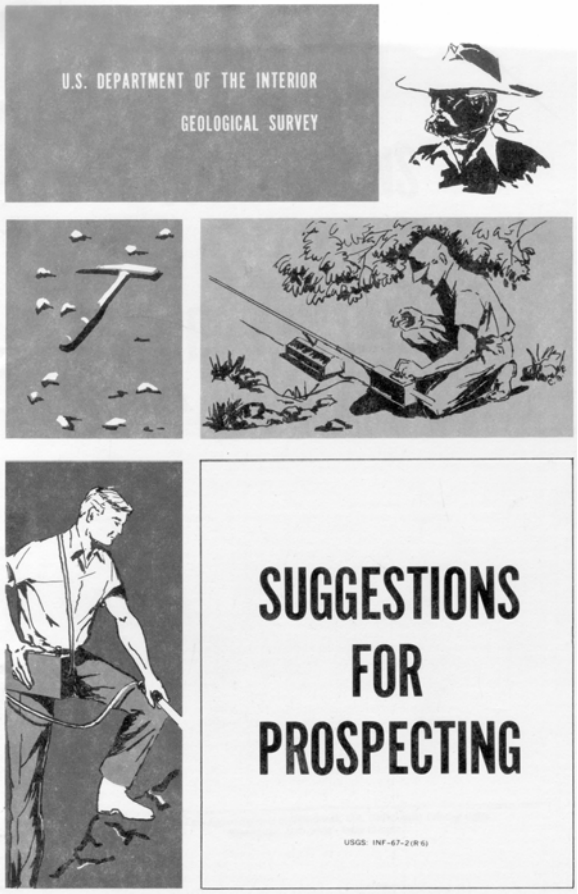

SUGGESTIONS FOR PROSPECTING

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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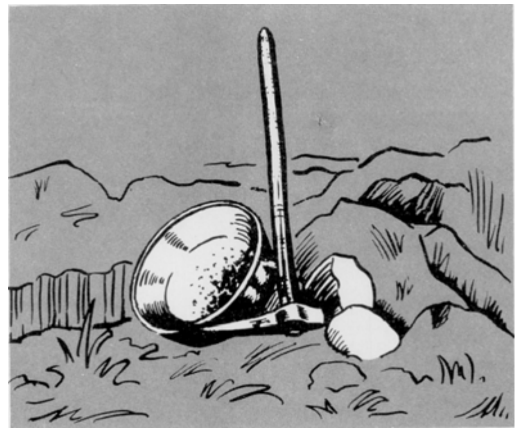
INTRODUCTION

Prospectors have made a tremendous contribution to the development of this Nation's mineral resources. Since the time of the earliest settlement, the need for iron for tools and guns, lead for bullets, and copper for utensils has prompted a search for sources of these metals. The lure of gold and silver provided the impetus for much of the development in the West between 1850 and 1910. Later, as the country's industrial demands for metals expanded to include zinc, molybdenum, tungsten, chromium, vanadium, and many others, these in turn were sought and found by prospectors. It is a mistake to suppose that uninhabited rugged mountains or desolate deserts have not been prospected; they probably have been.

Nearly one-half billion tons of metallic ores, principally iron and copper, are mined annually in the United States. Even greater amounts of ore must be found in the future to meet the Nation's increasing needs and to replace exhausted deposits. Because the easily found deposits have already been discovered, finding the new deposits will be difficult and will depend more and more on modern prospecting techniques.

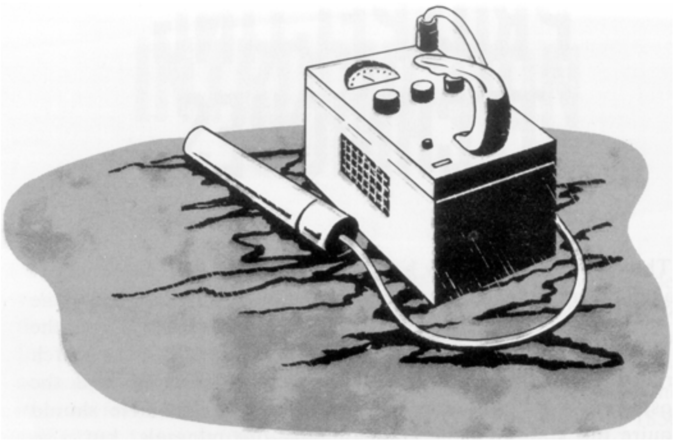


PROSPECTING TECHNIQUES

The prospector of today has advantages which to some extent make up for the increased difficulty of finding ore deposits. One of these advantages is a greatly increased knowledge about the geologic factors that have localized ore deposition. But the search for new deposits has become a complex undertaking, and the prospector should be as well informed as possible. He should acquire the ability to identify not only ore minerals, but also common rocks and their minerals, and he must be familiar with the main kinds of geologic structures. This knowledge is best acquired by academic training, but much can be obtained through use of such reference books as Lang (1956), von Bernewitz (1943), Walker (1955), and others listed at the end of this booklet. Geologic reports and geologic maps of areas of interest should also be studied. Topographic maps or air photographs of areas to be prospected should be obtained and used to plot sample locations and other appropriate data.

A prospector can outfit himself in various ways according to his means and the minerals that he seeks. Equipment can be used in many ways and its effectiveness depends in large measure on the versatility of the operator. For example, the radiation counter, of which the well-known Geiger counter is one, not only can detect radioactive minerals directly, but indirectly can do more. If placer deposits contain both gold and a heavy radioactive mineral like monazite, the radiation counter can lead to the gold concentrations by detecting the monazite that is concentrated with it. A “black light,” which is commonly used in prospecting for scheelite (an ore of tungsten), also is useful in identifying fluorescent calcite, barite, or fluorite which in turn can be clues to the location of metallic mineral deposits.

The residues left in the rocks after ore minerals have been removed by weathering also may be clues to ore deposits. The rusting of iron is a familiar example of the change in materials exposed to the weathering effects of air and moisture. Oxidation of primary ore minerals near the surface may result in the solution and removal of the ore-forming minerals from their original position. Where conditions are favorable these materials are carried downward and redeposited, thus enriching lower parts of the mineral deposit. In areas where the rainfall is great enough, however, the minerals may be dissolved and completely removed, resulting in a process of depletion rather than one of enrichment.



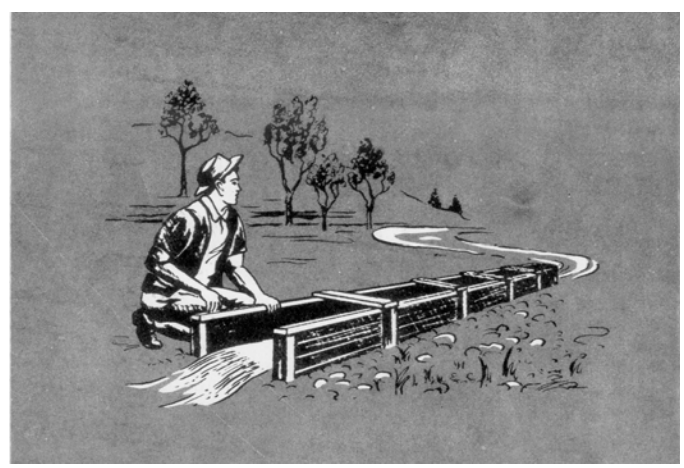
Regardless of what happens to the ore minerals during oxidation some evidence of their former presence remains. Commonly, iron oxides and iron hydroxides were formed and remain as brown or yellow stains and encrustations on the surface rocks. The solution of many of the minerals results in a sponge-like appearance. This iron-stained porous rock is called gossan and is evidence that primary minerals have been oxidized and at least partly removed; a search for primary minerals at depth in such places may be fruitful.

Mineral compounds containing copper, nickel, cobalt, molybdenum, uranium, and other metals may oxidize to form bright-colored secondary minerals on the surface rocks. These minerals are formed mainly in dry regions because many of them are soluble in water and may be removed in areas of heavy rainfall.

For centuries men have successfully located mineral deposits by following “float” uphill to its source. When rocks are being eroded, fragments of ore minerals are carried downhill by gravity and downstream by water. The train of fragments can be traced uphill to its source.

The systematic panning of stream sediment and residual soil for gold or other heavy and resistant minerals has long been used to find bedrock lodes. The gold pan, an indispensable prospecting tool, is versatile, efficient, inexpensive, and portable (Mertie, 1954). From any sample, an experienced panner can recover 80 percent of the minerals that are heavier than quartz (specific gravity 2.65). Even an inexperienced person can obtain a concentrate of heavy minerals from a sample that will contain virtually all of the coarse gold and platinum, and a high percentage of magnetite (specific gravity 5.2) and heavier minerals such as cassiterite, cerussite, columbite-tantalite, scheelite, and silver. Many minerals such as hornblende, biotite, muscovite, epidote, garnet, pyrite, cinnabar, and galena are easily recognized during the washing process, and the skillful panner can recover a high percentage of any of these minerals if he so desires. Even a sample that is “panned down” to only “black sands” generally contains a number of light-colored heavy minerals such as barite, zircon, sphene, monazite, and scheelite, in addition to magnetite, ilmenite, hematite, sulfides, and other dark-colored minerals. All these minerals can be clues to valuable deposits in nearby or upstream areas.

Other devices can be used in conjunction with a gold pan to test large samples. Dozens of varieties of sluice boxes, rockers, suction devices, and spiral concentrators have been used. An inexpensive portable sluice box for use in sampling placer deposits can be made from 3 pieces of 1/8-inch sheet aluminum, each 3 feet long and about 1-1/2 feet wide. The metal is shaped into flat-bottomed troughs about a foot wide with sides 3 inches high; the three sections are bolted end-to-end to form a 9-foot sluice. The bottom of the sluice box is fitted with carpet, burlap, wooden cross-slats or riffles, or other material to trap heavy minerals. Covering the material with a coarse screen prevents pebbles from clogging the carpet or burlap. Water is delivered to the sluice by means of a pump driven by a small gasoline engine, or the sluice can be placed in the stream in such a way as to use the natural flow of water. The bottom end of the sluice box should be partly closed to slow water flow, and to aid in trapping heavier particles. The carpet or burlap containing the heavy mineral concentrate is removed from time to time and placed in a tub and thoroughly washed. The washings are then further concentrated by panning. Working diligently, one man can wash a ton of gravel in a day and expect to recover 50 percent or more of the black sands present.



GEOCHEMICAL PROSPECTING

Many mineral deposits are not exposed at the earth's surface. They may either be concealed by thick soil cover, or they may lie buried beneath layers of rock. To find these deposits more complex techniques—based on geochemistry, geophysics, and geobotany can be very helpful. Most of these techniques require specialized training and, in some instances, expensive equipment.

Geochemical prospecting is based on systematic measurement of one or more of the chemical properties of rock, soil, glacial debris, stream sediment, water, or plants. The chemical property most commonly measured is the content of a key “trace” element. The purpose is to discover zones in the soils or rocks that contain comparatively high concentrations of particular elements that will guide the prospector to a hidden deposit. Such concentrations of indicator elements in rocks or soils constitute a geochemical “anomaly”. The actual amount of the key element in a sample may be very small and yet constitute an anomaly if it is high relative to the surrounding area. For example, if most samples of soil were found to contain about 0.00001 percent (0.1 part per million) silver, but a few contained as much as 0.0001 percent (1 part per million), the few “high” samples would be geochemical anomalies. Plots of analytical results on a map may indicate zones to be explored further.

Geochemical anomalies are classified as primary or secondary. Primary anomalies result from outward dispersion of elements from mineral-forming solutions. The “high” concentrations of metals surround the deposit and the dispersion of metals laterally or vertically along fractures may result in a leakage “halo” that extends hundreds of feet away from the deposit. Halos of this type are especially useful in prospecting because they may he hundreds of times larger than the deposit they surround and hence are easier to locate.

Secondary anomalies result from dispersion of elements by weathering. Some primary minerals, such as cassiterite, are resistant to chemical weathering and are transported by the streams as fragmental material. Other minerals may be dissolved and the metals may be either redeposited locally or carried away in solution in ground and surface waters. Some of the metal in solution may be taken up by plants and trees and can be concentrated in the living tissue. A great many studies have been made of the metal content of residual soils over sulfide deposits, and in general the distribution of anomalous amounts of metal in the soil has been found to correspond closely with the greatest concentration of metals in the underlying rock.

All the products of weathering in a drainage basin funnel through the system of streams and rivers that flow out of the area. The weathering products are partly in the form of chemicals in solution and partly in the form of sediments. Either or both can be sampled and tested, and their composition will reflect the chemical nature of the rocks in the drainage basin. The presence of an ore deposit in a drainage basin may thus be detected by analyzing for metals removed by weathering and either incorporated with the stream alluvium or carried in solution. The deposit can be located within the basin by sampling water and sediment from each successive tributary and determining which contain higher than normal amounts of metals. This procedure narrows the search to favorable areas.

Contamination of surficial material is an ever-present hazard in geochemical surveys. The most common sources of contamination are materials derived from mine workings. Such materials may become scattered widely over the ground, and the ore minerals in them may oxidize and go into solution, contaminating the soil, stream sediment, and water, and masking natural anomalies. Similarly, smelter fumes, windblown flue dust, and metallic objects introduced to the natural environment by man may also contaminate the soils and rocks.

Analytical methods used in geochemical prospecting must be sensitive enough to determine minute amounts of key elements, accurate enough to show small differences in concentration, fast enough to permit large numbers of samples to be analyzed in a day, and inexpensive. Wet chemical techniques are usually confined to rapid colorimetric procedures that require a minimum of equipment and reagents. Instrument techniques (such as emission spectrographic and X-ray fluorescence techniques) require expensive equipment and trained personnel, but usually yield a lower cost per determination if thousands of samples must be analyzed.

Wet Chemical Methods

Method of analysis for 27 elements have been devised for use in geochemical prospecting. These range from very simple procedures that can be accomplished in the field, through less simple procedures that can be carried out in an improvised laboratory at a campsite, to complex procedures that require a well equipped laboratory.

Simple procedures using special solvents to test for heavy metals (combined copper, lead, and zinc) are described in U.S. Geological Survey Bulletin 1152 (Ward, F. W., and others, 1963). Commercial kits for making such tests are available at prices ranging from about $50 to $200; they are advertised in many mining magazines.

Campsite tests, mostly requiring heating and leaching, are available for about 20 elements and are described in U.S. Geological Survey Bulletin 1152. From 30 to 80 analyses can be made per day by one man. Their precision is adequate for prospecting and the costs are not high. The equipment needed for some of these tests is available in commercial field kits at a cost of about $100 to $200. New procedures have been devised to determine gold (Lakin, H. W., and Nakagawa, H. M.,

1965) and silver (Nakagawa and Lakin, 1965) in field laboratories by trained personnel.

The more sophisticated methods of analysis, particularly those employing hazardous reagents or complicated procedures, are best done in a chemical laboratory. Laboratory methods usually permit about the same productivity as the campsite methods but require a trained chemist to perform them successfully.

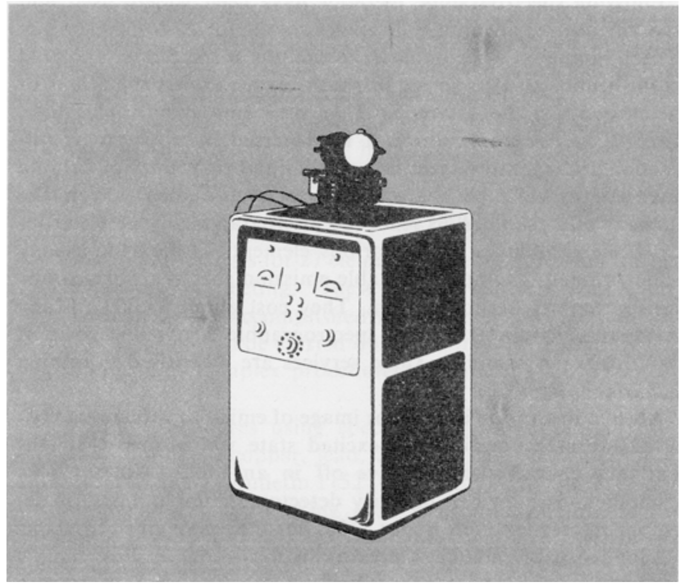
Instrument Techniques

The types of instruments used most for large-scale prospecting are emission spectrographs, X-ray spectrographs, and radio-activation units. They permit rapid identification of most of the chemical elements.

Emission spectrographic methods have been widely used and have the distinct advantage of giving results for 20 to 50 elements in each sample. To accomplish the analysis, a sample is vaporized by the heat of an electric arc or spark, which excites the atoms of the elements in the sample so that they emit light. This light enters a spectrograph where it is dispersed by a prism or diffraction grating into a spectrum containing bright lines of definite wave lengths which are characteristic for each element. From the intensity of these lines, as recorded photographically or electronically, the abundance of the various elements in the sample may be determined. Compact portable emission spectrographs can be transported in a station wagon. They cost about $8,000. Many commercial laboratories offer spectrographic analyses at costs of $10 to $20 per sample. These services are advertised in mining magazines.

Atomic absorption is a mirror image of emission spectrography in that atom vapors in an unexcited state will absorb the light that they characteristically give off in an excited state. This phenomenon is used in mercury detectors. Simple mercury detectors are available for under $100, but they may give erroneous results if organic matter is present in the sample. Less simple apparatus, such as one described by Vaughn and McCarthy (1964) will detect mercury in concentrations as low as a few parts per billion. The interest in mercury is two-fold. It not only is a valuable metal itself, but also it occurs in small quantities with many different ores, such as those of silver, gold, lead, zinc, and copper. The presence of mercury, therefore, may indicate the presence of these other metals. Furthermore, mercury is a volatile element and is transported as a gas that easily diffuses through small fractures and porous rock. Thus, a mercury halo presents a larger target for the prospector than halos produced by many other elements.

In X-ray spectrograph) (sometimes called X-ray fluorescence spectrography), the atoms in solid samples are excited by bombardment with X-rays and then release their acquired energy in a radiation spectrum characteristic of each element. An X-ray spectrograph is an instrument designed to utilize this property for determining the concentrations of elements in a sample. It requires high voltages and adequate shielding to protect the operator. A good installation costs $50,000 or more. Many commercial laboratories advertise X-ray analyses at rates of $2 or more per element per sample.



Radio-activation methods are based on the principle that some elements release neutrons when bombarded with high-energy gamma rays. A portable instrument developed by the U.S. Geological Survey emits gamma rays from a radioisotope of antimony and is fitted with a neutron proportional counter. When beryllium, for example, is bombarded with gamma rays, the beryllium releases neutrons which are recorded by the counter; thus beryllium can be detected in rocks when the instrument is passed over them. Commercial models of the device are available.

GEOPHYSICAL PROSPECTING

Geophysical prospecting combines the sciences of physics and geology to locate ore deposits. Familiar examples of geophysical prospecting include the use of geiger counters for detecting radioactive uranium deposits and magnetic surveys to find iron deposits.

Five major geophysical methods—magnetic, gravimetric, electrical, radiometric, and seismic—are successfully utilized in mineral exploration. Some of these methods require complex and costly instruments and highly trained operators. Others, however, are relatively simple and inexpensive. Among these are the magnetic and radiometric methods described below.

Magnetic Methods

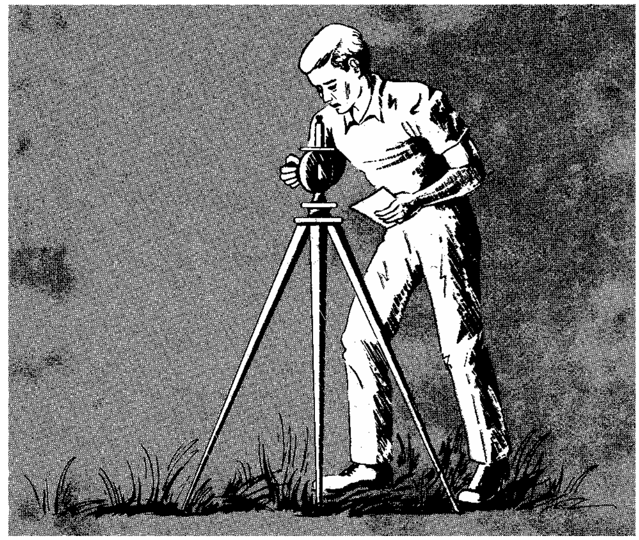
Magnetic prospecting is based on the fact that some minerals, such as magnetite, are themselves natural magnets. The needle in a compass held near a magnetite-rich rock behaves erratically because the earth's magnetic field is distorted by the local magnetic field. Minerals such as ilmenite (iron-titanium oxide), hematite (iron oxide), and pyrrhotite (iron sulfide), are weakly to moderately magnetic, and their effects can be recorded by sensitive magnetic instruments.

The common unit of measure for the strength of a magnetic field is the gamma. The strength of the earth's magnetic field in the United States ranges from a low of about 50,000 gammas in Texas to a high of 60,000 gammas in Minnesota.

Instruments such as the magnetometer and the dip needle are used directly to detect large anomalies over magnetic iron-ore bodies. The magnetic readings over weakly magnetic host rocks may depart from local average or “background” values by 10 to 500 gammas, but over magnetic iron-formation the readings may depart from background by 100 to 100,000 gammas. The magnetometer and dip needle can also be used to trace concealed rock formations that have magnetic properties differing from those of adjacent formations. For example, the prospector may know that copper is associated with an igneous rock such as quartz monzonite. If, as is often true, the quartz monzonite is more magnetic than the surrounding rocks, the magnetometer can be used to detect it beneath soil, talus, or other cover. Similarly, the “black sand” of placer deposits commonly contains grains of magnetite or ilmenite which affect the magnetometer and the dip needle. These instruments, therefore, may be used indirectly in the search for gold or "heavy minerals” that are in the “black sand.”

The dip needle is a pivoted magnetized needle enclosed in such a way that the case can be held vertically and the needle can rotate in a vertical plane. For use, the needle is set in a horizontal position by adjusting a counterweight that is attached to one arm of the needle. If no disturbing magnetic masses are present, the needle will remain in a horizontal position, but if a magnetic mass is present, the needle will be “pulled” away from the horizontal and thus will dip at varying angles, depending on the magnetic intensity of the disturbing mass and the orientation of the needle with respect to the magnetic field. In general, the more highly magnetic the rock mass, the steeper will be the angle of dip of the needle. Costs of dip needles range from about $75 to $250. The dip needle has been used chiefly in prospecting for iron deposits.

Magnetometers are more elaborate than dip needles and are of several different types. Schmidt-type magnetometers, or magnetic balances, are essentially carefully constructed dip needles or compasses, in which the angle of dip (for measuring the vertical component of the magnetic field) or the angle of declination (for measuring the horizontal component) is calibrated so that a reading in gammas can be obtained. Such magnetometers are used primarily to determine differences in magnetic field rather than total field. They require tripod mounting, careful leveling, and careful handling in operation because of their delicate construction. Under ideal conditions they can be read with an accuracy of a few gammas.



Other types of magnetometers, generally simpler to operate than Schmidt-type magnetic balances, include the fluxgate, torsion, and nuclear precession magnetometers. Principles and methods of operation of these instruments are described in modern textbooks.

Many commercial models of magnetometers are available, ranging in price from $200 to $5,000. The less expensive ones can be read with an accuracy of 20 to 100 gammas. Those in the intermediate range can be read with an accuracy of 5 to 20 gammas, and the most expensive ones can be read with an accuracy of 1 to 5 gammas.

Magnetic surveys may be conducted either along a series of lines or in a grid pattern. The spacing of stations is determined by the size of the area being prospected and the type of deposit being sought. Stations spaced 10 to 20 feet apart may be required to locate small magnetic anomalies associated with weakly or moderately magnetic rocks, but stations spaced 100 feet or more apart may suffice if strongly magnetic rocks are suspected in a large area. Power lines, rails, automobiles, and other large metallic objects should be avoided in any type of magnetometer survey because they create strong local magnetic fields that mask the anomalies inherent in the rocks.

Radiometric Methods

Naturally occurring radioactive elements such as uranium or thorium break down or decay to other elements or isotopes by emission of subatomic particles. Gamma rays (similar to X-rays but of higher frequency), alpha particles (nuclei of helium atoms), and beta particles (electrons) are the most common particles emitted during this process.

The portable Geiger and scintillation counters, which detect differences in the intensity of radioactivity, have been widely and effectively used in prospecting for uranium and thorium deposits in recent years. These instruments are sensitive to very small differences in amounts of radioactive elements in rocks, but they do not tell what element produces the radioactivity. These distinctions can be made by chemical analysis of a sample of the radioactive rock. The Geiger counter is a tube filled with a gas such as helium, argon, or krypton. A high-voltage wire extends into the central part of the tube. When gamma radiation or beta particles pass into the tube from a radioactive source, some of the rays collide with gas molecules and produce electrically charged particles which are then attracted to the central wire and produce electrical pulses. The electrical pulses can be translated into dial readings of counts per minute. Scintillometers utilize crystals of certain compounds, such as sodium iodide, which emit flashes of light when struck by radiation. A photoelectric cell "sees" the flash of light or scintillation and electronically counts the numbers of flashes per unit of time. This can be transmitted to a dial reading in counts per minute. Scintillometers are more sensitive than geiger counters.

In using radiation counters in the field, the most common procedure is to walk over the terrain while listening to the counts on earphones or watching the dial of the counter. Radioactive deposits may produce readings that are 10 or 100 times as great as "background." However, if the deposits are covered by even a few tens of inches of overburden, the radiation cannot be detected. In using a portable counter, one should be cautious about interpreting the information until it is verified by adequate sampling and chemical analysis. Prices for portable counters range from about $75 to $500.

INDICATOR PLANTS

Plants have been successfully used as aids in mineral prospecting, and under certain conditions may assist in locating buried mineral deposits. So many factors are involved, however, that it is not always possible to predict conditions under which plants will be of practical assistance.

Many plants, by means of their extensive root systems and the absorptive ability of their roots, effectively sample many of the elements that are within reach of the roots and transfer these elements to the branches, stems, and leaves, which can be chemically analyzed. Thus, under ideal conditions, the plant has sampled the underlying soil or rock in its root zone to depths of as much as 50 feet. The advantages to the prospector of being able to sample plants and thus obtain information about the metals that occur at considerable depth are at once obvious, although problems in interpreting this information may render this method of prospecting impractical under many field conditions. For a review of botanical prospecting methods, see Cannon (1960, p. 591-598).

CLAIM TO MINERAL DISCOVERY AND EXPLORATION

Once a promising mineral deposit is discovered, the prospector must know whether the deposit can be staked, purchased, or leased. On privately owned land, the mineral rights must be obtained from the owner, generally through purchase or lease. The acquisition of mineral rights on public land is regulated by State and Federal laws; these rights are generally obtained by staking a claim or by leasing the land from the appropriate governmental agency. Federal mining regulations are administered by the Bureau of Land Management, which has issued several pamphlets of interest to the Prospector. These include, "Information in Regard to Mining Claims on the Public Domain," and Circular 1941, "Lode and Placer Mining Regulations," and they are available free of charge from the Information Office, Bureau of Land Management, Washington, D. C. 20220. Prospectors in Alaska will also be interested in Bureau of Land Management Circulars 1852 and 1869, which pertain to mineral lands in Alaska. Bureau of Mines Information Circular 7535, "Locating Mining Claims on the Public Domain," by Marion Clawson (1950) is available free from the Publications Distribution Section, U.S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pa. 15213. Local offices of the Bureau of Land Management in many of the Western States, as well as State geologists or mine inspectors and officials at County courthouses, are other sources of information pertaining to the acquisition of mineral rights on public lands.

Special regulations apply to parts of the National Forests, and the location of mining claims is prohibited on some land under the jurisdiction of the Forest Service. Local Forest Supervisors and Forest Rangers can provide information on the regulations applicable to their area. Mining is prohibited in National Parks and National Monuments except where specifically authorized by law; Bureau of Land Management Circular 1941 lists these laws.

The prospector who succeeds in making a mineral discovery must consider how to explore the deposit in order to estimate its size and grade. Evaluating the economic potential of a deposit is sometimes difficult and may require the services of an experienced mining engineer. Estimates of the length, width, and depth of the deposit are needed to determine the tonnage of mineralized material present, and samples must be obtained for analysis to determine the grade of the deposit. Such samples must represent all the material that might be mined as ore, not just selected parts. For a review of sampling methods, see Lang (1956, p. 230-235).

SERVICES AVAILABLE TO PROSPECTORS

The U.S. Geological Survey does not maintain service laboratories, but informal advice and identification of rocks, minerals, and ores can be obtained from geologists at the various Geological Survey offices.

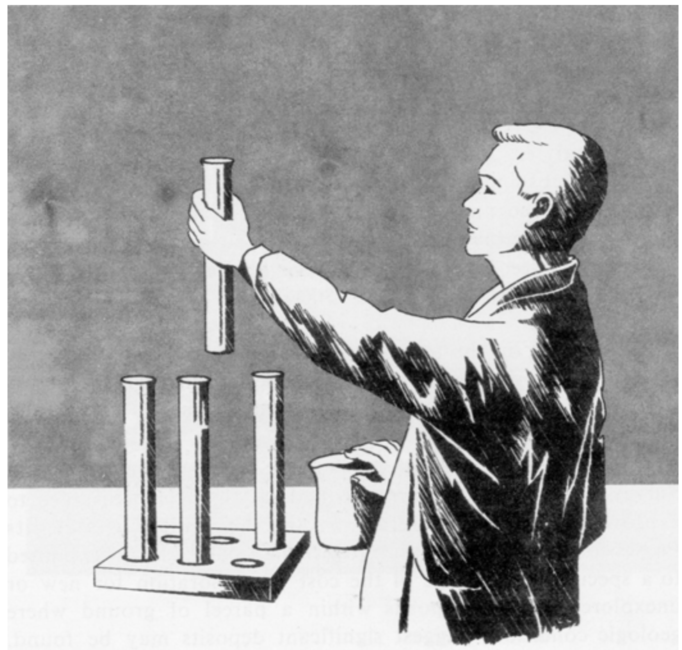
The State Geological Surveys will provide the prospector with much helpful information on State mining laws and the geology of specific areas within their State. Mineral identification service is also available at some State Geological Survey offices.

If a complete analysis is desired, the sample should be sent to a commercial chemical laboratory or assay office. Bureau of Mines Information Circular 7695 entitled, "Laboratories that make fire assays, analyses, and tests of ores, minerals, metals, and other inorganic substances," lists private concerns in the United States and Canada where mineral samples may be sent for identification and for other special tests to determine their value. This circular is available free upon request to the Publications Distribution Section, U.S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pa. 15213.

Information on the technology of mining, milling and metallurgy, safety practices, and other factors involved in mine development and operation may be obtained from the U.S. Bureau of Mines, Washington, D. C. 20242.

The U.S. Department of the Interior, through the Geological Survey, is authorized to provide Federal financial assistance to explore for certain minerals within the United States, its Possessions, and Territories. Government participation is limited to a specified percentage of the cost of exploration for new or unexplored mineral deposits within a parcel of ground where geologic conditions suggest significant deposits may be found. Exploration may be conducted from the surface or underground by any recognized and accepted procedure, including geochemical and geophysical methods. The applicant must own, lease, or have a valid interest in the property to be explored. Prospecting or grubstaking operations to look for favorable mineral-bearing areas are not eligible for financial assistance under this program. Repayment of the Government's share of the exploration costs, with interest, is by a royalty on production from the property. If there is no production, there is no obligation to repay.

More detailed information on this program, setting forth the mineral commodities currently eligible for Government financial assistance and the percentage of exploration costs contributed by the Government, may be obtained from the U.S. Geological Survey, Office of Minerals Exploration, Washington, D. C. 20242.



MAPS

The U.S. Geological Survey publishes many maps, in addition to those in book reports that are useful to the prospector. Among these are map indexes, geologic maps, mineral resources maps, and topographic maps. These and other Survey publications can be examined at many large public and university libraries throughout the country, and those still in print can be purchased. Descriptions of these publications and information concerning their purchase may be found in the catalog "Publications of the Geological Survey, 1879-1961," and its supplements, which can be obtained by writing to the Branch of Distribution, U.S. Geological Survey, Washington, D. C. 20242. Separate listings of the publications by State and depository libraries also are available from the Branch of Distribution.

Geologic maps show rock types and relationships, geologic structures such as faults and joint patterns, and mineral deposits. Most such maps are published by the

Federal and State Geological Surveys or in professional journals.

Mineral resources maps showing the locations of mines and quarries have been compiled by the Federal and State geological surveys. An additional series of maps showing the distribution of the principal source areas for most of the commercial metals and minerals in the conterminous United States have been published by the U.S. Geological Survey. The Missouri Basin Studies and the Tennessee River Basin Maps show the distribution of metallic and nonmetallic resources of the States within the drainage areas of these rivers.

Many mines are shown on maps of the national forests, issued by the Forest Service, U.S. Department of Agriculture. Information on these maps can be obtained from the U.S. Forest Service, Washington, D. C. 20250, the Forest Supervisor at the 10 regional field offices, or at local ranger stations.

Data compiled from aeromagnetic surveys of various areas have been published by the Geological Survey as Geophysical Investigations Maps. These have isomagnetic contours showing total magnetic intensity overprinted on sheets showing cultural features: some of them also show the geology, thereby facilitating the correlation of the magnetic anomalies with geologic features.

The U.S. Atomic Energy Commission conducted aerial radioactivity studies of many areas between March 1952 and June 1956, and issued maps showing the locations of areas of high radioactivity found on public lands outside the national parks, monuments, and wildlife preserves. File copies of these maps may be examined at the AEC depository libraries at the following locations:

U.S. Atomic Energy Commission
Casper Branch Office
148 North Beech Street
Casper, Wyo. 82630

U.S. Atomic Energy Commission
Grand Junction Office
Grand Junction, Colo. 81501

U.S. Atomic Energy Commission
Grants Branch Office
Torres Building
Grants, N.M. 87020

Library of Congress
Map Division
Washington, D. C. 20540

Copies of these maps may be purchased from the Map Division, Library of Congress, Washington, D. C. 20540, and generally from the AEC depository libraries.

The U.S. Geological Survey also conducted aerial radioactivity surveys on behalf of the Atomic Energy Commission. Results of these surveys were released as published maps for sale or as maps placed in open file. Published maps are listed under Geophysical Investigations, Maps and Charts, in the catalog, "Publications of the Geological Survey." Maps released only in open file are listed in Geological Survey Bulletin 1107 A, "Bibliography of the U.S. Geological Survey reports on uranium and thorium, 1942 through May 1958." This bulletin lists places where maps in open file can be inspected. Among the more centrally located places are the following:

U.S. Geological Survey Library
Room 1033, General Services Administration Building
18th and F Streets, N. W.
Washington, D. C. 20242

U.S. Geological Survey
Public Inquiries Office
504 Custom House
555 Battery Street
San Francisco, Calif. 94111
(Maps of areas west of the
Mississippi River only)

U.S. Geological Survey
Public Inquiries Office
15426 Federal Building
1961 Stout Street
Denver, Colo. 80202

U.S. Atomic Energy Commission
Grand Junction Office
Grand Junction, Colo. 81501

Topographic maps sold by the U.S. Geological Survey show the character and relief of land features by means of contour lines; the maps also show drainage, forest cover, cultural features, and the locations of many mines and quarries. Index maps showing the areas in each State for which topographic maps are available are free on request to the Geological Survey, Washington, D. C. 20242.

Aerial photographs for most parts of the United States are available from many government agencies at a nominal cost. Information concerning their availability for any locality can be obtained by writing to the U.S. Geological Survey, Map Information Office, Washington, D. C. 20242.

SELECTED PUBLICATIONS

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