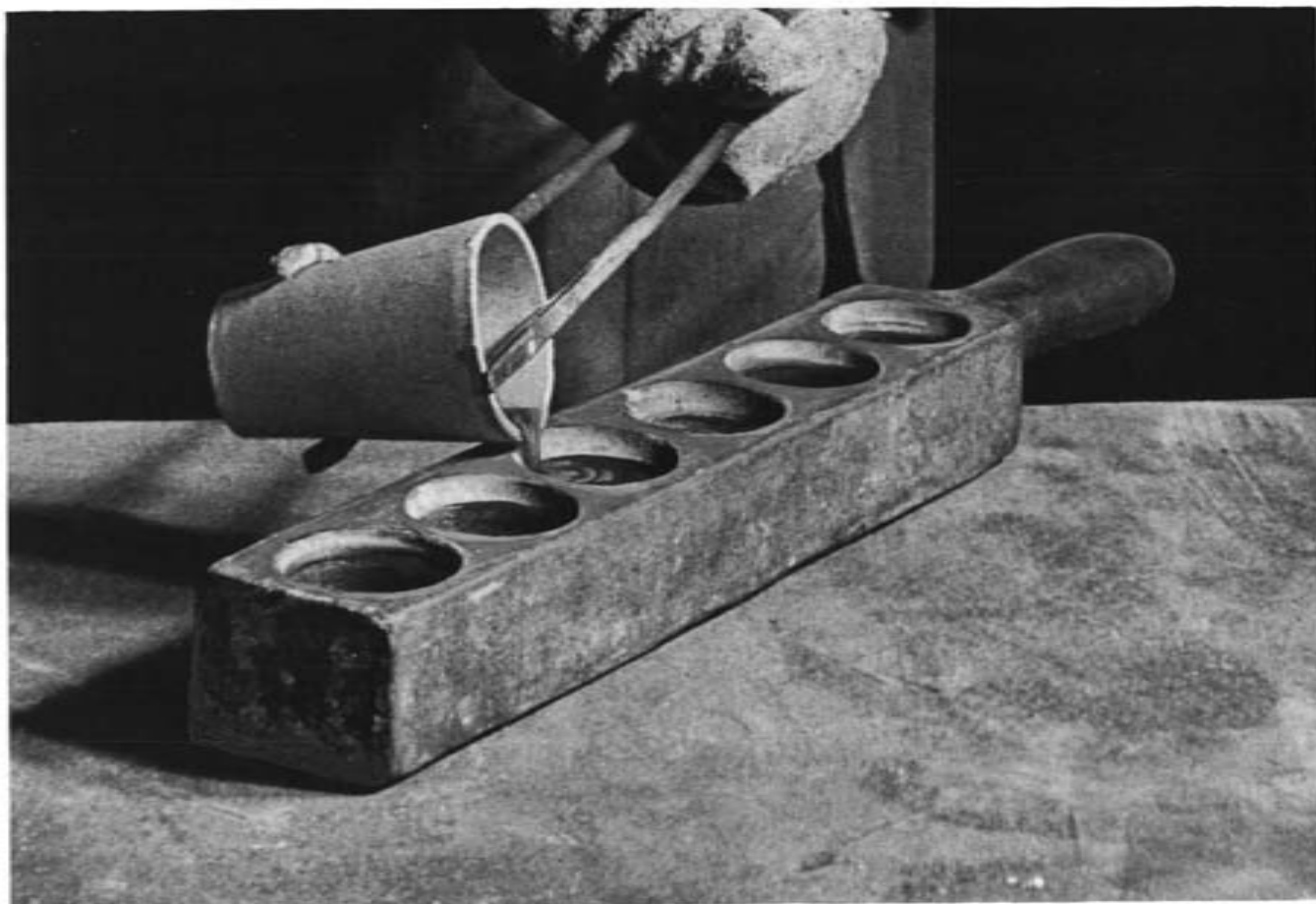
A mixture of ore and fluxes being put in a crucible for a precious metals assay.



**PLATE 15.**



**Placing the fireclay crucibles, containing ore and fluxes, in the electric furnace for fusion of the charge.**



Pouring the molten charge, after fusion in the furnace.

**PLATE 17.**

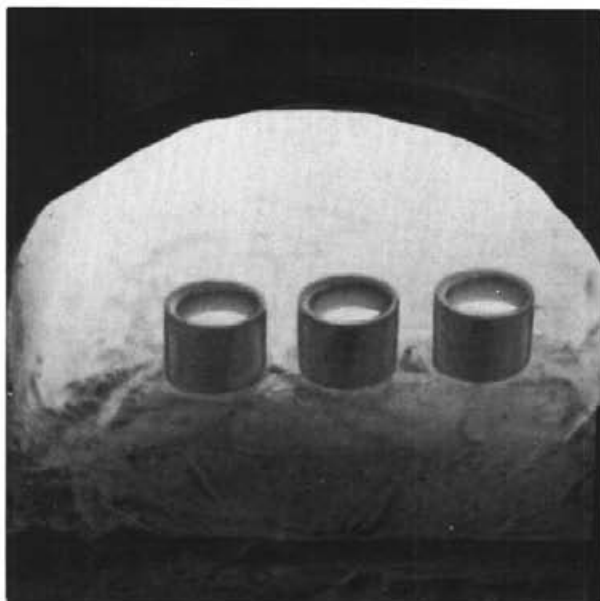


**A.—Cooled slag with lead button attached.**



**B.—The lead button containing all the precious metals, after the slag has been hammered from it and discarded.**

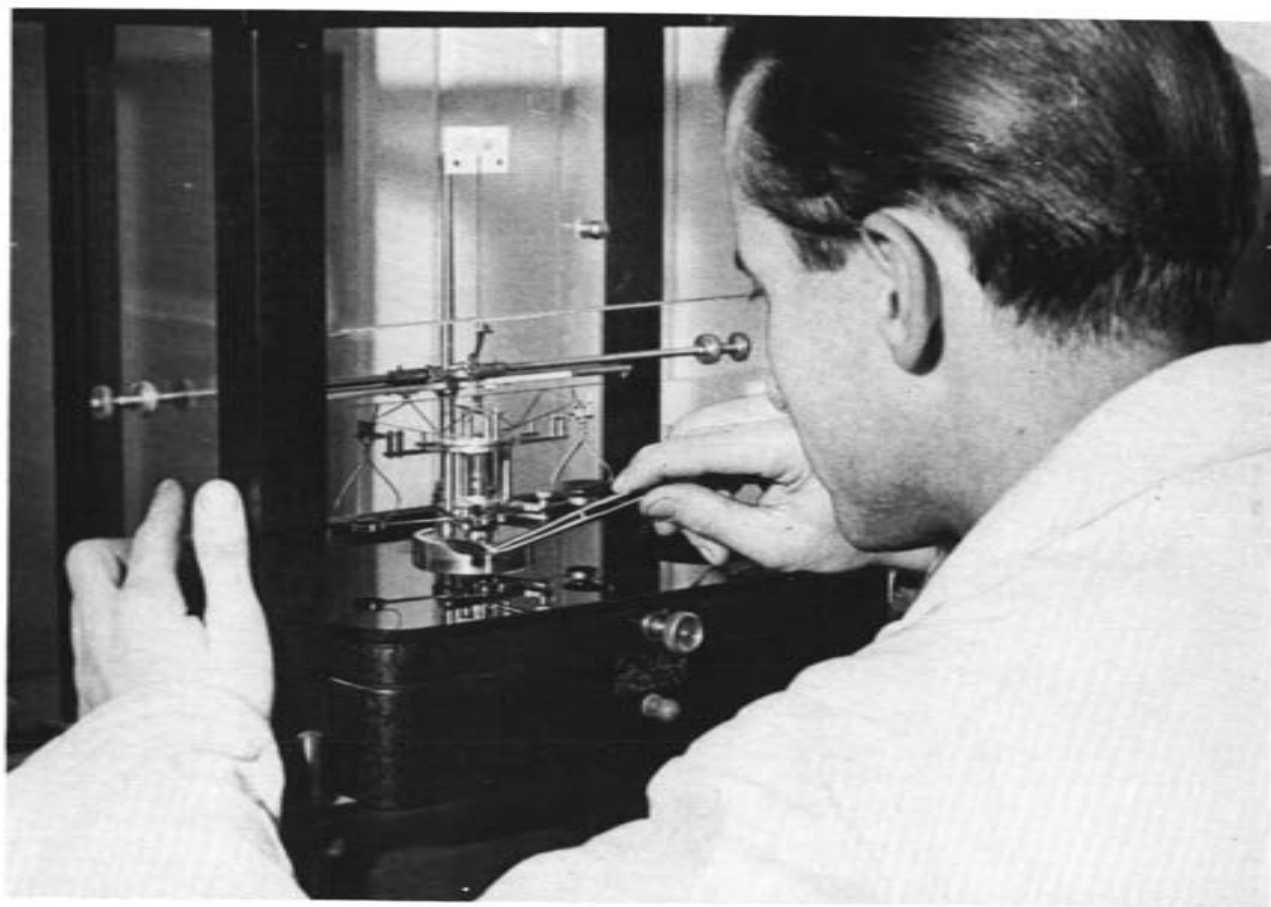
PLATE 18.



A.—Cupellation in progress in a furnace at about 1,200 degrees Fahrenheit. The bright surface visible in each of the cupels is molten lead. It is oxidizing to lead oxide, part of which is volatilizing and part being absorbed by the cupel itself.



B.—A cupel with an exceptionally large silver bead remaining at the completion of the cupellation process.



Weighing the gold bead on a sensitive balance.