BUREAU OF MINES

DEPARTMENT OF MINES AND RESOURCES

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THE SAMPLING AND EXAMINATION OF CLAY AND SHALE DEPOSITS

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Introduction

In response to many requests made to the Ceramic Section for information on the sampling of clay and shale deposits, the following memorandum has been written. Individual requests have in the past been answered by letters, which of necessity must be somewhat abbreviated. The more detailed instructions contained in this memorandum should serve as a better guide to the field man in selecting samples for examination in the laboratory.

While the instructions are applicable chiefly to large deposits of clay and shale, suitable for the manufacture of heavy clay products such as brick and tile, they can also be applied, in general, to the sampling of china clay, kaolin or pottery clay, which may occur in smaller and more irregular deposits.

Part III, "The Examination of Clay and Shale Deposits," has been included to give some indication of the economic features that must be considered in relation to such deposits.

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I. GENERAL INSTRUCTIONS REGARDING CLAY AND SHALE SAMPLES

The purpose of taking samples of clay or shale is to obtain as much information as possible regarding the quality and uniformity of the deposit. It is, therefore, essential to follow certain rules for sampling in order to be sure that the sample is reasonably representative.

The information gained from laboratory tests on a representative sample is important to the person in the field and to the Bureau of Mines. The former is interested in finding out if the clay or shale is of commercial value, and therefore, wants information on the type of material that is likely to be found when the deposit is developed. The Bureau of Mines is interested in gaining reliable information on the characteristics of the clays and shales found in various parts of the country.

The Bureau requires complete information on the location of the deposit. This should include County, Township, Lot, and Range Number if possible, along with the distance and direction from the nearest village or town. Reference might also be made to the location of the deposit relative to streams, rivers, lakes, the sea coast, or to railroads and highways.

Samples should be sent by mail or express prepaid to the Chief, Bureau of Mines, 568 Booth Street, Ottawa, Ontario.

Care should be taken to place the samples in heavy paper or small cloth bags, identified by a tag on the outside and a corresponding folded paper label inside. The bags should be placed in a small cardboard carton or box for shipping to the above address, with the sender's name and address clearly marked. Clay samples should never be sent in metal containers because of the danger of staining from rust and corrosion. A letter requesting a test for the proposed use of the clay and giving the location of the deposit is required. This should be sent to the above address separately and should not be included in the parcel with the sample.

As a service to the public and to the ceramic industries of Canada, facilities are available at the Bureau of Mines for testing clays and other ceramic materials, from domestic sources, without charge. Research and development work is also carried on to assist these industries.

II. THE SAMPLING OF CLAY AND SHALE DEPOSITS

A. Procedure for Exposed Cliffs or Banks

1. The face of the exposure should be cleared of all loose slumped material that has accumulated so that the sample can be taken from the undisturbed beds farther back in the bank. The loose weathered material is usually quite different from the undisturbed clay or shale in its ceramic properties. Toward the lower part of the bank it may be necessary to remove several feet of loose clay in order to expose the beds.

2. If a marked change in the colour or texture is noted from one bed to the next, provided the beds are at least 4 feet in thickness, a separate sample should be taken from each bed. Too much variation, along with thin bedding, is usually undesirable and a more uniform deposit should be sought. If the bed is quite thick, say about 10 feet, and shows little or no variation, one sample should be taken directly from top to bottom of the bed. If a bed is very thick, and uniform for 20 to 30 feet, it is advisable to take a separate sample across each 10 feet of thickness.

3. In sampling moist, plastic clays, use a trowel to cut out a continuous channel, 2 to 3 inches wide and about 1/2 inch deep, from top to bottom of the bed. From 1/2 to 1 lb. of clay per foot of thickness is required to give a 5 lb. sample, which is the quantity needed for laboratory examination.

4. In the case of hard shales, it is not possible to cut a uniform channel in the exposed face, owing to the irregular platy nature of the rock. However, by using a prospector's hammer, the face can be chipped continuously, and the fragments used to make up the sample. If a large slab breaks loose, a small representative piece should be broken from it and included with the sample. The weight of the sample required is the same as for the soft clays.

5. Stones are sometimes found in clay deposits and in general should be included with the sample unless they are large and infrequently found and can be removed from the clay in working the deposit. It is important to know the type and amount of stone

in a clay deposit and the sample should include a representative amount. Limestone is especially objectionable since it causes the disruption or "popping" of the surface of fired ware on exposure to the air. Stone in general is objectionable because it is injurious to clay working equipment.

6. Seams of sand or gravel less than one foot thick occurring in the clay should be taken along with the sample. Thicker seams or beds that might be removed in working the deposit, should not be included and separate samples of the clays occurring above and below should be taken. The presence of numerous interbedded sand lenses or other types of material that require removal is generally undesirable in a clay deposit. However, in the case of some very plastic sticky clays, it may be desirable to have interbedded sand lenses because the mixture of the two gives a blend that is more easily worked and fired.

Information regarding the presence of sand, gravel, or hard stony layers occurring with the clay or shale should be included in the letter relating to the sample. A simple sketch showing the relative position and thickness of the beds and the locations from which the various samples were taken, would also be helpful.

B. Procedure for Unexposed Areas Such as Fields

Samples are more difficult to obtain from areas where there are no cliffs or banks. This applies to fields and to the extension of deposits back from an exposed face.

Various methods are used for obtaining samples from such areas, including suitable core drills, the use of the hand auger, or the digging of test pits. In some cases advantage may be taken of new wells or excavations in order to obtain samples.

By using specially designed hand augers, and where the clays or shales are soft, samples may be obtained down to about 30 feet. Gravel and stone, if encountered, prevent the use of a hand auger. In general, the shales of western Canada are moderately compact and fairly soft, so that the hand auger can be used. In eastern Canada, where the shales are older geologically, they are much harder and the hand auger is unsatisfactory. When sampling with a hand auger, the same principles apply as were outlined for the sampling of exposed banks. All the clay or shale that is raised from the bore hole is saved, mixed, coned and quartered down to a 5 lb. sample. Care should be taken to remove contamination from overlying

beds, which may be picked up when the auger is withdrawn. Samples should be separated from one another if there is a distinct change in the type of material through which the auger is passing. If there is no apparent change in the nature of the material, a sample should be taken to represent each 10 feet of depth. Accurate records should be kept of the depths from which the various samples are taken.

Test pits may also be used in flat lying areas for obtaining suitable samples. These are dug by hand and should not be taken to depths greater than about 6 feet, unless adequate precautions are taken to support the sides of the pit with well placed timbers. Clays tend to slump when unsupported and care should be taken at all times to guard against accidents from this cause.

If samples are obtained from wells or excavations, the person interested in the clay should be on hand to supervise and collect them. In the case of wells, clay or shale should be laid out on the ground as the material is raised to the surface, noting the depth from which it is obtained. Samples may then be taken over each 10 feet unless otherwise indicated. In the case of an excavation, the exposed face should be sampled as if it were a natural cliff or bank.

C. Sampling Procedure for Full-Scale Tests

Procedures A and B, above, apply to the collecting of small preliminary samples, which are required to prove the possible commercial value of a deposit. When promising results have been obtained from such tests and before any serious commitments have been made toward the establishing of a plant, say for the production of brick and tile, a full-scale test of the clay or shale should be made. The factors mentioned under section III, "The Examination of Clay and Shale Deposits," should also be considered.

For a full-scale test by this laboratory, a large sample of at least 200 lb. should be taken by selecting representative material from four or five separate points on the site of the proposed pit.

Full-scale tests might also be arranged through the co-operation of an operating brick plant in the neighbourhood, where larger amounts of material can be tested under commercial conditions. The co-operation of equipment manufacturers might also present an opportunity to have samples tested for working properties.

III. THE EXAMINATION OF CLAY AND SHALE DEPOSITS

In examining a clay or shale deposit with a view to its commercial development, there are many factors that must be taken into consideration besides the preliminary testing of a few samples. These factors are very important and any one of them might mean the difference between success or failure in the project.

A. Location

The location of the deposit with respect to markets for the products, fuel for firing the kilns, power for operating the machines, transportation facilities, and a source of labour, should all be taken into consideration.

For heavy clay products, such as common brick, and drain tile, the margin of profit is usually small and the product will not stand the cost of long transportation to markets. Higher grade heavy clay products such as sewer pipe, face brick, and hollow building tile may often be shipped long distances to markets, while still realizing a profit.

High grade clays, such as kaolins, china clays, ball clays and refractory clays, and the products made from them, can be shipped long distances at a profit.

B. Overburden

The term 'overburden' applies to the layer of waste material overlying a deposit. This layer is usually sand, gravel, or soil and may vary in thickness from a few inches to several feet. In most cases it has no value for blending with the clay and can be regarded as waste which must be stripped from the top of the working face of the pit, before the clay is removed. The expense of stripping varies with the amount of the overburden and if it is thick, the cost may be prohibitive in carrying on the operation. Under some favourable conditions, where the overburden is sand and gravel, it may be possible to dispose of it as an aggregate for concrete construction work, for use as a road material, for fill in grading, or for blending with the clay that is being worked as a ceramic material. These various uses might be sufficiently profitable to pay all or most of the cost of removal of the overburden.

C. Drainage and Water Supply

In operating a clay pit, it is necessary to provide for ample drainage, to dispose of surface water, rain, or snow. A natural slope falling away from the working face

of the pit is an ideal condition, but drainage ditches may also have to be used. For pits without natural drainage, provision must be made for pumping to remove the water.

On the other hand, a source of water that will not fail during the dry season is essential for the operation of a clay plant, where large quantities are needed for tempering the clay to the required plasticity.

D. Equipment

The selection of the right kind of equipment for manufacturing and firing the clay products is important. An experienced clay manufacturer, a ceramic engineer, or a reliable equipment manufacturer should be consulted for advice on this matter. A great many disappointments and the loss of money can be avoided if this point is carefully investigated.

E. Reserves of Clay or Shale

The extent of the deposit must be proved in order to ensure an adequate supply of clay or shale for many years of operation. The supply should be sufficient for at least 20 years of operation, at the estimated rate of production, in the case of a deposit suitable for heavy clay products.

In order to prove the extent of a clay deposit of this type, and its uniformity throughout the area, a considerable amount of work is necessary. Samples should be taken by means of test pits, the hand auger, or by bore holes, at uniform distances over the area concerned. If a deposit is uniform in character and thickness, as determined by the preliminary sampling, a minimum number of samples may be required to determine the reserves. If the deposit is variable, the samples will have to be taken at more frequent intervals. For a deposit of average uniformity, one test pit or bore hole per acre should give a satisfactory estimate of the reserves. The number may be increased or decreased from this figure, depending upon conditions.

Higher grade clays, such as kaolins, china clays and refractory clays, usually occur in smaller and more variable deposits then the clays suitable for heavy clay products. With clays of this type no general rules can be laid down for the reserves required and the frequency of sampling.

F. Simple Field Tests

In examining clay and shale deposits, certain simple tests can be made in the field and at home which are useful in giving a rough evaluation of the clay. These tests are very useful to the person examing the clay, for checking its variability over the area.

The presence of carbonate of lime in the clay can be checked readily by placing a drop of dilute hydrochloric acid (muriatic acid) on a sample and observing if bubbles of gas are given off. A vigourous reaction which continues for several seconds indicates that the clay contains carbonate of lime, which is an undesirable constituent and generally means that the clay will be unsuitable as a ceramic material. A supply of hydrochloric acid can probably be obtained from a local druggist, in a suitable small bottle that can be carried in the field. Two ounces of acid is enough to make a great many tests, and it is convenient to have the bottle equipped with a small glass tube for placing single drops on the clay. The druggist should be asked for hydrochloric acid diluted with two parts of water. Care should be taken when handling hydrochloric acid since it is harmful to the skin and dangerous if it comes in contact with the eyes or if taken internally.

The drying properties of clay can be investigated quite easily by selecting a sample and grinding it down until the largest particles are not greater than one sixteenth of an inch in size. The ground material is then worked up to a plastic condition by adding water a little at a time. The ball of clay is then cut with a knife or a wire to give a cube about 2 inches to the side, and the surfaces smoothed off with a flat knife. Several of these cubes can be made up at one time so that more than one test can be made.

One sample should be dried slowly for at least three days. This can be done outside in the summer by placing the sample in the shade, or indoors in cold weather at average room temperature.

A second sample should be dried more quickly. Under outdoor conditions, it should be placed in the hot sun until thoroughly dry. Indoors, it should be placed near a stove, a hot air register, or above a hot water or steam radiator, but not in actual contact with too hot a surface.

A third sample should be dried rapidly by placing in an oven heated to 185 degrees F., as shown by the indicator on the door. The samples should be examined every 15 minutes during the first hour to see if surface cracks form. Such

cracks may close up when the block has dried out completely, and not be apparent on subsequent examination.

If a clay cracks under either of the first two treatments, it is a tender drying type and will give trouble in a commercial operation, unless special precautions are taken.

A good clay should withstand drying under all of the conditions mentioned above without cracking. Some clays crack under oven drying conditions but not under the slower rates of drying, and these are relatively satisfactory but may need special treatment if used commercially.

The presence of carbonate of lime, or the property of cracking in drying, generally indicates that the clay is of poor commercial value and that a better clay should be sought elsewhere. An enthusiastic field man who is searching for a good clay or shale for making brick and tile can save himself a great deal of time by learning to make the tests outlined above. If a sample passes the tests indicated above, it should be submitted to the laboratory for further investigation.

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