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NEW EQUIPMENT

Three items of laboratory and field equipment have been purchased that will be of great help in performing the services that are a portion of the Division's activities. The laboratory equipment consists of an X-ray unit with a spectrographic attachment and the field equipment includes two geophysical instruments.

Laboratory Equipment

A General Electric XRD-5 X-ray diffraction unit has been acquired by the Virginia Division of Mineral Resources at its laboratory in Charlottesville. The unit will be used in the study of various properties of geological materials such as rocks, clays, ores and other minerals. It will provide data that will benefit the utilization of native materials in the continuing expansion of the economic development of our State. A few of the ways in which this unit can be applied are:

1. To identify, evaluate, and classify minerals.
2. To distinguish between minerals having the same chemical composition, but differing in crystal structure and physical properties.
3. To determine chemical and physical changes that take place during changes in the temperature of materials.
4. To distinguish between mineral mixtures and compounds.
5. To determine changes produced in minerals by normal weathering, accelerated weathering tests, and other physical alterations.
6. To determine phase shifts in solid solutions.
7. To determine the quantities of minerals present in rock samples.
8. To determine the kinds and amounts of elements present in mineral samples.

In these and many other applications, the unit will provide rapid and accurate analysis of minerals. In many cases an analysis can be done in minutes which, by other methods, might take days or weeks or which cannot be done at all.

The X-ray unit may be set up either for diffraction or for emission spectrometry, becoming either a "diffractometer" or a "spectrometer". The diffractometer is used to identify and analyze compounds, and the spectrometer to identify and analyze elements. For example, common table salt is sodium chloride having the chemical formula NaCl. The diffractometer would indicate that the compound is NaCl and no other compound or mixture; the spectrometer would reveal that the elements present are sodium and chlorine, but would not indicate whether they existed in a mixture or a compound. Both methods are useful or necessary in determining the properties of materials.

The basis for analysis by X-ray diffraction is in the fact that practically all materials are composed of particles (atoms or molecules) which arrange themselves into crystal patterns peculiar to the material itself; no two different materials will take the same arrangement. X rays are directed at the substance which scatters the rays according to the particular pattern for a given crystal. By analyzing the pattern of scattered radiation, a "fingerprint" of the material is obtained that is just as positive an identification as are the fingerprints of people.

The basis for analysis by use of the X-ray emission spectrometer, on the other hand, depends upon the structure of the atoms of the different elements. When struck by X rays, the elements give off "secondary" X rays caused by bombardment of the striking rays. These secondary X rays are of particular wave lengths solely determined by atomic structure. The spectrometer measures these wave lengths, again giving a "fingerprint" identification of the atoms producing them.

The Division's unit is equipped for the analysis of several thousands of compounds and of elements down to atomic number 21 (Scandium). Additional accessories will be added to provide for analysis of elements down to atomic number 12 (Magnesium).

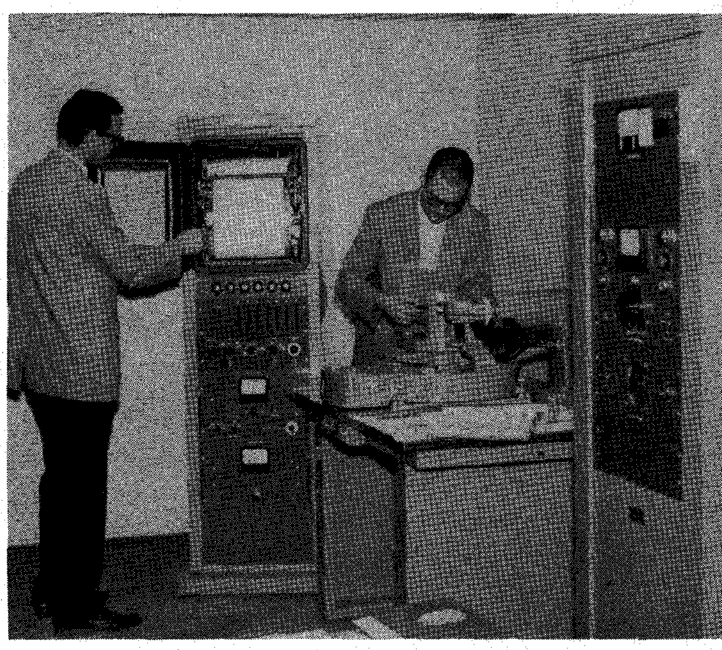
The XRD-5 X-ray diffraction unit (see photograph) consists of three main sections: a control panel at the right, a table with spectrogoniometer and X-ray tube in the center, and a X-ray detector panel at the left. Electrical power is supplied to the control unit which serves to regulate and distribute voltages as required by all the other components. The spectrogoniometer on the table scans the X rays that are scattered from the sample being analyzed. The scattered rays are picked up and converted to an electrical signal which is fed to the detector panel and used to drive the automatic strip chart recorder pen. The chart graph thus obtained is used as the identifying fingerprint of the sample being examined.

Use of the XRD-5 unit [redacted] is flexible enough for adaptation to new uses and techniques as applications and scientific progress develop. Meeting the challenge to provide for improved and expanded useful development of our natural resources will be greatly aided through the use of this new instrument.

Geophysical Field Equipment

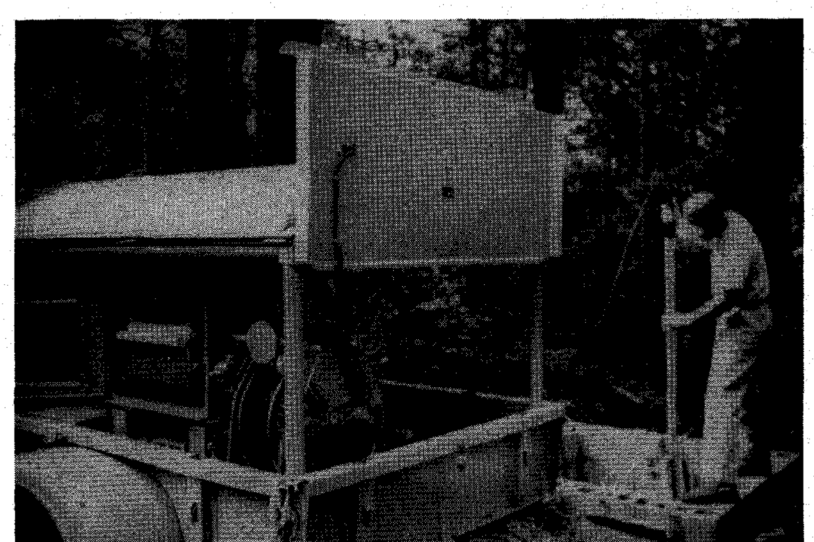
In order to locate mineral deposits, oil and gas structures, and ground-water resources that are concealed beneath the earth's surface, it is necessary to utilize all the information possible in the area of investigation. Some information is available from drill cores or well cuttings from previously drilled wells, but usually most of it must come from other sources. The materials that make up the earth's crust, the rocks and overlying soil mantle, have certain physical properties, such as specific gravity or weight, elasticity, magnetism, radioactivity, and electrical characteristics. In the search for mineral resources, by measuring one or more of these properties, it is possible to outline areas where the geological conditions are favorable for the occurrence of such resources thus minimizing the costs of more expensive types of exploration. In ground-water investigations, such information is valuable in locating well sites, in determining the depth of aquifers, and in evaluating the quality of water. The investigation and study of these physical properties is known as geophysics. A number of geophysical instruments have been designed to measure some of the earth's characteristics.

One group of such instruments is used to measure the electrical properties of the materials in the earth's crust and the determinations most commonly made are: the resistivity of the materials, and potential differences of natural earth currents.



XRD-5 X-ray diffraction unit (diffraction technique). Unit includes control panel (right), table with spectrogoniometer and X-ray tube (center), and X-ray detector panel (left).

Gish-Rooney resistivity apparatus. Four electrodes, reels with cables (foreground), power supply (to left of operator), and instrument assembly (in front of operator).



Widco well logger in operation. Tripod, sheave and cable to which the gamma ray probe is attached (right), cable drum (center), recording unit (left).

Both of these properties are influenced by the mineral and fluid content of the earth materials and vary in different rock formations and soils.

The Virginia Division of Mineral Resources has recently purchased two geophysical instruments to measure electrical characteristics of the rocks and soils. In order to make the measurements, one of these, a Gish-Rooney resistivity apparatus, is used on the surface of the ground whereas the other, a Widco logger, is used by lowering a portion of the instrument, or probe into a drill hole or well.

Gish-Rooney Resistivity Apparatus

The Gish-Rooney resistivity apparatus is used to record the resistivity of the materials in the earth's crust by taking a series of measurements at the surface. The complete apparatus consists of the measuring instrument assembly, a battery power supply, five metal earth electrodes, and associated cables and reels.

The usual method for making resistivity measurements is to drive the five electrodes into the earth, with four of them being equally spaced along a straight line. The fifth or neutral electrode is placed midway between the two center electrodes. Each of the electrodes is connected by cables to the measuring instrument assembly and the power supply. Measured current is sent through the two outer electrodes and a resulting potential difference between the two intermediate electrodes is recorded. By knowing the amount of current and the potential difference, the resistivity of a segment of the earth's crust may be determined. The depth below the surface from which data is obtained is proportional to the distance between the electrodes; by taking a series of readings with progressively greater electrode spacing, resistivity records are obtained from greater depths.

It is possible to interpret geologic conditions when the recorded resistivity values have been plotted in relation to the distance of electrode spacing.

Widco Well Logger

The Widco well logger measures certain electrical and radioactive properties of the rock layers through which a hole has been drilled. The information obtained is automatically recorded on a chart which provides an accurate and detailed picture of the local geology at the well-site. This means of investigating the rocks in a drill hole or a well provides valuable information with a minimum of delay and expense; it does not disturb the natural conditions in the well.

The well logger unit is mounted on a two-wheel trailer and is entirely self-contained. The power supply is a single-cylinder gasoline motor-generator mounted in the trailer. This generator supplies current for the electrical circuits and the automatic chart and pen drive. A cable drum, powered through a variable speed Vickers fluid transmission, is equipped with 2000 feet of steel-armored cable. Two types of probes are used, depending upon the type of record desired: a 3-1/2-foot electrode utilized in obtaining an electric log record and a 5-foot probe containing a scintillometer or radiation counter used in obtaining a radioactivity log record.

In operation the trailer is set up at the well and a small tripod and sheave for the cable are placed over the hole. The probe or electrode is then lowered on the steel cable into the well. The various impulses are transmitted by a conducting cable to the recording units in the trailer. These measurements are recorded continuously on chart paper as the probe or electrode is pulled up and the results may be interpreted immediately by the operator.

In practice the electric log is the first one that is made. A log of this type may be obtained only in the uncased portion of holes below the fluid level. The electric log consists of two curves which are recorded simultaneously: a spontaneous potential curve, usually called the S. P. curve, and a resistivity curve. The S. P. curve is a record of the potential changes between the electrode in the hole and a ground electrode at the surface. This curve shows formation changes and the presence of porous zones in the rocks which may contain water or petroleum. The resistivity curve is composed of a number of readings of the resistance offered by the rocks to the passage of an electric current. This curve reflects primarily the nature and distribution of the fluids in the various rock layers. It is useful in determining formation changes and boundaries and in distinguishing the nature of fluids in the rocks. Fresh water or oil has a high resistivity, whereas, salt water characteristically has a low resistivity.

The other type of log record that may be made with the Widco well logger is the radioactivity or gamma ray log. This log may be obtained in either a cased or uncased hole and it does not require the presence of water or drilling mud. The gamma ray probe contains a battery-powered scintillometer or radiation counter which measures the relative amount of natural radioactivity being emitted by the rocks. Continuous measurements are recorded on a chart as the probe is slowly lowered or raised in the hole. These measurements are transmitted to the surface and recorded as a single continuous curve. All rocks contain radioactive materials in small but measurable amounts. The amounts differ widely with the various kinds of rocks; however, certain generalities may be made: coal and salt beds have a low radioactivity, while shaly sandstone and dark shales usually have a high radioactivity. The gamma ray curve is useful in defining the depths and boundaries of rock units and also may give clues as to the nature of the rock.

It should be emphasized that a positive identification of the rock types cannot be made from either the radioactive log or the electric log. Such identification may be made only by visual examination of well cuttings or cores. The most satisfactory evaluation may be made from a well log which is supplemented by cores or cuttings from a nearby control well. A trained observer may often make interpretations with a high degree of confidence, especially as logging experience grows in any given area.

The Widco well-logging equipment has both immediate and long-range application in the solution of practical geological problems in Virginia. The information obtained is valuable at once in evaluating a water or oil well. By providing a permanent record of the local geology, the log charts may be used in planning future operations in an area. The logs of several wells studied together furnish data for the construction of maps which show aspects of subsurface geology over a wide area. The Division will be able to solve geologic problems and give advice based on detailed subsurface knowledge as it builds a file of well-log records.

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SUMMER FIELD PROGRAM

Nine field projects were conducted by the Division during the 1958 summer field season. Six of these projects included both geologic mapping and mineral resource investigations, one was a study of water-well locations, and two were studies directed toward an inventory of all active mines and quarries.

H. R. Hopkins began a geologic mapping and mineral resources investigation project in an area in Albemarle and Louisa counties that has never been studied in detail. A portion of this work will be directed toward the correlation of the formations in this area with formations already mapped and studied to the southwest, mainly in the Lynchburg and Dillwyn quadrangles. The project is scheduled for completion during the 1959 field season.

Neil Hillhouse completed a geologic mapping and mineral resource investigation project in parts of Nelson and Amherst counties. This is an important area economically, as titanium ores and aplite are produced in these counties. Hillhouse has at his disposal drill cores and records from the U. S. Bureau of Mines and has the cooperation of the mineral producers in the area. The study of this area will lead to a better understanding of the occurrence of the economic mineral deposits and possibly to the discovery of additional deposits.

P. F. Chen began mapping the geology and investigating the mineral resources of an area in western Bedford County that has never been studied in detail. Feldspar is being quarried in Bedford County just east of this area. Titanium ore was produced in adjacent Roanoke County to the southwest. This project will be completed about December 1, 1958.

William B. Brent extended previous geologic mapping in Rockingham County. He will continue this mapping project during the next field season in order to complete the entire county. A county report on the geology and mineral resources will be prepared for publication. Limestone, marble, and zinc ore are being produced in the county.

Rhesa M. Allen extended the geologic mapping of the Blue Ridge into portions of Rockingham and Greene counties. His work in Rockingham County is to be incorporated into the Rockingham County report, mentioned above. The work in Greene County will be extended northward into Madison County.

Harold J. Prostka completed the mapping of the soapstone area in Albemarle and Nelson counties. This project was started in 1957 in cooperation with the Alberene Stone Corporation, when William M. Fairley began the mapping project in these two counties.

Whitman Cross made a study of water-well locations in the western half of Albemarle County. Most of this area is underlain by crystalline rocks and the purpose of this study was to determine the relationship between topography and the yield of wells.

David T. Bloor began an inventory of the coal mines in Buchanan County, the leading coal-producing county in the State. There are over 900 operating mines in the county, 400 of which were visited. The mine locations were plotted on topographic maps and data were collected from the operating companies. This study is scheduled for continuation during the next field season.

Richard F. Pharr visited active mines and quarries, exclusive of coal mines, throughout the State. The location of each mine and quarry was plotted on a map and statistics concerning each operation were recorded. Such information is vital on obtaining accurate data on the mineral production in the State. The information gathered during this study will be used in the preparation of a mineral resources map of the State.

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ABSTRACTS OF NEW PUBLICATIONS

Bulletin 73. INDUSTRIAL LIMESTONES AND DOLOMITES IN VIRGINIA: JAMES RIVER DISTRICT WEST OF THE BLUE RIDGE, by R. S. Edmundson. xi + 137 pp., 7 pls., 1 fig., 8 tables, 1958.
Price: $2.00

The area described in this report is approximately 2,100 square miles or about two-thirds of the James River drainage basin west of the Blue Ridge. Natural boundaries include the Blue Ridge on the southeast and a part of Allegheny Mountain along the West Virginia-Virginia line. The southern boundary ties in closely with the area described in a report by Dr. B. N. Cooper (1944) entitled New River-Roanoke District, the first in the series of publications on the industrial limestones and dolomites in Virginia. The James River district on the north joins the area previously described by the writer (1945) in the second report of the series entitled Northern and Central Parts of Shenandoah Valley.

The James River district contains deposits of high-calcium limestone averaging about 97 percent calcium carbonate. The New Market limestone, where free of chert, and the Murat facies of the Lincolnshire limestone are the important high-calcium limestones in the southeastern part of the district. Quarryable thicknesses of the New Market occur also near the southwestern end of Warm Springs Valley. Other formations, locally containing units of high-calcium limestone, comprise a part of the Helderberg group in the central and western parts of the district.

Extensive exposures of Shady dolomite, containing more than 42 percent magnesium carbonate, are described from the general vicinity of Natural Bridge Station and Buchanan in Rockbridge and Botetourt counties. Most of the sampled dolomite units in the Waynesboro, Elbrook, Conococheague, and Beekmantown formations contains less than 40 percent magnesium carbonate.

Special study was made of the carbonate rocks suitable for chemical use and favorably located near railroads. Limestones, containing less than 95 percent calcium carbonate, were studied locally in some detail. Descriptions of the belts of industrial limestone and dolomite are supplemented by a geologic map, sections, physical tests, and chemical analyses.

Bulletin 74. GEOLOGY AND MINERAL RESOURCES OF THE LYNCHBURG QUADRANGLE, VIRGINIA, by W. R. Brown. xii + 99 pp., 14 pls., 6 figs., 9 tables, 1958. Price: $2.00

The Lynchburg quadrangle is in south central Virginia near the western limit of the Piedmont physiographic province. It includes an area of about 248 square miles, mostly in Campbell County, but also partly in Amherst, Bedford, and Appomattox counties.

Rocks of the area are predominantly metasedimentary and metaigneous and, with the exception of Quaternary alluvium and very minor Triassic diabase, are probably of Precambrian and lower Paleozoic age. Three groups recognized are, from oldest to youngest: (1) a complex of granitoid, gneissic, and migmatitic rocks, called Virginia Blue Ridge complex in this report; (2) a "late Precambrian" group consisting of Lynchburg formation and Catoctin greenstone: and (3) the Evington group of metasediments and metavolcanics. These outcrop in broad northeasterly-trending belts, the positions of which are controlled by three large regional structures which extend across the quadrangle. These structures are, from northwest to southeast: part of the core and southeast flank of the Catoctin-Blue Ridge anticlinorium, the James River synclinorium, and the Sherwill anticline.

The Virginia Blue Ridge complex constitutes the core of the Catoctin-Blue Ridge anticlinorium. In this area it consists of a gradation from Pedlar formation on the northwest, through Marshall gneiss and into Reusens migmatite on the southeast. The Marshall gneiss and at least parts of the Pedlar formation appear definitely to be products of a granitization, of which the Reusens migmatite is an outer zone. These core rocks are flanked on the southeast by Lynchburg formation, which seems to rest unconformably upon the Reusens migmatite. Catoctin greenstone, which in some areas overlies the Lynchburg formation is a transgressive unit in this area, being interlayered in part with the upper Lynchburg and also with the overlying Candler formation, the oldest unit in the Evington group. This Lynchburg-Candler contact has been mapped as the Martic overthrust, but the widely repeated general sequence: Lynchburg - Catoctin - Candler, and the transgressive nature of the Catoctin greenstone strongly oppose this interpretation.

Near the central part of the quadrangle, the Lynchburg formation and Catoctin greenstone dip southeastward beneath rocks of the Evington group, which lie in the trough of the James River synclinorium; in the southeast corner they emerge on the northwest flank of the Sherwill anticline. Within the James River synclinorium, rocks of the Evington group are closely folded and are repeated in numerous places by high-angle faults. These faults, once considered to be normal faults, are of reverse type. The nature of faulting, along with other evidences, indicate the sequence in the Evington group to be chronologically the reverse of that as previously interpreted.

Sill-like bodies of amphibolite and hornblende gneiss are abundant in parts of the Lynchburg formation. These have been generally interpreted to be metagabbros, but there are indications that many or all in this area may be products of metasomatism. Ultrabasics which occur in the Lynchburg and older rocks appear to be no younger than Catoctin greenstone; also, those in the upper Lynchburg may be volcanic rather than plutonic as commonly supposed.

Chief mineral resources in the area are marble (limestone), "Virginia Greenstone", sand, manganese, iron, barite, granite and other rough building stones. The first three are in important production at present. Manganese has been produced

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periodically and sporadically over the last 75 years; iron ore deposits, although not worked since the eighties, are not exhausted but are small; known deposits of barite are few and small.

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NEW QUARRIES

The Virginia Stone and Construction Corporation opened a new quarry 2 miles east of Fort Chiswell on U. S. Route 11 in Wythe County. Limestone and dolomite being quarried at present is being used for road aggregate.

Glen H. Belton recently opened a limestone quarry near East Stone Gap in Wise County to produce road aggregate.

Fredericksburg Stone Company is operating a granite quarry near Fredericksburg, Spotsylvania County. About 59 years ago monumental stone was produced at this quarry site. The present operators will produce crushed stone as well as some riprap.

Riverton Lime and Stone Company has opened a quarry and plant near Amherst, Amherst County. This quarry is in a granite gneiss and the products include both roadstone and concrete aggregate.

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The publications listed below are obtainable ONLY from the Alderman Library, University of Virginia, Charlottesville, Virginia.

Roberts, J. K., 1942, ANNOTATED GEOLOGICAL BIBLIOGRAPHY OF VIRGINIA: The Dietz Press, Richmond, Virginia, xi + 726 pp.
Price: $5.00

Rogers, W. B., 1884, GEOLOGY OF THE VIRGINIAS: D. Appleton & Co., New York, New York, xv + 832 pp.
Price: $5.00

Taber, Stephen, 1913, GEOLOGY OF THE GOLD BELT IN THE JAMES RIVER BASIN, VIRGINIA: Univ. Virginia Dissertation, Charlottesville, Virginia, x + 271 pp.
Price: $1.00

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