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FIELD AND LABORATORY METHODS USED BY THE GEOLOGICAL SURVEY OF CANADA IN GEOCHEMICAL SURVEYS

No. 8

# PREPARATION OF GEOLOGICAL MATERIALS FOR CHEMICAL AND SPECTROGRAPHIC ANALYSIS

P. J. Lavergne

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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## ABSTRACT

This paper outlines methods for the preparation of rock, soil, stream sediment, mineral concentrate, and biological samples for chemical and spectrographic analysis, and contains a list of the necessary equipment to carry out the preparatory work.

Field and Laboratory Methods Used by the
Geological Survey of Canada in Geochemical Surveys

NO. 8

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## INTRODUCTION

The methods described in this paper are based on a number of years experience in preparing rock, mineral, soil, stream sediment, and biological materials in a well established laboratory for chemical and spectrographic analysis. With slight modifications they can be adapted for use in a field laboratory.

The procedure for preparing rock samples for analysis is described first and is followed by those for soil and stream sediment samples, mineral separations, and biological materials. A list of the equipment required for crushing, grinding, and sieving rock samples and for the preparation of biological materials and mineral separations is given in the appendix.

## PREPARATION OF ROCK SAMPLES FOR ANALYSIS

### General Precautions

Field men selecting and shipping rock, soil, stream sediment, etc. samples for analysis should always bear in mind the problem of contamination from sample to sample, the loss of samples owing to incorrect labelling, and the ease of handling in the preparation laboratory. Some of the points to note are the following:

1. Dry all rock samples before packing in plastic bottles or in canvas, plastic, or paper bags.

2. Pack each rock sample individually in a good grade canvas bag. If plastic bags are used some method of keeping the samples from cutting the bags and hence contaminating others must be devised. Avoid packing more than one sample in each bag.

3. Soil and stream-sediment samples should be packed in a heavy paper bag secured with a waterproof cement. This permits drying in the bags before shipment. If plastic bags are used for collecting soil and stream-sediment samples, the materials should be dried before shipment in the plastic bags. Fine-grained samples of soil, stream-sediment, or limonitic

precipitates should be dried and shipped if possible in plastic bottles with tight-fitting caps. The bottles should not normally be filled more than three-quarters full in order to facilitate mixing before preparation and analysis.

4. Carefully tie or otherwise secure all bags to prevent escape of the material from the bags. If plastic bags are used plastic-covered metallic wire ('twist ems') provides a good rapid method of securing the bags.

5. Clearly mark the sample number on the bags or plastic bottles in two places if possible, using some good indelible marking pen or pencil. The field man is solely responsible for the sampling procedure in the field, the numbering system, and for making sure that the samples arrive at the laboratory clearly marked. To avoid errors all unmarked or unintelligible marked samples are discarded as a matter of routine.

6. Include a copy of the sample descriptions, sample numbers, instructions, etc. in the box of samples and send a duplicate copy to the laboratory technician by mail.

## Procedure

Since rock samples will differ widely in their constitution, weathered characteristics, size, etc. the method employed in their preparation for chemical spectrographic analysis must be flexible and capable of adjustment to give good results for any type of sample.

When the laboratory technician receives the samples he must decide either on written instructions or in consultation with the geologist submitting the samples what is the best method of preparing the samples. The method described below is a general one capable of modification to deal with most rock samples.

The flow sheet in Figure 1 gives the systematic steps for the preparation of rock samples with minimum contamination. Briefly these are:

1. Clean the crusher, grinder, and ball mill according to the method given below under the heading "Precautions to avoid contamination" (section 5).

2. Cut all wrapping paper sheets for transfer of the samples and rolling of samples one day ahead if possible. This is to permit the escape of static charges from the paper and prevent part of the fine mesh material from adhering to the paper.

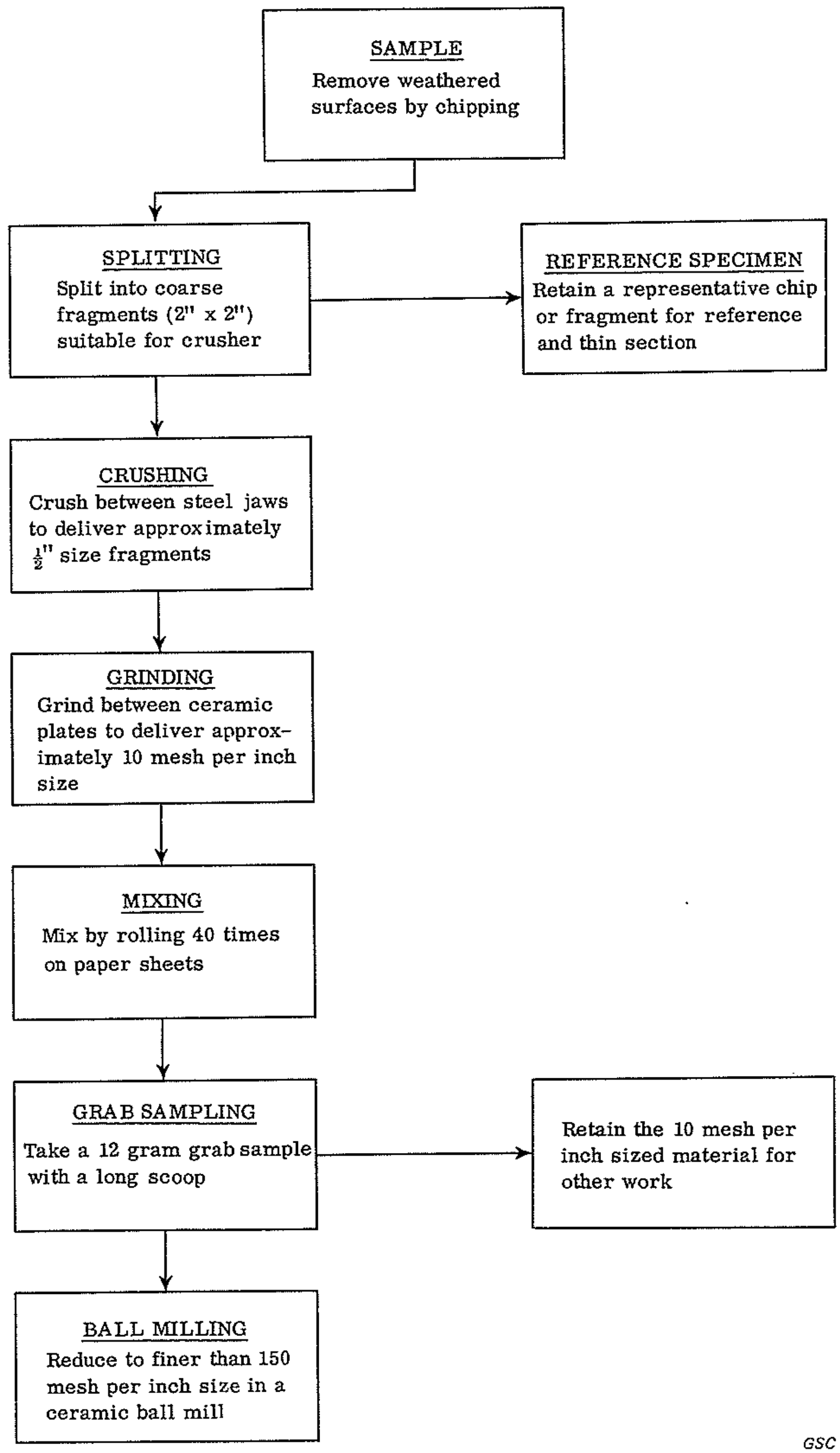


Figure 1. Flow sheet for preparation of rock samples for analysis with minimum contamination

3. Arrange all samples to be crushed and ground in numerical order of their sample numbers. Mark vials, bags, etc. to contain ground samples with proper identification numbers before proceeding with any of the preparation procedures. This step is essential in order to check possible contamination from one sample to another. If contamination does occur the order in which the samples were crushed and ground must be known in order to locate the specific source or sample responsible for the contamination.

4. Work if possible in groups of 12 or 24 samples and carry these through all the steps given below before commencing to work on another group. Experience has shown that this procedure is time conserving and leads to fewer errors.

5. Remove weathered surfaces from rock samples if this is desired by the geologist submitting the samples.

6. Break the rock samples into coarse fragments (2" x 2") suitable for the jaw crusher by means of a rock splitter (Plate I). Retain a representative fragment for reference, for thin sectioning, etc.

7. Crush the sample in the steel jaw crusher to fragments 1/2 inch diameter or smaller, suitable for grinding.

8. Grind the sample by passing it between ceramic plates to deliver material of 10 mesh per inch size. For most work ceramic plates should be used on the grinder. For certain types of work not requiring high accuracy, or for mineral separation, steel plates may be used. These introduce small amounts of iron and other elements in the steel into the sample. A magnet can be used to remove the steel particles from the sample, but it should be noted that magnetic minerals such as magnetite and pyrrhotite are also removed by this procedure.

9. Mix the sample thoroughly by rolling 40 times on a sheet of wrapping paper.

10. Scoop a 12 gram grab sample from the 10 mesh material. Several methods may be employed to obtain a good grab sample. The best way is probably by sectioning the sample into four parts and taking equal amounts from each of the parts to make up the 12 gram grab sample. Retain the remaining 10 mesh material for other work.

11. Reduce the 12 gram grab sample to minus 150 mesh in the ceramic ball mill (Plate IV).

12. Place the final ground sample in a numbered bag or plastic bottle.

For exceptionally hard rocks such as hornfels, chert, or dense amphibolite, modifications to the rock crusher and pulverizer are necessary, as follows:

The movable jaw of the rock crusher should be made of mild steel rather than cast iron. The stationary jaw should also be constructed of mild steel and redesigned so that it is 1 1/2 inches thick at the top end and 1/2 inch thick at the lower end and curved along its length in a manner such that the pieces of rock are repeatedly squeezed at right angles as they pass downward through the jaws to the point of discharge (Plate II).

The pulverizer should be fitted with ceramic disks reinforced with a steel ring (Plate III), as outlined in a previous publication (Lavergne, 1965)[1].

Using these modifications to the crusher and pulverizer, the following procedure for preparing exceedingly hard rock samples is recommended:

1. Split the rock sample into 2 inch pieces.

2. Crush these pieces in the jaw crusher to 3/4 inch size using the normal flat bearing plates.

3. Recrush the 3/4 inch material in the jaw crusher using the curved steel plates to minus 1/4 inch.

4. Grind the minus 1/4 inch material to minus 60 mesh in the pulverizing machine fitted with ceramic plates reinforced with steel rings.

5. Regrind the minus 60 mesh to minus 100 mesh or smaller if required. At all times the operator must ensure that the ceramic plates do not touch each other during the grinding operation.

## PREPARATION OF SOIL AND STREAM SEDIMENT SAMPLES

The procedure to be followed in the preparation of these materials depends on the type of analysis to be carried out on the samples. In certain cases complete analysis of the whole sample may be desired whereas in other cases only the minus 80 mesh fraction of the samples is required for analysis. The latter is generally suitable for most types of geochemical surveys using soils or stream sediments.

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[1] Names and/or dates in parentheses refer to publications listed in the Selected Bibliography.

When the whole sample is required for analysis the same procedure as that given for rock samples is carried out beginning at step 8. Prior to this all samples should be dried and all lumps of clay, etc. broken up by means of a baker's rolling pin or some other suitable non-contaminating instrument. Stones and other types of foreign material such as roots should be removed either by hand picking or by a large mesh stainless steel sieve.

When only the minus 80 mesh fraction is required, the sample, after the lumps in it are broken up, is passed through an 80 mesh stainless steel sieve[1]. The undersize is caught on a sheet of wrapping paper, rolled, and retained as the sample. The oversize is discarded.

If the sample is to be analyzed by the standard colorimetric methods no further treatment is necessary. For spectrographic work, however, the samples should be ground to minus 200 mesh and ashed at 500°C to remove the organic matter.

## PREPARATION OF MINERAL CONCENTRATES

Several methods may be used in preparing mineral concentrates after the rock, soil, or stream-sediment samples are properly ground and sized. These include hand panning, superpanning or other mechanical panning, heavy liquid separation, magnetic separation, flotation, and hand picking.

A general flow sheet for the preparation of mineral concentrates is given in Figure 2. Briefly the steps are as follows:

1. Clean the crusher and grinder thoroughly, prepare paper sheets, and arrange samples in numerical order.

2. Remove weathered surfaces from rock samples if this is required by the geologist submitting the samples.

3. Break the rock samples into coarse fragments (2" x 2") suitable for the jaw crusher by means of a rock splitter. Break up lumps in soil samples. Retain a representative fragment of the rock sample for reference, thin sectioning, etc. Retain a representative sample of the soil or stream-sediment if required by the geologist.

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[1] Stainless steel sieves with the mesh soldered to the frame are a serious source of contamination. Only sieves in which the mesh is secured to the frame by a friction flange should be used.

4. Crush the sample in the steel jaw crusher to fragments 1/2 inch or smaller.

5. Grind the sample by passing it between either ceramic or steel plates on instructions from the geologist submitting the samples. If steel particles are to be avoided use ceramic plates. The sample should be ground in stages to avoid producing a large amount of fine material. First, grind all of the sample to pass 80 mesh and then successively grind the 80 mesh material to pass 100, 150, and 200 mesh respectively. The final size of the ground material will depend on the size of the individual minerals in the rock, soil, or stream-sediment samples. This size should be determined by the geologist by microscopic methods.

6. Wash the sample in warm water to remove fine material that floats or material that slimes. Addition of a small amount of detergent will facilitate the wetting of the particles and depress much of the fine material that floats. Generally the slimes can be discarded, but if they are to be recovered they can be caught on a filter paper for further work.

7. For mineral separation several methods are available, and the one to be used will depend on what minerals are to be separated. Furthermore, experience and patience are required to make good mineral separations. For sulphides, superpanning followed by magnetic separation, flotation, or hand-picking methods are generally employed. For magnetite, superpanning followed by magnetic separation is generally successful. For silicate minerals heavy liquids may be used. Some minerals can only be separated by the tedious hand-picking method under the microscope. A general scheme for separating the sample into its various mineral components is shown in Figure 2. This can be modified in a number of ways as experience dictates.

## PREPARATION OF BIOLOGICAL MATERIALS

Biogeochemical samples of living or dead plant or animal materials are generally collected in paper or plastic bags. In some cases the samples may have been air dried before shipment; if not, they should be unpacked as soon as received and air dried in a well-ventilated, dust-free room. It is particularly important to open samples in plastic bags as soon as possible, otherwise the samples will mould and putrefy.

Careful precautions should be taken to avoid contamination of biological materials by dust in the room in which they are dried and prepared. If samples are dusty on receipt from the field they should be rinsed, prior to drying, in metal-free water containing a small amount of detergent.

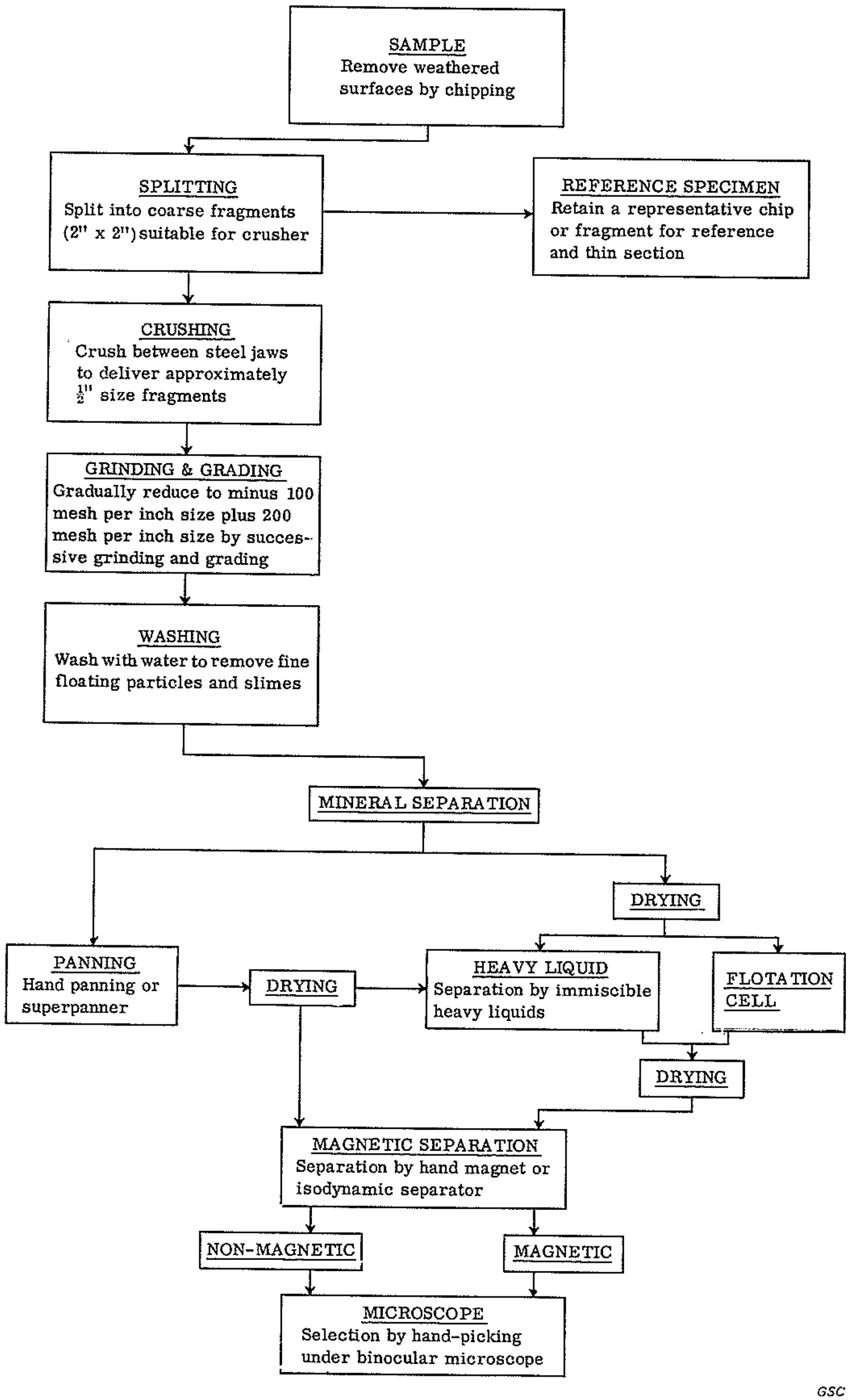


Figure 2. Flow sheet for preparation of mineral concentrates

Biogeochemical samples are generally dried at 80°C for eight hours or until a constant weight for the samples is obtained. This temperature is lower than that recommended for soils or stream-sediments because some organic compounds in animal and vegetable matter are volatile above 80°C. To avoid contamination it is advisable to dry biological materials in an oven used solely for this purpose. Samples in which mercury is to be determined require special treatment because of the extreme volatility of mercury compounds.

After drying, biogeochemical samples are generally weighed prior to analysis so that the results can be expressed on an oven-dry basis. From this point onward a variety of methods for preconcentration of the elements in the samples may be carried out. These include dry ashing, wet ashing, solvent extraction, and specialized chemical preconcentration methods. These are not discussed in this paper because they belong more properly in the field of analysis of biological materials and will be discussed in other publications in this series.

A general flow sheet for the preparation of biological materials is given in Figure 3. Briefly the steps are as follows:

1. Unpack the samples and open the bags in a dust free-room.

2. If the samples are dusty or if the geologist so desires, the biological materials may be washed in metal-free water containing a small amount of non-contaminating detergent.

3. Split the samples into portions and number them a, b, c, etc. The number of portions will depend on the type of analyses required and will be determined by the geologist for whom the work is done.

4. Dry the various portions (subsamples) in an oven at 80°C for eight hours or until the samples attain a constant weight. Avoid drying the biological samples with soils or other geochemical samples. It is best to use an oven specially set aside for biogeochemical samples. This step should be omitted for samples in which mercury is to be determined.

5. Weigh each of the subsamples and record the weights as oven-dry weights.

6. If desired by the geologist the subsamples may be ground or milled or pressed into pellets prior to ashing.

The procedure for milling plant material is given by Ward and Johnson (1962). They recommend a mechanical mill and stress that it should be thoroughly cleaned between the grinding of individual samples.

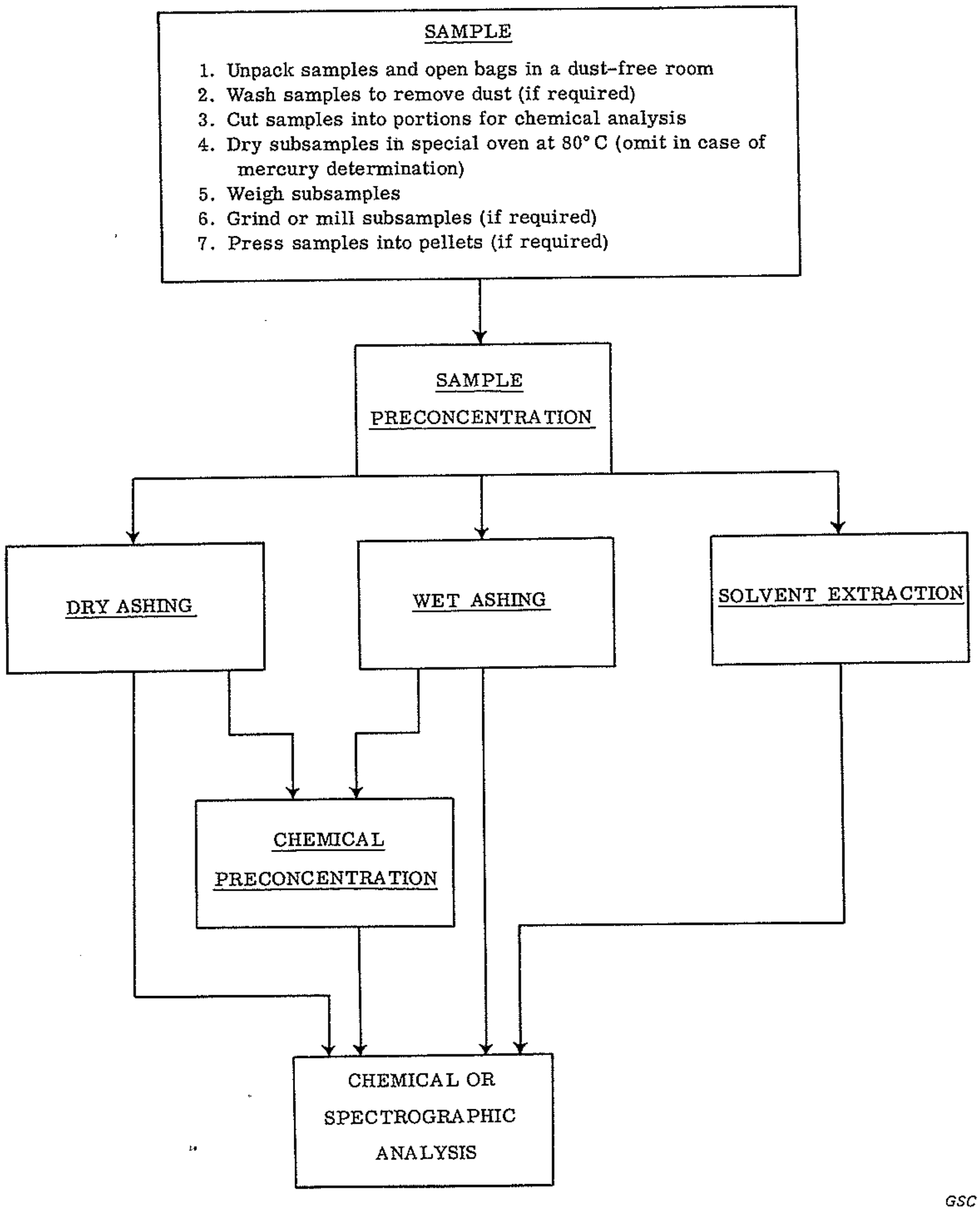


Figure 3. Flow sheet showing the steps in sample preparation of biological samples and the main stages in the chemical analysis of biological materials

Grinding with a mortar and pestle may be necessary in special instances, such as in analysis of molybdenum.

The method for pressing samples into pellets is described by Ward et al. (1963). Briefly, it consists of drying the organic material at 60°C, grinding it in a Wiley mill, taking 5 or 10 grams of the material, and compressing it into a pellet by means of a stainless steel cylinder placed in a press. The advantage of using pellets is that more samples can be dry ashed simultaneously with greater ease, there is less chance of contamination, and more uniformity of dry ash. Pellets are also more convenient when carrying out wet ashing procedures.

## PRECAUTIONS TO AVOID CONTAMINATION

Contamination from sample to sample, from samples with high concentrations of specific elements, from crushers and grinders, from other preparatory equipment, and from sample bags, bottles etc. must be avoided. Checks for contamination at all stages of sample preparation should be carried out frequently to avoid costly repetitive work. Listed below are a few points on avoiding contamination, cleaning equipment, etc.

1. Samples of ores or materials with a high concentration of any specific element must not be prepared in the same equipment as those for rocks, soils, stream-sediments, etc. In fact, two separate sets of equipment in different rooms, one for ores and the other for rocks, soils, stream-sediments, etc. must be provided. Biological materials should be prepared in a room entirely separate from those where rocks, soils, and ores are prepared.

2. The crusher and grinder are the principal sources of contamination in the preparation of rock, soil, and ore samples. When a mortar and pestle are used these may also be sources of contamination. In general a very low (generally negligible) amount of contamination in the form of steel flakes is introduced into rock and other samples by the crusher. Relatively little can be done about this minor amount of contamination except to make sure that the plates of the crusher are not set too close and to avoid if possible repeated abrasion by the jaw plates on the larger fragments of rock.

Considerable amounts of steel particles, containing various elements for the hardening of the steel, are introduced into rock and soil samples by grinders with steel plates. For certain types of work this is not serious. For other types of work, especially trace-element work, ceramic grinding plates are essential. These introduce a little alumina and insignificant amounts of other elements.

3. All crushers, grinders, and tables for mixing, rolling, splitting, and sampling the ground materials must be fitted with dust hoods, both for health reasons and to avoid contamination of samples by the dust, which otherwise would spread around the sampling room. The design of dust hoods and dust collectors cannot be discussed here. In general it is preferable to have separate ducts and suction fans for each type of machine and for each preparation table, or to have one large suction fan and central duct with cut-off dampers in each of the subsidiary ducts serving the various machines and tables. The latter arrangement facilitates better cleaning since the suction can be increased at one site by cutting off all of the other ducts.

Dust collectors and precipitators come in a number of designs, and those organizing a preparatory laboratory should consult the commercial brochures. Dust-proof motors are desirable on all machines, suction fans, etc. If dust-proof motors are not available, the ordinary types of motors should be mounted outside the dust hoods if possible.

4. Tough fine-grained rock samples such as hornfels, certain varieties of metavolcanic rocks, and cherts are generally difficult to prepare without breakage of and contamination from the crusher jaws and grinding wheels. To minimize the contamination a mild steel movable jaw for the crushing machine, in place of the normal cast iron one, has been found to give better results. This modification is described on page 16 and shown in Plate II. In addition to these modifications on the crusher it has been found desirable to use ceramic plates rather than steel plates on the grinder for the preparation of tough fine-grained rocks. To prevent excessive breakage and cracking of the ceramic plates they should be reinforced with a steel ring as described by the writer in a previous publication (Lavergne, 1965) and shown in Plate III.

5. Crushing and grinding machines are best cleaned by means of a high pressure stream of air from an air line or vacuum cleaner directed upon the jaws, grinding plates, etc. In this case an appropriate dust hood with good suction is a prerequisite on each of the machines. Otherwise the machines should be cleaned with a vacuum cleaner with good suction.

Crusher jaws should be cleaned with a steel wire brush as the air stream is directed on the jaws. After this treatment the jaws should be wiped with a damp cloth and immediately dried with a dry cloth.

The steel plates of the grinding machine are best cleaned with a stiff paint brush as the air stream is directed on the plates. When the grinder is fitted with ceramic grinding plates, thorough cleaning is best achieved by grinding a small quantity of pure quartz sand between the plates, followed by the air stream and stiff brush treatment.

6. Both the crushing and grinding machines should be mounted on 1/2 inch wooden blocks to facilitate cleaning beneath them.

7. Ceramic ball-mill cartridges and balls should be washed in water containing a little non-contaminating detergent after each sample. If this is not satisfactory a little pure quartz sand should be milled in the cartridges for a short time followed by washing in water. During the milling of the pure quartz sand the frame holding the cartridges should be reversed at least once for thorough cleaning of the balls and cartridges. An occasional bath in boiling hydrochloric acid followed by rinsing in metal-free water will clean both ceramic balls and cartridges thoroughly and give them a fresh appearance. This latter type of treatment is recommended when all traces of contamination from one sample to another are to be avoided.

8. For most types of trace-element work stainless steel sieves with the stainless steel screens attached to the frame by friction flanges should be used. Screens soldered to the frames have been found to introduce serious contamination and should be avoided.

The screens of sieves are best cleaned with a stiff paint brush whose hair has been cut to a length of approximately 1 inch. A forced air blast is also useful in cleaning sieves, although in many cases the grains tend to stick in the screen and have to be dislodged with the paint brush or in certain persistent cases with a needle. For certain types of work where contamination is to be reduced to a minimum the stainless steel screens should be washed carefully in metal-free water and dried immediately after each sample. For other types of work it may be desirable to have a separate set of sieves for each project.

9. The pan of the superpanner is best cleaned with very fine-grained silica sand. This treatment should be carried out frequently to keep the pan in a sparkling condition.

10. Magnetic separators and other apparatus used in mineral separations are generally cleaned with a paint brush and an air blast. After cleaning, the electro-magnetic separators should be allowed to vibrate for a short time to remove any particles still adhering to the operating parts.

11. The risk of contamination of biological materials is much greater than in the case of rocks, soils, or stream-sediments, owing to the high factor of preconcentration involved in the analysis of the biological materials. For example, suppose a small flake of a molybdenum lubricant containing 10 micrograms molybdenum inadvertently falls into a 10 gram soil sample containing 10 ppm molybdenum. If the sample is homogenized and subjected to chemical analysis the result will be about 10 per cent higher, owing to the contamination, which is not significant in many cases. If the same molybdenum-bearing flake falls into a 10 gram sample of oven-dried

plant material and the plant material is then dry ashed and subjected to a chemical preconcentration step a forty-fold increase in the molybdenum content of the sample can be expected. This is admittedly an extreme case, but it does focus attention on the need for care in the preparation of samples of biological materials.

12. Preparation of more than one sample at the same time in the same room should be avoided, because chips or dust from one sample may contaminate the others.

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# APPENDIX

The following lists the various equipment required for the preparation of rock, mineral, soil, stream-sediment, and biological materials for chemical and spectrographic analysis.

## Rock Splitter

Type: Friction type, hydraulic, either manually or power operated. Plate I shows a hydraulic, power-operated rock splitter suitable for most types of work.

Bench: The bench should be of heavy wood construction, 30 inches high, and have a wooden top. A tray arrangement built into the top below the rock splitter facilitates the collection of the rock fragments.

Hood: A ventilation hood is not required.

Cleaning: The rock splitter should be cleaned with a stiff steel brush and air blast.

## Core Splitter

Type: Friction type, manual, to split core 6 to 8 inches long.

Bench: The bench should be of heavy wood construction at least 3 feet long, 3 feet wide, and 30 inches high. An ancillory bench at least 6 feet long, 3 feet wide, and 4 feet high should be provided for laying out the drill-core boxes. The excess height permits the examination of the core without undue fatigue from bending.

Hood: A ventilation hood is not required.

Cleaning: The core splitter should be cleaned with a stiff steel brush and air blast.

## Crusher

Type: Several different models are available with or without motors. Two capacities are generally quoted by the manufacturers: (1) a standard model with 400 lb. per hour capacity; 2 1/4" x 3" jaw opening and a reduction size of 3/4" to 1/2"; fitted with a v-belt and a 1 hp electric motor; (2) a heavy duty model with

Type: (cont'd) 800 lb. per hour capacity; 2 3/8" x 4" jaw opening and a reduction size of 3/4" to 1/2"; fitted with a v-belt and a 2 hp electric motor. The standard model is preferable (Plate II).

Bench: The bench sould be of heavy wood construction, 2 feet wide, 3 feet long, and 2 feet high. The crusher should be securely bolted to the wooden top of the bench and the bench as a whole either weighted at the bottom by embedding the legs in a cement block or alternatively bolting the legs to the floor.

Hood: A good ventilation hood with a 6" stack should be provided. This hood should be so constructed as to permit ready access to the crusher openings.

Cleaning: The crusher should be cleaned with a stiff steel brush and air blast.

Modifications: For field use the crusher can be fitted with a 2 or 3 hp gas engine where electric power is not available. For trace element work the tray receiving the crushed rock should be made of stainless steel.

For exceptionally hard rocks the movable and stationary jaw plates as supplied by the manufacturer may require modification to prevent breakage and undue contamination. The movable jaw plate should be constructed of mild steel with no change in dimensions or design. The stationary jaw plate should be made of mild steel and redesigned so that it is 1 1/2 inches thick at the top end and 1/2 inch thick at the lower end and curved along its length in a manner such that the pieces of rock are repeatedly squeezed at right angles as they pass downward through the jaws to the point of discharge (Plate II).

## Pulverizer

Type: Several models are available. The model selected should be capable of pulverizing at least one pound of 1/4-inch quartz fragments in one grinding to 100 mesh in one minute. The direct-driven rotating disk type pulverizer with a built-in sealed electric motor is recommended and has been used successfully by the writer both in the field and headquarters laboratory. Where electric power is unavailable in the field a belt-driven rotating disk pulverizer fitted to a 2 or 3 hp gas engine is satisfactory.

Bench: The bench should be of heavy wood construction and of suitable size to accommodate both the pulverizer and engine.

Hood: A good ventilation hood should be provided. This hood should be so constructed as to permit ready access to the entry spout and ground sample tray and also to permit rapid and efficient cleaning.

Cleaning: The pulverizer should be cleaned with a stiff steel brush and air blast if steel plates are used and with a stiff paint brush and air blast when ceramic plates are employed.

A reverse polarity switch to change the direction of rotation of the moving disk should be provided on electric models. This permits the cleaning of both sides of the grooves in the disks when using quartz sand and also distributes the wear on the disks during sample preparation.

Modifications: For trace-element work the sample tray should be made of stainless steel.

Either steel or ceramic disks may be used on most pulverizers. For ordinary work the steel disks are satisfactory, but for trace-element work ceramic plates are nearly obligatory.

To prolong the life of ceramic plates, reinforcement by means of a mild steel ring is necessary (Lavergne, 1965) (Plate III).

## Ball Mill

Type: Paint shaker fitted with frame holding ceramic grinding cartridges, as shown in Plates IV and V[1]

Modifications:

1. The holding jaws of the paint shaker must be reinforced by welding an aluminum bar between the guide pins and the adjustable screw.

2. The U bolt holding the jaws to the rocker arm should be replaced by a properly fitting clamp adapter for stability.

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[1] Adapted with modifications from a similar ball mill used by the United States Geological Survey, Denver, Colorado.

Construction of Frame to hold Cartridges:

1. Cut 4 pieces of plywood 1/2" x 8 1/2" x 11".

2. Cut 6 holes, evenly spaced and large enough to take the ceramic cartridges, through 2 pieces of plywood.

3. Glue and secure with screws the pieces of plywood with the holes to the pieces without the holes.

4. Insert a 3/8" soft rubber pad in each of the sunken wells of the two pieces of plywood.

5. Install one 3/8" bolt with wing nut to hold the frame together.

6. When in use seal the ceramic cartridges with adhesive tape to prevent escape of finely ground material.

## Mixing Tables

Description: Mixing tables should be of solid wood construction with wooden or stainless steel tops. The treated wooden top is preferable. The dimensions may vary to suit the individual, but should not be less than 30 inches wide by 30 inches long and 3 feet high.

Hood: Mixing tables must be fitted with a suitable hood for removing dust. The hood should be so constructed that it permits easy manipulation of the sample.

## Drying Cabinet

A drying cabinet is essential for stream-sediment and soil samples. The cabinet should be of sufficient size to dry at least 200 samples. simultaneously. Since most samples of stream-sediment and soil are dried in the field the following type of cabinet is suggested.

Size: 4 feet square by 7 feet in height.

Construction: Of 1/4-inch plywood on a 2" x 4" wooden frame. A lift-up type door with counter balance should be fitted on the front, and if possible this door should have a glass port hole.

Insulation: The walls, roof, and floor should be lined with aluminum foil stapled to the plywood. This serves as a heat reflector and reduces the fire hazard.

<u>Heat source:</u> A propane gas stove with at least two burners is advisable. The stove should have a precise adjustable control. A metal sheet should be installed 12 inches above the flame to prevent samples from accidentally falling into the flame.

<u>Trays:</u> Four or more trays to hold the wet samples are required. These trays should have a latticed bottom to permit circulation of the air around the samples and should fit into the cabinet one above the other. The lower try should be at least 2 feet above the gas burners, and the other trays should be spaced at intervals of a foot above one another.

<u>Ventilation:</u> A 6-inch hole in the top of the cabinet is sufficient for ventilation purposes. The door on the front of the cabinet should be left open an inch or so during drying.

<u>Temperature Control:</u> A cheap, insert-type thermometer should be fitted in the side of the cabinet in a convenient place. The temperature inside the cabinet should be maintained at about 140°F during the drying operation. At this temperature it requires approximately 24 to 48 hours to dry thoroughly the wet-stream-sediment samples in kraft paper sample bags.

## Ancillory Equipment

In addition to the above basic equipment a great variety of ancillory machines and articles are required for the preparation of geological materials for analysis. Some of the more important of these are listed below:

Beakers - assorted sizes.

Balance - 800 gram capacity.

Brushes - assorted sizes - bristle and steel.

Funnels - assorted sizes.

Magnets - hand type

Magnetic separator - isodynamic type.

Microscope - binocular.

Sieves - assorted sizes. For trace-element work stainless steel sieves should be used. The mesh of these sieves should be secured by a friction flange and not by solder.

Sieve shaker - mechanical

Vacuum cleaner.

Hand mortars and pestles - agate, ceramic, and steel types.

Power mortar - fitted with both ceramic and steel mortars and pestles.

Buckboard - both steel and ceramic types.

Flotation cells.

Gravity separators - Superpanner fitted with stainless steel pan (Plate VI) and Wilfley table.

Heavy liquids and ancillory equipment such as separatory funnels, flasks, etc.

Sample splitters - for trace-element work these should be made of stainless steel or aluminum.

Vacuum pump - for use in heavy-liquid work.

Electric hot plates.

Mechanical vibrator pad.

Prospector's pans - assorted sizes.

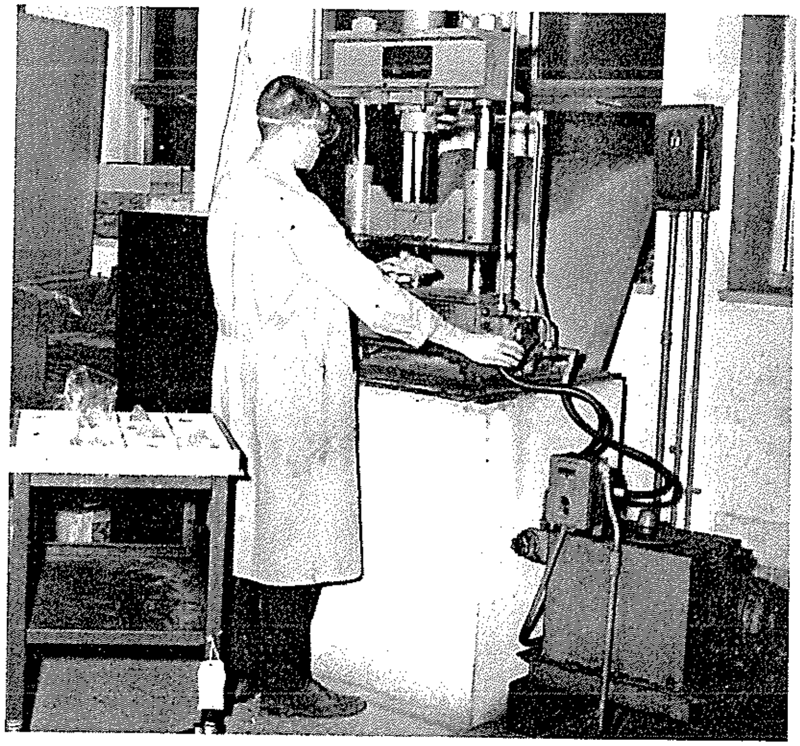

Plate I. Hydraulic, power operated rock splitter.

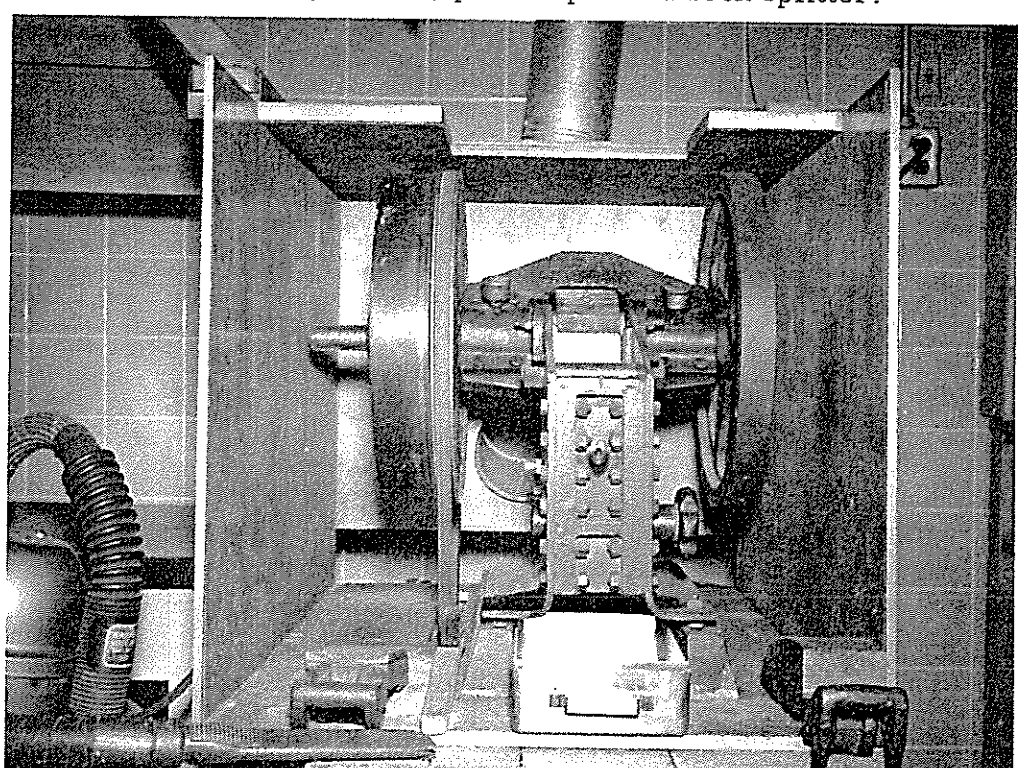

Plate II. Jaw crusher with modified (right) and unmodified (left) jaw plates.

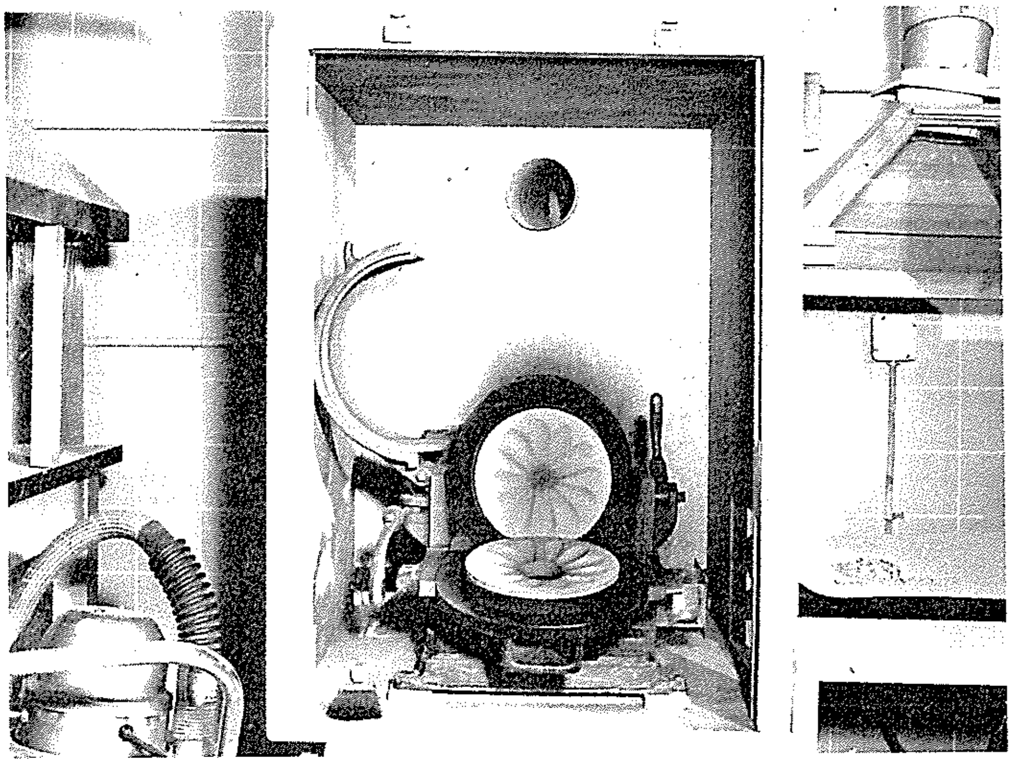

Plate III. Pulverizer with reinforced ceramic disks.

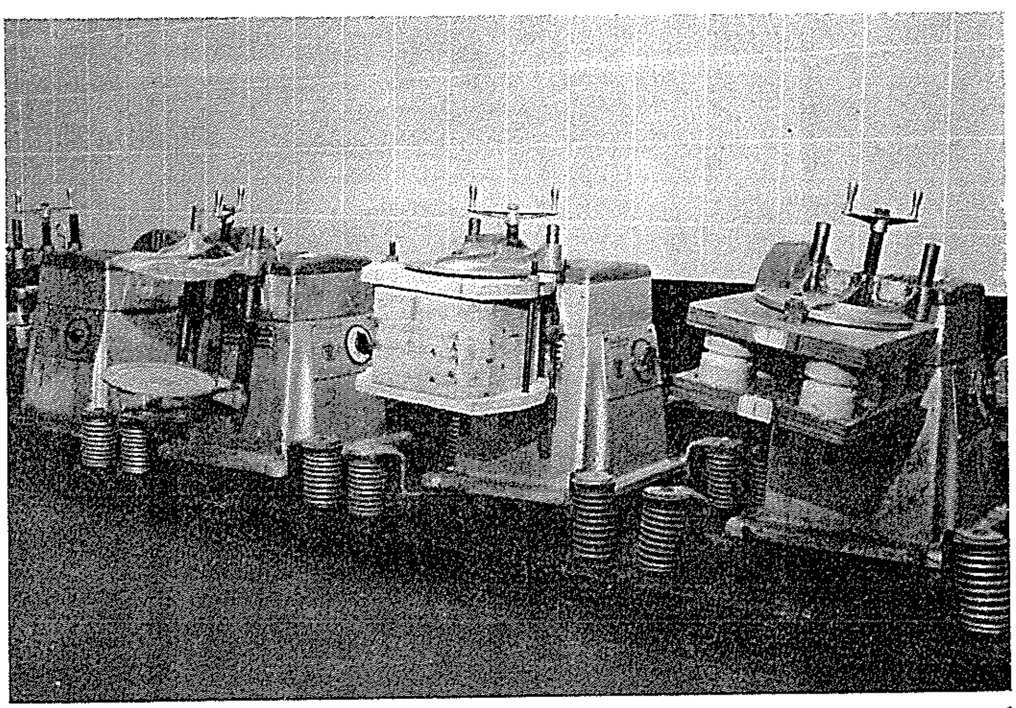

Plate IV. Paint shaker ball mill. The middle paint shaker holds a box for cleaning the ceramic balls with ground quartz.

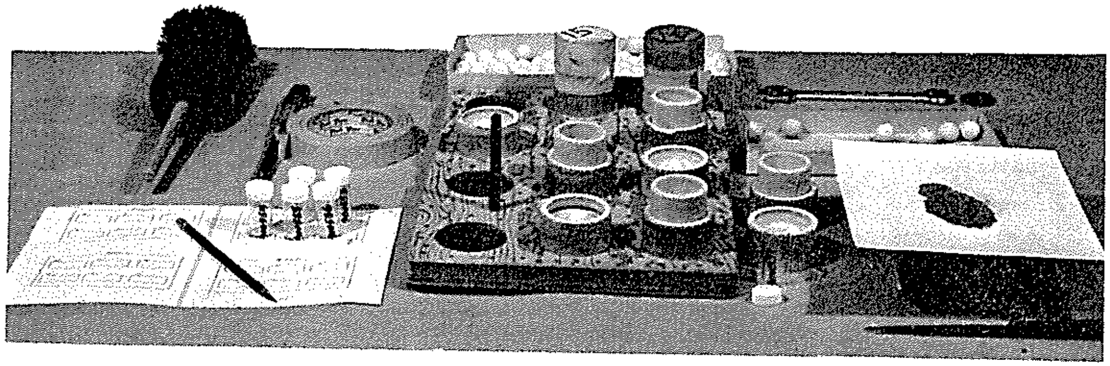

Plate V. Dismantled sample cartridges for ball mill.

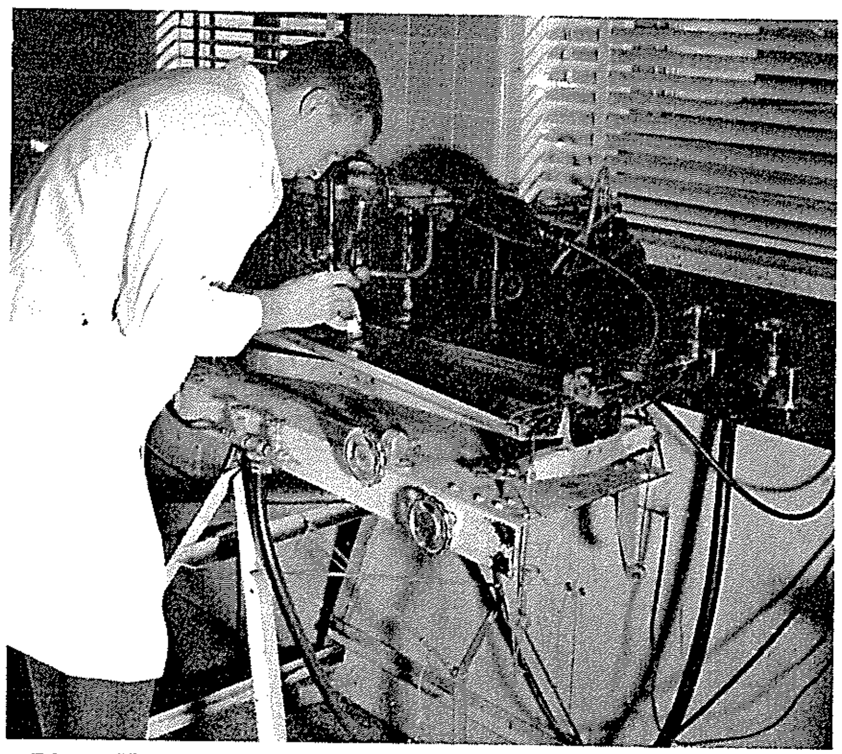

Plate VI. Superpanner.