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Bureau of Mines Information Circular/1977

Assaying Ores, Concentrates, and Bullion

Revision of Information Circular 7695

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8714r

Assaying Ores, Concentrates, and Bullion

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By H. H. Heady and K. G. Broadhead

UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES

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ASSAYING ORES, CONCENTRATES, AND BULLION

Revision of Information Circular 7695

by

H. H. Heady [1] and K. G. Broadhead [2]

ABSTRACT

This Bureau of Mines report provides specific information regarding the analysis of ores, concentrates, and bullion. It describes analytical services provided by some Federal agencies, and discusses analytical techniques applicable to the precious metals. The appendixes list Bureau of Mines State Liaison Offices and commercial assay laboratories.

INTRODUCTION

Sharp increases in the world market prices of gold and silver have generated a renewed interest in prospecting and mining. Almost simultaneously there has been an upsurge of interest in the platinum-group metals owing not only to a shortage of these metals but also to prospecting activity--particularly in the Western United States. Still another factor contributing to the booming interest in the noble metals is the recent legislation (Public Law 93-373) effective December 31, 1974, that permits citizens of the United States to buy and possess gold. As a result of this situation, many citizens are seeking information and advice regarding investing, prospecting, mining, milling, refining, and analyzing the noble metals.

This paper is a revision and updating of Information Circular 7695 (6).[3]

FEDERAL AND STATE AGENCIES

Many mineral samples are sent to Government agencies with the request that they be assayed or chemically analyzed. It should be emphasized that there are no Federal agencies, except for the U.S. Mints, where assays and quantitative analyses are made for the public.

Many of the States maintain a Bureau of Mines, a Geological Survey, or some similar organization, frequently at a State university, where minerals

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[1] Supervisory research chemist.
[2] Chemical engineer.
[3] Underlined numbers in parentheses refer to items in the list of references preceding the appendixes of this report.

found by residents of the State will be identified free of charge. Usually, a charge is made for assays. Specific tests, as on clays, are made by some of these offices.

The Federal Bureau of Mines, although it attempts to avoid duplication of services rendered by State agencies, is authorized to give advice regarding prospective markets. It does not compete with private assayers and chemists, but it will accept samples sent to its field laboratories, and identify them by visual or microscopic inspection. This examination is usually sufficient to indicate whether the material has commercial value, or at least if the expense of an assay would be warranted. Except in connection with its own technical investigations, no assays or other special tests are made by the Bureau of Mines. A general statement of policy regarding the Bureau's mineralogical services that are available to the public is included in the Federal Register (11).

The U.S. Geological Survey and the Smithsonian Institution also make mineral identifications of specimens as a public service. However, neither of these agencies nor the Bureau of Mines will provide such services on long suites of specimens submitted by mineral dealers, well drillers, or others, when such work can be done regularly by commercial concerns.

The U.S. Mint, Denver, Colo., provides assays of ores for gold, silver, copper, lead, and zinc. The U.S. Mints also perform assays of gold and silver bullion. The special services provided, the charges involved, and the locations of U.S. Mints are presented in the Code of Federal Regulations, Title 31--Money and Finance, published by the Office of the Federal Register, General Services Administration. A copy of this regulation can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

PROCEDURE FOR OBTAINING ORE SAMPLES

The economic exploitation of a mineral deposit follows a more or less set sequence. Invariably, the first step is identification to determine whether the ore to be mined or the mineral to be sold is actually what it is thought to be. An identification is a qualitative examination designed to give information as to what a substance may be rather than how much of it may be present.

If the identification shows the material to be one of possible commercial value, the next step is to take a sample representative of the exposed face or outcrop for assay or quantitative chemical analysis. Preliminary consideration also should be given to certain economic aspects. For example, no mineral deposit, irrespective of its size and grade, is of immediate value if it is so inaccessible that the product cannot be mined, processed, transported, and sold at a profit on a competitive market.

Sampling should always be made on a fresh surface. There are two suggested ways of proceeding, of which the second is the more reliable.

First method: With a hammer, knock off chips of approximately equal size at regular intervals over the whole width of the mineral occurrence.

Second method: Draw two parallel lines 3 inches apart, marking the width to be sampled. With a cold chisel, or a moil of tempered steel, cut out a groove, one-half inch or so in depth, for the whole length between the two lines. The material thus chiseled out will constitute the sample. It is very important to carefully collect the whole of the detached material, both chips and dust, on a sheet of canvas, strong cotton, or cloth.

A sample thus obtained will be fairly representative of the mineralization at the place where it was taken. In order to make an estimate of the value of a mineral deposit, it will be necessary to repeat the sampling process at regular intervals, about every 20 feet, and at the same time, take note of the location and the length of the grooves thus made. Bag and number each sample separately.

If the analyses of samples taken in this manner show promise, the succeeding steps in the procedure are (1) a thorough sampling of the deposit to determine grade and tonnage available, (2) beneficiation or smelting tests, (3) a marketing survey, and (4) consideration of such engineering factors as mining methods, design of concentration or treatment plant, water and power supply, and estimates of costs.

These operations are usually difficult and expensive and should be carried out under the guidance of trained engineers. The development of a prospect from the original discovery to a producing mine is a major undertaking that requires considerable capital and experience.

Advice as to how to proceed with a project may be obtained from a number of sources. Advice of a general sort, requiring no field work or laboratory testing, can be obtained from the Bureau of Mines. (See appendix A.) For projects where a paid, professional consultant is needed, names and addresses may be found in the advertising sections of appropriate trade journals. The Directory of Members of the American Institute of Mining and Metallurgical Engineers, 345 East 47th Street, New York 10017, lists the names and addresses of mining engineers and metallurgists available for consultation. For names of consultants specializing in metallurgical and chemical problems, a useful source is the classified directory of the Association of Consulting Chemists & Chemical Engineers, 50 East 41st Street, New York.

PROCEDURE FOR SAMPLING BULLION AND SCRAP

The proper sampling of bullion and/or scrap precious metals, such as electronic, dental, or jewelry scrap, is very difficult and requires the utmost precautions. According to Bugbee (3), the principal problem encountered in sampling bars or ingots involves the irregular distribution of the various constituents caused by segregation when the bar freezes from the molten state. When a bar or ingot is poured, solidification begins first at the cooler walls of the mold, and the constituent having the highest melting point solidifies first. The material that freezes last, near the upper middle of the bar, is therefore enriched in the lowest melting point metal. Obviously, the best way to sample material of this type would be while it is molten and homogeneous. Since this is normally impossible except to the refiner, drilling or sawing the bar offer the best alternatives. Sawing is more laborious and destroys the continuity of the bar since it would have to be sawed completely through. In drilling the bar, it is important to sample both the ends as well as the middle and to drill either completely through the bar or to drill half way through from both sides. The material removed from the bar must, in turn, be carefully sampled for assay or, in some cases, remelted and either sampled while molten or frozen rapidly by pouring into water so that segregation does not occur. Proper sampling of obviously heterogeneous metals such as industrial, jewelry, or dental scrap requires that the material be melted prior to sampling. The sampling of scrap electronic parts consisting of circuit boards, and components such as transistors and integrated circuits, is a difficult task and requires an assay on each constituent and an estimate on their total number. It may be feasible in some cases, such as in sampling circuit boards, to roast the sample to remove the organic material and then analyze the ash for the metal values of interest.

DESCRIPTION OF TESTING TECHNIQUES

Various testing techniques are available to the public at commercial laboratories, the choice of which depends on the problem to be solved. The most useful techniques are described to familiarize the reader with their application as well as their limitations.

Chemical Analysis

A chemical analysis is often used to determine how much of a particular element is present in a sample. Chemical analyses are normally very precise and accurate, but they are often less sensitive and more time consuming than instrumental analyses. It is because of these disadvantages that wet chemical techniques are usually not suitable for the determination of the noble metals (gold, silver, platinum-group metals) in ores and concentrates. In recent years, there has been a merging and combining of chemical and instrumental techniques to take advantage of the best features of both approaches. For example, an ore sample might be put into solution and separated chemically into fractions that are subsequently analyzed for selected elements by either standard chemical or atomic absorption procedures.

The value of a quantitative analysis depends on how representative the sample is of the total bulk of material to be tested. No ore or mineral deposit is uniform throughout; consequently, an analysis of a sample consisting of a single specimen or a few randomly chosen pieces of rock is useless in attempting to evaluate a potential deposit. This information can be obtained only by prescribed scientific methods of sampling.

Fire Assay Analysis

The term "fire assaying" is applied to a quantitative determination procedure in which a precious metal is separated from impurities by a fusion process and weighed to determine the amount of that metal present in the original sample. This method is normally used for the determination of gold and silver in ores, concentrates, and in various metal alloys. It can also be used in conjunction with atomic absorption and spectrographic procedures (2, 12) for the determination of platinum and the platinum-group metals. Excellent texts have been written on fire assaying by Bugbee (3) and Shepard and Dietrich (10).

In general, the procedure involves the addition of various fluxing materials to the ore or sample, which when heated to about 1,900° F form a readily fusible homogeneous slag. Concurrent with the slag formation, a collecting or alloying metal, usually lead, is produced in the molten mass by reduction of part of the slag mixture. The noble metals are reduced from the mass and simultaneously collected by the droplets and mist of falling lead, forming a pool at the bottom of the slag. The molten mix is poured into an iron mold, and after cooling, the lead bullion containing the noble metals is physically separated from the glasslike slag and treated by a process called cupellation. This separates the lead from the precious metals by oxidizing the lead, which is absorbed into a special bone-ash dish called a cupel. The precious metals are left as a small bead on the surface of the cupel. In an analysis for gold and silver, the bead is weighed on a special balance that gives the combined weight of gold and silver in the sample. The bead is then treated with dilute nitric acid, which dissolves the silver but does not put any of the gold into solution. The bead is then reweighed to determine its gold content. In the analysis of platinum or the platinum-group metals, usually a small, known amount of silver is added before the fusion process. The resulting bead after cupellation is then analyzed by either spectrographic or atomic absorption methods.

Although there are many advantages to the use of fire assay, probably the most important is that there are no ores, concentrates, or alloys that cannot be analyzed by this method if it is properly performed. Furthermore, large and, consequently, more representative samples may be analyzed. In addition, the procedure has excellent sensitivity, less than 0.005 oz/ton of gold may be determined, and the method is specific for the noble metals. The detection limit for each of the platinum group metals is about 0.001 oz/ton, based on the analysis of an assay ton (29.2 grams) by a fire-assay-spectrographic procedure. The disadvantages are that the technique is normally applied only to the noble metals. It requires more time and therefore is more costly than some other procedures. It also requires special balances and furnaces not normally found in a chemical laboratory.

Optical Emission Spectrographic Analysis

This analysis technique is based upon the principle that when a sample is heated to high temperature in an electrical arc, causing the sample to be volatilized completely, each element present in the sample emits a unique spectra that can be used to identify that particular element. In usual practice, a very small amount (5 to 50 mg) of finely pulverized ore sample (or filings if the sample is metallic) is vaporized completely, and the resulting spectra is recorded and used to determine the metals present. This general procedure can also be used to estimate the approximate concentration of each metal detected. If necessary, this technique can be further specialized to permit the quantitative determination of selected elements. The chief advantage of a spectrographic analysis is that 30 to 50 elements can be readily determined at quite low concentration levels. Consequently, a large number of samples can be surveyed rapidly to determine their general elemental composition. An important disadvantage is that most of the noble metals cannot normally be detected below about 30 parts per million (about 1 oz/ton) in ores and concentrates. Another disadvantage in applying this technique for detecting precious metals at low concentrations is the possibility of misidentification due to interferences from other elements in the sample. Since the usual requirement is to detect noble metals at concentration levels as low as 0.01 oz/ton, the spectrographic approach is not recommended. More specific information on spectrographic analysis may be gained from a good text such as the one by Aherns and Taylor (1).

X-Ray Analysis

In X-ray fluorescence analysis, the sample is exposed to a high-intensity gamma ray or X-ray beam, which causes each element present in the sample to emit characteristic X-rays that can be used to identify the respective elements. The intensity of this secondary X-radiation from the sample is also directly proportional to the concentration of each element that is present. In ordinary practice, a small amount of finely pulverized sample is placed in the X-ray instrument and excited by the X-ray beam. The whole range of emitted X-rays can be recorded to determine which elements are present, or X-rays emitted from a particular element can be counted and compared with those of known standards to determine the exact concentration. The main advantages of this X-ray fluorescence technique are that it is simple, rapid, highly reliable, and quite accurate providing proper calibration has been achieved for each type of sample being analyzed. Some disadvantages are that this technique is matrix-dependent and, consequently, it cannot be used to determine the metal content of ores, concentrates, or alloys without first being carefully calibrated to handle each particular type of material. Another disadvantage is that most of the noble metals cannot be detected below about 50 to 100 parts per million (2 to 3 oz/ton). Therefore, this approach is not recommended for the direct determination of gold, silver, or the platinum-group metals in ores or concentrates. Liebhafsky, Pfeiffer, Winslow, and Zemany (7) give an excellent discussion on the application of X-ray fluorescence analysis techniques.

Another useful tool is X-ray diffraction (8). This technique is based upon the fact that the crystal structure of any given sample causes the incident X-rays to be diffracted in a manner characteristic of that particular material. The resulting X-ray diffraction pattern is like a fingerprint for that material, and can be used to identify it even in the presence of other crystalline materials. Over 20,000 different minerals, metals, and compounds have been catalogued by their characteristic X-ray diffraction patterns.

The use of this catalogue simplifies the identification of the various components in any crystalline sample. The advantage of X-ray diffraction is that it tells something about the composition and structure. Ordinarily, X-ray diffraction is not used to make quantitative determinations. However, in special cases, such as the determination of free silica in a coal mine dust sample, it is feasible to make quantitative analyses.

Atomic Absorption Analysis

Atomic absorption is based on the fact that a free atom is capable of absorbing light of the same wavelength it would normally emit. If light emitted by an element inside a special lamp is passed through a gaseous cloud containing this element in the atomic state, then the atoms from this element, and only this element, will absorb this light. In practice, the gaseous cloud is formed by aspirating a solution of the sample to be analyzed into a flame of sufficient temperature to reduce the element to its atomic state. The absorbance of the light from the special lamp by the aspirated sample solution is then compared with the absorbances of suitable standards analyzed in a similar manner. Prior to analysis, the sample obviously must be put into solution with suitable solvents. In gold analysis, this can be accomplished readily with aqua regia, a mixture of nitric and hydrochloric acids. For the analysis of gold and the platinum-group metals, dissolution and direct analysis of ores or concentrates is impractical; the very small absorption signal from the low levels of these metals that are normally encountered is masked by light scattering in the flame caused by high concentrations of dissolved solids (4). Consequently, it is necessary to resort to methods involving organic extraction of the precious metals from the acid solution and analysis of these extracts, or the use of fire assay to preconcentrate the precious metals into a small bead that can be dissolved and analyzed by atomic absorption. Using an acid digestion-organic extraction method on a 1-gram sample, less than 0.01 ounce of gold per ton of ore may be measured. If a fire assay preconcentration is used, the sensitivity can be extended still further. Atomic absorption analysis, when properly applied, has few disadvantages, and it is fast, accurate, and economical. It has the advantage that the equipment is comparatively inexpensive. Furthermore, since the method may be employed for the analysis of most metals, many testing laboratories use this technique. An excellent and comprehensive text on this type of analysis is the one by Ramirez-Muñoz (9).

Neutron Activation Analysis

This method of analysis is based on the principle that when a sample is subjected to bombardment by neutrons, some of the stable atoms that make up the sample will absorb neutrons and become radioactive. These radioactive atoms will, in turn, emit gamma rays the energies of which are characteristic of the particular elements. Using suitable and rather sophisticated electronic counting equipment, these gamma rays can be detected, and the elements and amounts present in the sample can be determined. Alternatively, to obtain greater sensitivity and avoid interferences, the activated sample may be dissolved and the elements of interest chemically separated prior to being counted. For gold and silver, the direct electronic method has excellent sensitivity, but for the platinum-group metals, chemical separation techniques are required. This type of analysis would not normally be utilized for ores or concentrates. Analysis of the noble metals by this method is usually limited to rather esoteric samples, such as moon rocks, filings from ancient coins, and geological samples with exceedingly small and noneconomic amounts of metals present. Only small samples are usually irradiated in nuclear reactors, and consequently any material that is not clearly homogeneous, such as a gold ore, can give erroneous results. Furthermore, the method is expensive and is only performed commercially in a few laboratories.

Bullion Assay

The analysis of gold or silver bullion is more complex, time consuming, and expensive than a standard fire assay. This is readily understandable since the material the sample represents is very valuable and, therefore, the analysis warrants the utmost attention. Great care must be exercised in obtaining proper samples that are truly representative of the whole material. The assay of gold and silver bullion is expressed in parts per thousand called fineness. For example, a gold bullion containing 99 percent gold, or 990 parts per thousand, is 990 fine.

The assay for silver in silver bullion or gold bullion may be accomplished either by cupellation or by wet chemical volumetric methods. The cupellation method is subject to more errors, and if accurate values are needed, as in the assay of fine silver bullion, the chemical procedure must be applied. The errors in the cupellation assay for silver are corrected by means of a check or proof assay of a synthetic sample of approximately the same weight and composition as the bullion sample. The check and bullion samples are cupelled side by side, and it is assumed that the losses as determined for the check sample also apply to the bullion. Therefore, the method involves a preliminary assay to determine the approximate composition of the bullion before the check assay can be prepared. The sample size normally taken is about one-half gram. The assay of fine silver bullion, greater than 990 fine, is normally accomplished by a wet chemical procedure called the "Gay Lussac--U.S. Mint Method" (5). In this technique, the silver sample, about 1 gram, is accurately weighed, dissolved in nitric acid, and about 99.8 percent of the silver is precipitated with a 100-ml NaCl solution that has been previously standardized with pure silver. Subsequent milliliter additions of the diluted standardized NaCl solution are added until no further precipitation occurs. A more recent refinement of this method uses atomic absorption to determine the small amount of silver remaining in solution after the initial precipitation with the standardized NaCl solution.

The general method of assaying gold bullion is by cupellation and parting accompanied by check or proof assays on synthetic alloys corresponding to the composition and weight of the bullion (3, 10). Therefore, the method usually requires a preliminary assay to obtain an approximate analysis. As in the case of silver bullion analysis, the check and bullion samples are cupelled side by side, and any loss or gain in the check sample, which is called the surcharge, is applied to the bullion sample. In the parting process, which separates the silver from the gold, the silver-gold ratio must be kept between

2 to 4 parts silver to 1 part gold, otherwise proper parting will not be achieved. Consequently, silver must normally be added to both the bullion and proof sample. The resulting bead from the cupellation must be rolled very thin and parting procedure must be carefully standardized. In both the silver and gold bullion assay, results are obtained on duplicate samples.

PRICES AND FEES

The trade generally recognizes three qualities of work. The first and lowest priced analysis is designated by such terms as routine, engineer's survey, and preliminary. A higher priced, more careful analysis is called control, and third and most expensive is called umpire. Unfortunately, there is no way of setting up standards of quality on the basis of accuracy because some elements, such as iron or copper, can be determined in the usual samples with little effort to a high degree of accuracy, whereas others require time-consuming procedures and great skill, in spite of which accuracy of results is only fair.

The price ranges listed are typical of the prices being quoted by commercial laboratories as of January 1, 1977, for routine analyses. The listed values are for single, finely ground samples. An extra charge of $1 to $5 per sample is assessed if the sample has to be prepared for analysis. Discounts are usually granted if many samples of the same type are submitted at one time.

	Fire assay	Atomic absorption
Gold	$4- $8	$3-$7
Silver	4- 8	3- 7
Gold and silver	6- 9	4- 8
Platinum	20-[1]70	25-35
Platinum-group	7- 30	-

[1]A combination fire assay-chemical analysis.

Higher prices are charged for the assay of the richer samples, such as bullion, sweepings, and jewelry. Control and umpire analyses cost two to three times the price of routine analyses.

A qualitative spectrographic analysis to determine the general elemental composition costs about $15 to $30 per sample. An X-ray diffraction analysis to determine the mineral composition of a sample costs about $30 to $50.

Most of the common metals in ores, concentrates, and alloys can be determined with reasonable accuracy by atomic absorption. The cost is $1.50 to $3 for the first element, plus about $1 to $2 for each succeeding element in the same sample. Some of the metals that can be determined by this technique are bismuth, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, tin, and zinc.

A few laboratories perform mineralogical services, the cost of which varies with the type of analytical work required. Typical services and estimated costs are as follows:

Petrographic and mineralogical examination	per hour	$10
Thin sections	per sample	$4- 14
Polished sections	do	4- 15
Grain mounts	do	4- 10
Particle size distribution	do	25- 35
Specific gravity	do	4- 6

REFERENCES

1. Aherns, L. H., and S. R. Taylor. Spectrochemical Analysis. Addison-Wesley Publishing Co., Inc., Reading, Mass., 2d ed., 1961, 429 pp.

2. Broadhead, K. G., B. C. Piper, and H. H. Heady. Fire Assay-Emission Spectrographic Determination of Iridium, Ruthenium, and Osmium. Appl. Spectr., v. 26, No. 4, 1972, pp. 461-467.

3. Bugbee, E. E. A Textbook of Fire Assaying. John Wiley & Sons, Inc., New York, 3d ed., 1940, p. 221.

4. Elliott, E. V., and K. R. Stever. Problems in Determining the Noble Metals in Ores. Atomic Absorption Newsletter, v. 12, No. 3, 1973, pp. 60-62.

5. Furman, N. H. (ed.). Standard Methods of Chemical Analysis. D. Van Nostrand Co. Inc., Princeton, N.J., 6th ed., 1966, pp. 985-988.

6. Klahold, B. R. Laboratories That Make Fire Assays, Analyses, and Tests of Ores, Minerals, Metals, and Other Inorganic Substances. BuMines IC 7695, 1954, 20 pp.

7. Liebhafsky, H. A., H. G. Pfeiffer, E. H. Winslow, and P. D. Zemany. X-Ray Absorption and Emission in Analytical Chemistry. John Wiley & Sons, Inc., New York, 1960, 357 pp.

8. Nuffield, E. W. X-Ray Diffraction Methods. John Wiley & Sons, Inc., New York, 1966, 409 pp.

9. Ramirez-Muños, J. Atomic Absorption Spectroscopy. Elsevier Publishing Co., New York, 1968, 495 pp.

10. Shepard, O. C., and W. F. Dietrich. Fire Assaying. McGraw-Hill Book Co., Inc., New York, 1940, 277 pp.

11. U.S. Bureau of Mines. Policy Statement on Mineralogical Services. Federal Register, v. 40, No. 134, July 11, 1975, p. 29308.

12. Whitehead, A. B., and H. H. Heady. Fire-Assay Emission Spectrographic Method for Platinum, Palladium, Rhodium, and Gold. Appl. Spectr., v. 24, No. 2, 1970, pp. 225-228.

APPENDIX A.--STATE LIAISON OFFICES

Local Information

The U.S. Department of the Interior has established, through its Bureau of Mines, State Liaison Officers to represent each of the States and territories. The primary mission of these Officers is to conduct the Bureau's business that can best be accomplished at the State and local levels, to insure participation of appropriate organizations within the State in actions of mutual concern, and to serve as a Federal point of contact. The Liaison Officers are familiar with the mining and metallurgical activities in their particular geographical areas. Accordingly, they are available to provide information and advice to private citizens and people in industry who are interested in prospecting, mining, milling, refining, and analyzing precious metals. The attached list of State Liaison Officers is provided as a matter of general interest and service to the public.

Bureau of Mines, U.S. Department of the Interior, Liaison Program Office Directory

Alabama
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box L
University, Ala. 35486
(205) 758-0491

Alaska
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room G-81, Federal Bldg.
Anchorage, Alaska 99501
(206) 442-0151

Arizona
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 1012
2721 North Central Ave.
Phoenix, Ariz. 85004
(602) 261-3357

Arkansas
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 3331, Federal Office Bldg.
Little Rock, Ark. 72201
(501) 378-5965

California
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 3046
650 Capitol Mall
Sacramento, Calif. 95814
(916) 440-2417

Colorado
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 820, Bldg. 67
Denver Federal Center
Denver, Colo. 80225
(303) 234-4205

Connecticut
See New Hampshire

Delaware
See Maryland

Florida
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 204
547 North Monroe St.
Tallahassee, Fla. 32301
(904) 222-6218

Georgia
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 431
19 Martin Luther King, Jr., Dr., SW
Atlanta, Ga. 30334
(404) 221-6204

Hawaii
See California

Idaho
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 203
4620 Overland Rd.
Boise, Idaho 83705
(208) 384-1084

Illinois
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 102, Jefferson West No. 1
525 W. Jefferson St.
Springfield, Ill. 62702
(217) 525-4368

Indiana
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 113
Seventh and College Sts.
Bloomington, Ind. 47401
(812) 339-6139

Iowa
See Missouri

Kansas
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Suite 220, Federal Bldg./
U.S. Courthouse
444 S.E. Quincy
Topeka, Kans. 66603
(913) 295-2520

Kentucky
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 269
John C. Watts Federal Bldg.
330 West Broadway
Frankfort, Ky. 40601
(502) 875-4120

Louisiana
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 119, Federal Bldg. and
Courthouse
707 Florida St.
Baton Rouge, La. 70801
(504) 387-0181, ext. 374

Maine
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box 228
Augusta, Maine 04330
(207) 622-6171, ext. 292

Maryland
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Columbia Plaza
Room 907
2401 E St., N.W.
Washington, D.C. 20241
(202) 634-1272

Massachusetts
See New Hampshire

Michigan
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 1121, Commerce Center Bldg.
300 Capitol St.
Lansing, Mich. 48933
(517) 372-1910, ext. 681

Minnesota
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box 1660
Twin Cities, Minn. 55111
(612) 725-4535

Mississippi
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 408, 301 Bldg.
301 North Lamar St.
Jackson, Miss. 39202
(601) 969-4208

Missouri
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box 1187
Rolla, Mo. 65401
(314) 364-5555

Montana
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
636 North Logan
Helena, Mont. 59601
(406) 449-5297

Nebraska
See Kansas

Nevada
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 306, Post Office Bldg.
705 North Plaza St.
Carson City, Nev. 89701
(702) 882-9380

New Hampshire
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Post Office and Federal Bldg.
Newmarket, N.H. 03857
(603) 659-3101

New Jersey
See Pennsylvania

New Mexico
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 104, U.S. Courthouse/
Federal Bldg.
Santa Fe, N. Mex. 87501
(505) 988-6624

New York
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Suite 203
1659 Central Ave.
Albany, N.Y. 12205
(518) 869-9536

North Carolina
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box 2828
Raleigh, N.C. 27602
(919) 755-4166

North Dakota
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 7, 207 E. Broadway
Bismarck, N. Dak. 58501
(701) 255-4011, ext. 378

Ohio
See Indiana

Oklahoma
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
168 Post Office Bldg.
N.W. Third St.
Oklahoma City, Okla. 73102
(405) 231-4521

Oregon
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Suite 7, Standard Insurance Bldg.
475 Cottage St., NE
Salem, Oreg. 97301
(503) 399-5755

Pennsylvania
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box 783
Federal Square Station
Harrisburg, Pa. 17108
(717) 782-4474

Puerto Rico
See Florida

Rhode Island
See New Hampshire

South Carolina
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
403 Columbia Bldg.
Main and Gervais Sts.
Columbia, S.C. 29201
(803) 765-5561

South Dakota
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 261, Federal Bldg.,
U.S. Courthouse
515 Ninth St.
Rapid City, S. Dak. 57701
(605) 342-1950

Tennessee
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
1109 Parkway Towers
404 James Robertson Parkway
Nashville, Tenn. 37219
(615) 749-7254

Texas
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 782, Federal Bldg.
Austin, Tex. 78701
(512) 397-5781

Utah
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
1600 East First South St.
Salt Lake City, Utah 84112
(801) 524-5383

Vermont
See New Hampshire

Virginia
See North Carolina

Washington
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
Room 205
Evergreen Plaza Bldg.
711 S. Capitol Way
Olympia, Wash. 98501
(206) 753-9445

West Virginia
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box 428
Charleston, W. Va. 25322
(304) 343-6181, ext. 443

Wisconsin
See Minnesota

Wyoming
State Liaison Office
Bureau of Mines
U.S. Department of the Interior
P.O. Box 1796
Cheyenne, Wyo. 82001
(307) 778-2220, ext. 2481

Headquarters Office
Washington, D.C.

Chief, State Liaison Program Office
Bureau of Mines
U.S. Department of the Interior
Room 901, Columbia Plaza
2401 E St., N.W.
Washington, D.C. 20241
(202) 634-1272

APPENDIX B.--COMMERCIAL ASSAY LABORATORIES

The following listing of assay laboratories, arranged alphabetically by State, is compiled as a public service. This listing does not necessarily include every commercial laboratory in each State, nor does the Bureau of Mines vouch for or recommend these laboratories over any others.

Alabama

Southern Testing Laboratories
129 West Valley Ave.
Birmingham, Ala. 35209

Vester J. Thompson, Jr., Inc.
Box 9253
Mobile, Ala. 36609

Alaska

Alaska Minerals and Materials Laboratory
3944 Spenard Rd.
Anchorage, Alaska 99503

Alaska Testlab
4040 B St.
Anchorage, Alaska 99503

Chemical & Geological Laboratories of Alaska, Inc.
P.O. Box 4-1276
Anchorage, Alaska 99509

Resource Associates of Alaska, Inc.
3230 Airport Rd.
Fairbanks, Alaska 99701

Arizona

American Analytical & Research Laboratories
3441 East Milber St.
Tucson, Ariz. 85714

Arizona Testing Laboratories
815 West Madison
Phoenix, Ariz. 85007

Iron King Assay Office
Iron King Mine
P.O. Box 14
Humbolt, Ariz. 86329

Jacobs Assay Office
1435 South 10th Ave.
Tucson, Ariz. 85713

Rochin Assay Office Inc.
P.O. Box 1323
Douglas, Ariz. 85607

Skyline Labs Inc.
Hawley & Hawley Division
1700 West Grant Rd.
Tucson, Ariz. 85705

Southwestern Assayers & Chemists, Inc.
710 East Evans Blvd.
Tucson, Ariz. 85713

Valley Assay Office
1010 Lemon
Tempe, Ariz. 85281

Arkansas

None

California

AIMS, Inc.
1360 Bayport Ave.
San Carlos, Calif. 94070

Abbot A. Hanks, Inc.
115 Indiana St.
San Francisco, Calif. 94107

Caltest Analytical Laboratories
20 McDonnel
Sonoma, Calif. 95476

Clarkson Laboratory & Supply, Inc.
1144 30th St.
San Diego, Calif. 92102

Robert E. Craig & Company
P.O. Box 577
Sun Valley, Calif. 91352

Eisenhauer Laboratories
1110A East Edna Pl.
Covina, Calif. 91724

GMG Assay Office
432 West Main St.
Quincy, Calif. 95971

Heavy Metals Laboratories
1415 Colorado St.
Santa Monica, Calif. 90404

John D. Hess
Testing Corp.
356 East Main St.
El Centro, Calif. 92243

Hummel & Christianson Consulting Engineers
102 East Aliso
Ojai, Calif. 93023

J & J Smelting & Refining Corp.
17474 Catalpa
P.O. Box 727
Hesperia, Calif. 92345

Kem's
14039 East Don Julio Rd.
La Puente, Calif. 91747

Metallurgical Laboratories, Inc.
1142 Howard St.
San Francisco, Calif. 94103

Miles D. Rombough Laboratories
3069 Del Paso Blvd.
Sacramento, Calif. 95815

Minerals Engineering
417 South Hill St. Room 1099
Los Angeles, Calif. 90013

Morse Laboratories
1525 Fulton Ave.
Sacramento, Calif. 95825

Ralph E. Pray, D.Sc.
Mining & Metallurgy Research Laboratories
40 North Sycamore Ave.
Pasadena, Calif. 91107

Quality Control Laboratories
2606 North Durfee
El Monte, Calif. 91732

Reed Engineering
1140 North Lemon St.
Orange, Calif. 92667

San Joaquin Research Laboratories
2253 South El Dorado
Stockton, Calif. 95206

Twining Laboratories, Inc.
2527 Fresno St.
Fresno, Calif. 93721

Twining Laboratories of So. Calif., Inc.
3310 Airport Way
Long Beach, Calif. 90801

Wilkinson Assays
9491 Sierra Ave.
Fontana, Calif. 92335

Colorado

Accu-Labs Research, Inc.
11485 West 48th Ave.
Golden, Colo. 80401

Alan D. Breese, Sr.
1947 South Decatur St.
Denver, Colo. 80219

Brown Laboratory
2263 Broadway
Grand Junction, Colo. 81501

CDC Associates, Inc.
5401 Western Ave.
Boulder, Colo. 80301

Colorado Analytical Laboratory
240 South Main
Brighton, Colo. 80601

Colorado Assaying Company
2244 Broadway
Denver, Colo. 80205

Colorado School of Mines Research
Institute
P.O. Box 112
Golden, Colo. 80401

Coors Spectro-Chemical Laboratory
Division of Coors Porcelain Co.
600 Ninth
Golden, Colo. 80401

Ernest Engineering Co.
734 East Second Ave.
Durango, Colo. 81301

Fluo-X-Spec Analytical Laboratory
718 Sherman St. (rear)
Denver, Colo. 80203

G X Labs, Inc.
16948 South Golden Rd.
Golden, Colo. 80401

Grand Junction Laboratories
439 North Ave.
Grand Junction, Colo. 81501

Thomas E. Hancock
120 South Walnut
Hayden, Colo. 81639

Hazen Research, Inc.
4601 Indiana St.
Golden, Colo. 80401

Mile High Placers
P.O. Box 483
Golden, Colo. 80410

Minerals Assay Laboratory
549 Noland Ave.
Grand Junction, Colo. 81501

Natural Resources Laboratory
1100 Simms
Lakewood, Colo.
Mailing address:
P.O. Box 702
Edgemont Branch
Golden, Colo. 80401

Herbert M. Ochs
81 South Elati St.
Denver, Colo. 80223

Charles O. Parker & Co.
William Bealer, Owner
2114 Curtis St.
Denver, Colo. 80205

Root and Norton
West Animas Valley
Durango, Colo. 81301

Root and Simpson, Inc.
1310 East 17th Ave.
Denver, Colo. 80218

Skyline Labs, Inc.
12090 West 50th Pl.
Wheatridge, Colo. 80033

Specomp Services, Inc.
917 Lincoln Ave.
Steamboat Springs, Colo. 80477

George Treder Assayer
1413 Idaho Springs
Idaho Springs, Colo. 80452

<u>Connecticut</u>
York Research Corp.
1 Research Dr.
Stamford, Conn. 06904

<u>Delaware</u>
Brandt Associates Inc.
50 Blue Hen Dr.
Newark, Del. 19713

Lehight Testing Laboratories, Inc.
P.O. Box 1241
Wilmington, Del. 19898

<u>Florida</u>
Technical Services Inc.
P.O. Box 52329
Jacksonville, Fla. 32207

Thornton Labs, Inc.
1145 East Cass St.
Tampa, Fla. 33601

Georgia
Dunn Laboratories, Inc.
717 Edgehill Ave., NW
Atlanta, Ga. 30318

Law & Company
635 Angier Ave., NE
Atlanta, Ga. 30308

McMillan Research
1221 Barclay Circle, SE
Marietta, Ga. 30060

Metallurgical Engineers of Atlanta
3480 Oakcliff Rd.
Doraville, Ga. 30340

Hawaii
None

Idaho
Boise Assayers & Metallurgy
1519 Main
Boise, Idaho 83706

Idaho Assaying & Metallurgy
707 North 27th
Boise, Idaho 83702

Peter Mack
166 King
Wallace, Idaho 83873

Silver Valley Laboratory
308 North Taylor
Osburn, Idaho 83849

Illinois
Charles C. Kawin Company
2671 Gardner
Broadview, Ill. 60153

Chicago Spectro Services Laboratories, Inc.
4846 South Kedzie
Chicago, Ill. 60632

Commercial Testing and Engineering Company
228 North LaSalle
Chicago, Ill. 60601

Factory Standards Laboratory, Inc.
416 North State St.
Chicago, Ill. 60610

Pittsburgh Testing Laboratory
4418 Roosevelt
Hillside, Ill. 60612

Robert W. Hunt Company
810 South Clinton
Chicago, Ill. 60607

Scientific Control Laboratories, Inc.
3136 South Kolin
Chicago, Ill. 60623

Taussig Metallurgical Associates, Inc.
6955 North Hamlin
Chicago, Ill. 60645

Indiana
ATEC Associates of Indiana
5150 East 65th St.
Indianapolis, Ind. 46220

O A Laboratories, Inc.
1437 Sadlier Circle, West Drive
Indianapolis, Ind. 46239

Sherry John M. Laboratories
2112 Kilgore Ave.
Muncie, Ind. 47304

Iowa
Analytical and Testing Laboratories
7004 Carpenter
Des Moines, Iowa 50311

Patzig Testing Labs, Inc.
2215 Ingersoll
Des Moines, Iowa 50311

Twin City Testing and Engineering Labs, Inc.
529 Logan
Waterloo, Iowa 50703

Kansas

Arrow Laboratories, Inc.
123 W. 12th
Wichita, Kans. 67201

Means Laboratories, Inc.
419 N. Handley
Wichita, Kans. 67213

Topeka Testing Laboratories
101 N. Kansas
Topeka, Kans. 66603

Kentucky

Frazier's Laboratory
Marion, Ky. 42064

Louisiana

Gulf South Research Institute
7700 GSRI Ave.
Baton Rouge, La. 70808

Hydro-Chem Analytical
1020 Florida St.
Baton Rouge, La. 70802

Kem-Tech Labs
16550 Highland Rd.
Baton Rouge, La. 70808

Shilstone Testing Lab, Inc.
814 Conti St.
New Orleans, La. 70112

Maine

John S. Cummings, Inc.
Bangor International Airport
Bangor, Maine 04401

Maryland

Penniman and Browne, Inc.
6252 Falls Rd.
Baltimore Md. 21209

Strasburger and Siegel
1403 Eutaw Pl.
Baltimore, Md. 21217

Massachusetts

Arnold Green Testing Laboratories, Inc.
East Natick Industrial Park
6 Huron Dr.
Natick, Mass. 01760

Arnold Green Testing Laboratories, Inc.
2 Millbury St.
Auburn, Mass. 01501

Arnold Green Testing Laboratories, Inc.
98 Paris St.
Everett, Mass. 02149

Arnold Green Testing Laboratories, Inc.
Springfield, Mass. 01104

J. Dirates & Co., Inc.
Notre Dame St.
Westfield, Mass. 01085

Eastern Smelting & Refining Co.
37 Bubier St.
Lynn, Mass. 01903

Skinner & Sherman
New England Laboratories
227 California St.
Newton, Mass. 02195

Michigan

Detroit Testing Laboratory
8720 Northend
Oak Park, Mich. 48237

Michigan Technological University
Institute of Mineral Research
Houghton, Mich. 49931

Minnesota

Lerch Brothers, Inc.
P.O. Box 8
Hibbing, Minn. 55746

Mississippi
Brown-Agee Laboratories of Mississippi
879 Foley St.
Jackson, Miss. 39202

Environmental Protection Systems
106 Upton Dr.
Jackson, Miss. 39209

Micro-Methods, Inc.
5106 Telephone Rd.
Pascagoula, Miss. 39567

Mississippi State Chemical Lab
P.O. Box 2198
Mississippi State, Miss. 39762

Southern Technical Services, Inc.
1627 Westhaven Blvd.
Jackson, Miss. 39209

Missouri
Bruce Williams Laboratories
620 Joplin St.
Joplin, Mo. 64801

General Testing Laboratories
1517 Walnut
Kansas City, Mo. 64108

Industrial Testing Laboratories
2350 South Seventh Blvd.
St. Louis, Mo. 63104

St. Louis Testing Laboratories
2810 Clark Ave.
St. Louis, Mo. 63103

Montana
Butte Minerals Laboratories
P.O. Box 3867
600 East Aluminum
Butte, Mont. 59701

Foundation & Materials Consultants, Inc.
839 Front St.
Helena, Mont. 59601

Frontier Laboratories
P.O. Box 159
Melrose, Mont. 59743

Northern Testing Laboratories, Inc.
P.O. Box 411
600 South 25th St.
Billings, Mont. 59103

Western Laboratories
P.O. Box 537
3131 Airport Rd.
Helena, Mont. 59601

Yapuncich, Sanderson & Brown Laboratories
13 North 32d
Billings, Mont. 59101

Nebraska
Harris Laboratories, Inc.
624 Peach St.
Lincoln, Neb. 68502

Nebraska Testing Laboratories
4453 South 67th St.
Omaha, Neb. 68117

Omaha Testing Laboratories
2917 Douglas
Omaha, Neb. 68102

Nevada
Humboldt Geochemical Lab
744 South 5th
Elko, Nev. 89801

Humboldt Laboratories
Grass Valley Rd.
Winnemucca, Nev. 89445

Nevada Assay Office
5800 Reno Highway
Fallon, Nev. 89406

Nevada Testing Laboratories LTD
300 Boston Ave.
Las Vegas, Nev. 89104

Rocky Mountain Geochemical Corp.
840 Greg
Sparks, Nev. 89431

Edward S. Shedd
939 West Robinson
Carson City, Nev. 89701

Silver State Minerals Testing Lab
6274 East Charleston Blvd.
Las Vegas, Nev. 89122

Weideman's Mining Laboratory
3160 Deer Run Rd.
Carson City, Nev. 89701

New Hampshire
None

New Jersey
International Testing Labs
580 Market St.
Newark, N.J. 07105

Ledoux & Company
359 Alfred Ave.
Teaneck, N.J. 07666

Standard Testing Labs
309 Cortlandt St.
Belleville, N.J. 07109

U.S. Testing Co., Inc.
1415 Park Ave.
Hoboken, N.J. 07030

New Mexico
Albuquerque Assay Laboratory
4115 Silver Ave., SE
Albuquerque, N. Mex. 87108

Grants Assay Lab
1400 West Santa Fe Ave.
Grants, N. Mex. 87020

Martin and Carlisle Chemical Laboratory
715 San Mateo Blvd., NE
Albuquerque, N. Mex. 87108

Silver City Testing Laboratories, Inc.
1024 Hudson St.
Silver City, N. Mex. 88061

New York
Hammerschlag Moe Inc.
158 Canal St.
New York, N.Y. 10013

Hoover & Strong Inc.
119 West Tupper St.
Buffalo, N.Y. 14201

Pitkin Lucius Inc.
50 Hudson St.
New York, N.Y. 10013

Rodman & Yaruss Refining Co. Inc.
17 West 47th St.
New York, N.Y. 10036

North Carolina
Froehling & Robertson, Inc.
P.O. Box 2058
Asheville, N.C. 28802

Law Engineering Testing Co.
P.O. Box 18288
Raleigh, N.C. 27609

Southern Testing and Research Laboratories
P.O. Box 350
Wilson, N.C. 27893

North Dakota
None

Ohio
CTL Engineering Inc.
2860 Fisher Rd.
Columbus, Ohio 43204

Crobaugh Laboratories
3800 Perkins Ave.
Cleveland, Ohio 44114

National Spectrographic Laboratories, Inc.
19500 South Miles
Cleveland, Ohio 44128

Wadsworth Testing Laboratory
P.O. Box 208
1600 Fourth St., SE
Canton, Ohio 44701

Oklahoma

Rockwell International
Tulsa Division
Analytical Laboratories
2000 N. Memorial Dr.
Tulsa, Okla. 74115

Southwell Labs
1838 S.W. 13th
Oklahoma City, Okla. 73108

United States Testing Co., Inc.
1341 N. 108 East Ave.
Tulsa, Okla. 74116

Oregon

Department of Geology and Mineral Industries
1069 State Office Bldg.
Portland, Oreg. 97201

Lawre L. Hoagland
7018 SE 17th St.
Portland, Oreg. 97202

Montana Assay Office
610 SW Second St.
Portland, Oreg. 97201

Pennsylvania

Allentown Testing Lab. Inc.
754 E. Fairview St.
Bethlehem, Pa. 18108

Ambric Testing Labs
4041 Ridge Ave.
Philadelphia, Pa. 19129

Booth Garret Blair
180 S. Main St.
Ambler, Pa. 19002

Conwell E. L. & Co.
2024 Arch St.
Philadelphia, Pa. 19103

General Testing Labs. Inc.
241 S. Jefferson
Allentown, Pa. 18102

Materials Consultants and Laboratories, Inc.
1567 Old Abers Creek Rd.
Monroeville, Pa. 15146

McCreath Labs. Inc.
236 Liberty Ave.
Harrisburg, Pa. 17101

Pittsburgh Testing Laboratory
850 Poplar
Pittsburgh, Pa. 15220

Smith Rudy & Co.
20 N. 3d St.
Philadelphia, Pa. 19109

Spectrochemical Laboratories, Inc.
8350 Frankstown Rd.
Pittsburgh, Pa. 15221

Rhode Island

Arnold Greene Testing Laboratories, Inc.
15 Bellows St.
Warwick, R.I. 02888

South Carolina

Commonwealth Laboratory, Inc.
112 Greenacre Rd.
Greenville, S.C. 29607

Environmental Analytics, Inc.
P.O. Box 21427
Columbia, S.C. 29221

Industrial NDT Co. Inc.
3409 Spruill Ave.
Charleston, S.C. 29405

South Dakota

Whitewood Assayers
Box 299
Whitewood, S. Dak. 57793

Tennessee

Atek Labs, Inc.
P.O. Box 38
Corryton, Tenn. 37721

Environmental Science & Engineering, Inc.
Mays Chapel Rd.
Mt. Juliet, Tenn. 37122

Steward Laboratories, Inc.
5815 Middlebrook Pike
Knoxville, Tenn. 37921

Technical Laboratories, Inc.
515 Cherokee Blvd.
Chattanooga, Tenn. 37405

Texas

Dickinson Laboratories
201 North Clark
El Paso, Tex. 79905

Western Weighers, Subsidiary of Hawley & Hawley
Assayers & Chemists, Inc.
P.O. Box 3471
El Paso, Tex. 79923

Utah

American Chemical and Research Laboratories
32 East 3335 South
Salt Lake City, Utah 84115

Chemical and Mineralogical Services
445 West 2700 South
Salt Lake City, Utah 84115

Crismon and Nichols
440 South 500 West
Salt Lake City, Utah 84101

Material Research, Inc.
1380 South West Temple St.
Salt Lake City, Utah 84115

Rocky Mountain Geochemical Corp.
1323 West 7900 South
West Jordan, Utah 84084

Rogers Research and Analysis, Inc.
68 South Main St.
Salt Lake City, Utah 84101

Tay Con Laboratories
2040 Fortune Rd.
Salt Lake City, Utah 84104

Union Assay Office, Inc.
269 Brooklyn Ave.
Salt Lake City, Utah 84101

Ute Research Laboratories
40 North 400 West
Salt Lake City, Utah 84116

Vermont

None

Virginia

Commercial Testing & Engineering Co.
1825-31 Lindsay Ave.
Norfolk, Va. 23504

Froehling & Robertson, Inc.
P.O. Box 27524
Richmond, Va. 23261

Law Engineering Testing Co.
P.O. Drawer QQ
McLean, Va. 22101

Penniman & Browne, Inc.
1725 Arlington Rd.
Richmond, Va. 23230

Washington Testing Inc.
2930 Eskridge Rd.
Fairfax, Va. 22030

Washington

Bennetts Chemical Laboratory, Inc.
901 South Ninth St.
Tacoma, Wash. 98405

J. M. Knisely Engineering Corp.
5807 Fourth Ave., South
P.O. Box 3724
Seattle, Wash. 98124

Laucks Testing Laboratories, Inc.
1008 Western Ave.
Seattle, Wash. 98104

Rocky Mountain Geochemical Corp.
6319 North Helena St.
Spokane, Wash. 99207

Tacoma Assay Office
518 Security Bldg.
Tacoma, Wash. 98402

Technical Service Laboratories
North 1003 Washington St.
Spokane, Wash. 99201

West Virginia

Commercial Testing & Engineering Co.
626 Broad St.
Charleston, W. Va. 25323

Wisconsin

None

Wyoming

Chemical and Geological Laboratories
420 W. 1st St.
Casper, Wyo. 82601

Natural Resources Research Institute
College of Engineering
University of Wyoming
Box 3038, University Station
Laramie, Wyo. 82070

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