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DEPARTMENT OF MINES, MINERALS, AND ENERGY DIVISION OF MINERAL RESOURCES - THE STATE GEOLOGICAL SURVEY

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The Division of Mineral Resources was the fifth state geological survey in the United States formed through legislative action[1]. During the 1834-35 session, the House of Delegates of the General Assembly passed legislation on March 6, 1835 authorizing "...a Geological Reconnaissance of the State...." The Division of Mineral Resources is the fourth organizational name that has been given to the "Geological Survey." The historical sequence of name changes since its inception in 1835 are the Geological Survey of Virginia (1835-43), Virginia Geological Survey (1908-54), Division of Geology (1954-57), and Division of Mineral Resources (1957-present).

The survey operated "continuously" from 1835 through April 1842. During this period, William Barton Rogers (first Director) submitted a report titled "Report of the Geological Reconnaissance of the State of Virginia" in 1836. He continued to collect and compile information that resulted in six annual reports. The report for 1841 was very brief and was mainly a plea to extend and fund the survey until April, 1843. The General Assembly agreed to extend the survey only until April, 1842. The survey was not funded again until 1904, funding again ceased in 1906, but was restored in 1908. From 1908 to the present, Virginia has had a viable, continuously funded geological survey that has made major contributions to the understanding of the geological framework and mineral resources of the Commonwealth.

Funds were almost non-existent for publications (except for the annual reports) of the survey's data that had been obtained by Rogers. Emma Rogers worked to collect and compile her husband's reports, papers, and letters during the two years following his death in 1882. It was through Emma Rogers' efforts that a geologic map of Virginia was published in 1884. This was the first comprehensive geological map of Virginia. The printed map contained the results of Rogers' geology of Virginia, West Virginia, and the eastern part of Kentucky; the scale of the map was "1=1,520,640th of Nature, or 24 Eng. Stat. Miles to One Inch."

The principal role of any geological survey is to serve as the primary source of accurate, timely, and objective information on geological and mineral resource matters related to its geographic area. The Division of Mineral Resources and its predecessors have and continue to perform this function for the Commonwealth and its citizens. The Division currently plans and performs activities that address the changing earth-science needs of Virginia. The Division staff's range of knowledge and required expertise is necessarily becoming broader as the demands and technologies of modern society become more complex. Two of the Division's fundamental activities, the examination of the geology and mineral resources and the preparation of geologic maps of the Commonwealth, are the traditional work of a state geological survey. In addition, the Division manages the topographic mapping program of the Commonwealth, in cooperation with the U.S. Geological Survey.

The Division provides services to a wide range of clients such as industry, various governmental units, planners, academia, consultants, landowners, and the general public (Figure 1). Information and interpretation appropriate to the various needs are supplied through consultations, correspondence and telephones, presentations to scientific organizations and non-scientific groups, seminars, and through Division publications and open-file data. The diversity of staff skills and specialties allows the Division to supply authoritative answers and assistance on a broad variety of earth-related

[1]The history of the Division of Mineral Resources was researched by C. R. Bruce Hobbs. His history is published in "The State Geological Surveys . A History" edited by A. A. Socolow, pages 432-442. The brief highlights mentioned above are taken from his history.

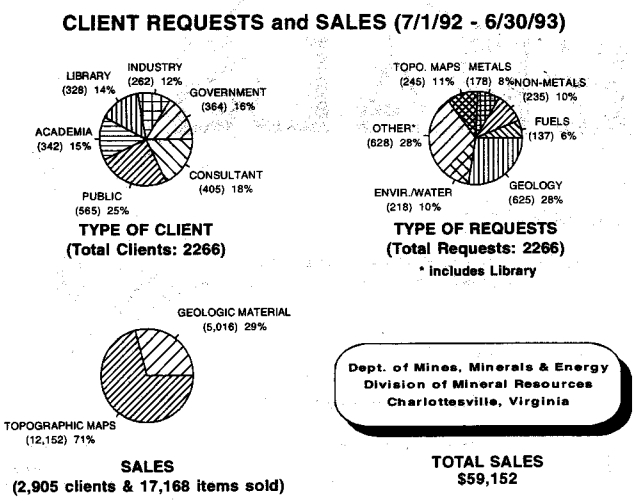

Figure 1. Summary of client requests and sales for the period July 1, 1992 through June 30, 1993.

topics.

The conduct of carefully-planned scientific and technical investigations and the organization and dissemination of the resulting information are basic to client service. Through these investigations, the Division attempts both to meet the immediate needs of the Commonwealth and to anticipate changing circumstances and opportunities that may become important to Virginia in the future. The Division's intention is to have accurate information available to meet client needs as they arise. Staff knowledge of changing socio-economic conditions such as land use, economic development, the environmental effects of development, and changing mineral markets and resource specifications is essential to the Division's planning for the future. During the past two decades, the traditional mineral resource and geological studies of the Division have been supplemented by use of sophisticated techniques such as geophysics, geochemistry (Figure 2), and development of computer-based databases.

Rapidly evolving concepts of modern geologic thought, together with increasing amounts of data, are enabling geologists to have a better understanding of the geologic framework of Virginia. The expanding knowledge and databases are useful both in providing client assistance in areas where little data were previously available and in performing modern reexaminations of areas studied in the past.

Growing governmental and public concern with the environmental effects of man's development require increasing staff knowledge and participation in supplying geologic data that can be used in decision making (Figure 1). In all of its research and related activities, the Division strives to maintain the highest standards of scientific and technical competence and objectivity by employing well educated, experienced, and competent individuals.

MINERAL RESOURCES

In terms of contribution to the economy of the State, the most important mineral resources of Virginia are coal, crushed stone, sand and gravel, lime (limestone and dolomite), and

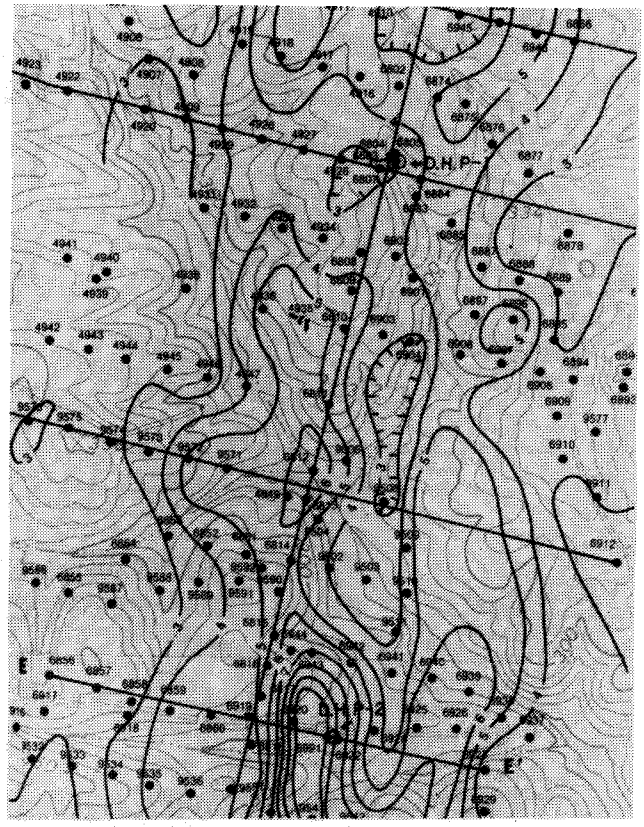

Figure 2. Contour map showing uranium concentration and sample locations (Krason, 1988).

natural gas. Virginia ranks seventh in coal production, fifth in production of crushed stone, twenty-fourth in sand and gravel production, and eighth in production of lime. In addition, Virginia contains a world-class deposit of kyanite that is mined in Buckingham County. This is the only deposit of kyanite currently being mined in the United States. Virginia is also the only producer of a feldspar marketed as "Virginia Aplite" and the second leading producer of vermiculite.

The non-fuel mineral resources of Virginia may be broadly divided into metallic and non-metallic categories. Although the last metal mine in Virginia, the zinc and lead mine at Austinville, closed in December, 1981, there is continuing interest in the Commonwealth's precious and base-metal metallic resources. Virginia, as well as several other Appalachian states, were important gold producers during the last century. Although Appalachian gold mining declined as more economic deposits were discovered elsewhere, the high price of gold in the 1980s renewed interest in eastern U.S. deposits. Massive sulfide deposits of the Piedmont, especially those bearing copper, lead, and zinc as well as precious metals (gold and silver), are also of interest, with that interest fluctuating in accordance with world metal prices.

The Division of Mineral Resources aided in the assembly of a detailed database on the metallic resources of Virginia. During the past several years this information was compiled and entered into the U.S. Geological Survey's Mineral Resources Data System (MRDS), from which it may be accessed

directly by computer. Most of the old gold mines and prospects (approximately 300) of the State have been located and their geology is summarized in several recent publications. Studies of tin and tantalum deposits have been made in the last few years. These metals which would be of national interest, should foreign sources be cut off.

A wide variety of non-metallic deposits, the industrial minerals and rocks, are of great interest and importance to Virginia. These include crushed and dimension stone, sand and gravel, limestone for cement and lime production, as well as kyanite, soapstone, feldspar, iron-oxide pigments, vermiculite, gemstones, and clay materials. The Division assists these industriesby providing geologic information as well as specific commodity data. Crushed stone, and sand and gravel are used for construction of roads, buildings, airport runways, and railroads and are basic components in concrete and asphalt. Other rock and mineral materials are produced for industrial and chemical uses, such as for making glass, cement, steel, bricks, wallboard, insulation, roofing, and refractories. Agricultural uses of mineral materials include lime, fertilizer, and feed supplements. The increased use of lime and high-calcium limestone rock to aid in removal of SO_2 and NO_x emissions from the stacks of coal fired boilers is becoming more important in the "Environmental Decade" of the 1990s.

The importance of the minerals industry to Virginia's economy is seen from its extraction industries. In 1992, there were 127 surface coal mines and 297 underground coal mines in operation. In 1992, approximately 42.5 million tons of coal were mined in Virginia; the value placed on this coal is 1.48 billion dollars. The coal was mined in Lee, Wise, Dickenson, Buchanan, Scott, Russell, and Tazewell Counties. The direct impact from this activity occurs in the southwestern part of the state. However, the indirect impacts are equally important. The indirect impacts occur in the "expenditures" of salaries and wages in local communities; in equipment, services, and goods purchased from suppliers; in the rail transportation industry; and in our export facilities. A conservative estimate of the indirect impact of coal mining in 1990 was a billion dollars in additional economic activity, plus 400 million dollars in rail revenues that generated an additional 100 million dollars in wages and 800 million dollars from the "indirect" activity generated by rail transport; and an additional 120 million dollars was generated in wages and other economic activity at the Port of Hampton Roads (Zipper, 1992).

The non-fuel minerals industry is also an important aspect of Virginia's economy (Figure 3). In 1992, there were 497 surface and 4 underground non-fuel mines in operation. In 1992, approximately 70.6 million tons of non-fuel minerals with a value of 415,952 million dollars (preliminary) were produced from sites throughout Virginia. Most of this production is from about 140 stone quarries and 275 sand and gravel operations. Production in 1990 was valued at 412 million dollars and had a direct wage impact of more than 104 million dollars. The "indirect" impact of the aggregates industry is just as important as that of the coal industry.

In 1990, gross earnings of 1.2 billion dollars out of the State's total of 16 billion dollars is attributed to the non-metallic minerals, construction, and stone, clay, and glass products industries; provided jobs for about 200,000 workers

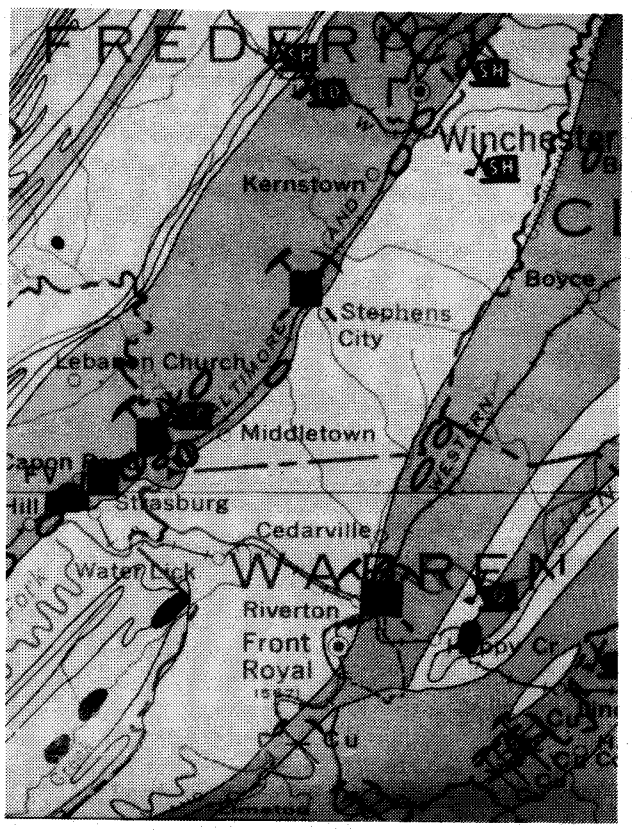

Figure 3. Map showing mineral resource operations and prospects (Sweet, 1983).

with earnings of another 1.2 billion dollars (Prosser, 1992). Other facts regarding the non-fuel industries are: about 12,500 tons of aggregate are needed for each mile of a two-lane highway; 15,500 tons are needed for a school, 3 million tons for an airport, and 300 to 400 tons of aggregate are needed in the construction of a typical single family home (Prosser, 1992). According to the Virginia Aggregates Association, aggregate makes up approximately 95 percent of every ton of asphalt and 80 percent of each cubic yard of concrete. In the Association's 1991 fact sheet, they state that over 80 percent of all aggregate is moved by truck and that the aggregate is used within forty miles of where it is produced, that the haul distance largely controls the price of aggregate ($0.15-0.20 per ton mile), and that the average production life of a crushed stone quarry is 40 to 50 years or more.

Crude oil production in 1992 occurred in Lee and Wise Counties with Lee County providing about 71.5 percent of the total production of 12,881 barrels. The production was from 40 wells. Natural gas production showed a marked increase in 1992. In 1992, 18.7 billion cubic feet of conventional natural gas and 6 billion cubic feet of coalbed methane gas was produced from the southwest fields. This increase in production of gas from 14.9 billion cubic feet in 1991 to 24.7 billion cubic feet in 1992 is mainly due to an increase of about 5 billion cubic feet of coalbed methane gas. Over 162 miles of pipeline were constructed in 1992 (Virginia Division of Gas and Oil, 1993).

From the brief synopsis given above; it is obvious that the mineral industry in Virginia is extremely important to the

economy and well-being of our citizens. In 1992, the mining industries in Virginia provided direct jobs for 14,115 individuals. From the coal used to provide energy to the aggregates used for our infrastructure uses (recreation, landscaping, agriculture, railroads, shorelines, transportation, construction, environmental), we can see that our mineral resources are an essential part of the Commonwealth's economy.

Some of the major projects and significant investigations that the Division has been involved in and have completed since 1989 follow and for some, a brief statement is given (Figure 4).

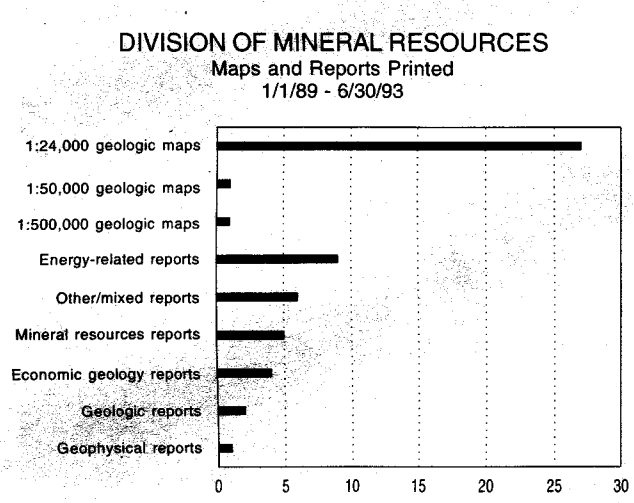

Figure 4. Summary of Division of Mineral Resources' printing for the period January 1, 1989 through June 30, 1993.

Mineral Resources Projects and Investigations

- Carbonate Resources Project. This project involves the sampling and analysis of over 5,000 samples of carbonate rocks to determine the purity for various industrial uses. One of the project's main objectives is to provide data on carbonate materials that may be suitable for abatement of SO_2 and NO_x emission from coal-fired plants. Adherence to the Clean Air Act will reduce airborne emission, improve the environment and may reduce acid rain. Virginia has numerous potential sites where suitable carbonates might be utilized for this purpose. All data is computer accessible. First publication (Northern Virginia) is Publication 108.
- Mineral Resources Maps and Computer Database Project. Maps at a scale of 1:24,000 are being prepared that depict the location of fossil fuel, industrial mineral (non-metallic) and metallic mines, quarries, prospects, and occurrences of minerals. Mineral resource maps are very important to consultants and exploration companies and for environmental uses. The data will be computer accessible.
- Copper, lead, and zinc resources in Virginia (Publication 93).
- Mineral-Sand Studies - Virginia Inner Continental Shelf. The projects were done in cooperation with the U.S. Minerals Management Service (Publication 103).
- Gold mineralization, and tin, base metals, and thorium anomalies at Yankee Horse Ridge, Irish Creek Tin Area, Rockbridge County, Virginia (Publication 112).
- Tantalian and niobian resources in Virginia (Publication 115).

Energy-related Projects and Investigations

- Coal Mine Map DataBase Project. The Division is organizing mine map data and preparing maps for the principle coal beds that depict deep mine and surface mine locations, and gas, oil, and coalbed methane well locations. The project has as the ultimate goal, the creation of a Geographic Information System (GIS) system for the Virginia coalfield area to be used for regulatory, environmental, natural hazard, and mineral resource purposes. The cooperative project is between the Office of Surface Mining, Division of Mined Land Reclamation, and the Division of Mineral Resources.
- Coal Quality Project. The data from this project include the classical chemical and physical testing and trace element and major and minor oxide analysis needed by industry planners to evaluate Virginia coal for its suitability for specific uses. The report contains results from analyses of 375 coal samples from 32 major coal seams (Publication 122). The project is in cooperation with the U.S. Geological Survey.
- Impact of multi-seam mining Project. The study was done to evaluate existing automated data processing techniques to determine the factors controlling the safe extraction of the maximum amount of coal. The report (Publication 104) gives computer modeling techniques to determine reliable estimates of minable coal reserves for use in long-range planning and for conservation of energy resources. The project was done in cooperation with the U.S. Geological Survey.
- Geology and petroleum potential of Mesozoic and Cenozoic rocks, offshore Virginia (Publication in preparation). The project was done in cooperation with the U.S. Minerals Management Service.
- Oil and gas well data and geology, Lee County, Virginia (Publication 113).
- Oil and gas well analyses of hydrocarbon potential of Buchanan, Dickenson, and Wise Counties, Virginia (Open File Report OF 92-2).
- Coal resources estimate for Lee County, Virginia (Publication 111). The project was done in cooperation with the U.S. Geological Survey.
- Available coal resources study of Appalachia 7.5-minute quadrangle, Virginia-Kentucky (Publication 118). The project was done in cooperation with the U.S. Geological Survey.
- Exposed and inferred Early Mesozoic basins onshore and offshore, Virginia (Publication 94).
- Energy resources and facilities in Virginia (Publication 100).
- The Valley coalfield in Montgomery and Pulaski Counties (Publication 124).

GEOLOGIC RESEARCH

The basic tool of the geologist is the geologic map (Figure 5). The geology is drawn on the best available base map and contains information about the surface distribution of different types of rocks as well as the locations of mineral deposits. The three-dimensional geometry of rock masses, together with subsurface information obtained from wells, seismic surveys and other geophysical studies, allow the geologist to look, if only dimly, deep into the earth.

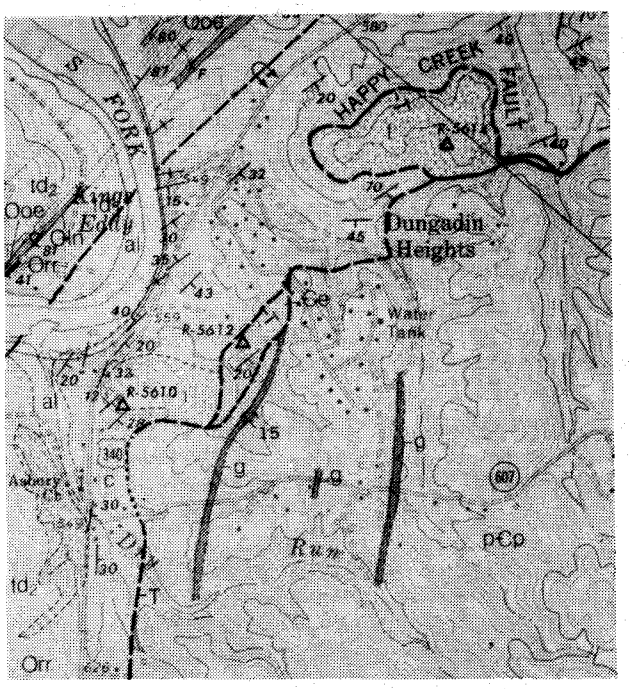

Figure 5. Southwest corner of the Front Royal geologic map (Rader and Biggs, 1975).

Geologic mapping can be conducted at any scale, from those depicting the general geology of a region, state or country, to those depicting in great detail the geology of a mineral deposit. The principal detailed mapping scale of the Division is 1:24,000. When larger areas need to be depicted, other scale maps are used, such as the 1:50,000, 1:100,000, 1:250,000, and 1:500,000.

Some of the major projects and significant investigations that the Division has been involved in and have completed since 1989 follow and for some, a brief statement is given (Figure 4).

- o 1993 Geologic Map of Virginia (1:500,000 scale). This project was started in June, 1992 after a review of the accomplishments made in the 1:250,000 scale geologic mapping program that started in 1984 in cooperation with the U.S. Geological Survey's COGEOMAP program. The map represents over 100 staff years of geologic mapping.
- o Southwestern Virginia Coalfield Geologic Mapping (1:24,000 scale). The field mapping aspects and the publication of geologic maps that cover the Southwestern Virginia coalfield was completed in 1989 and represents approximately 42 staff years of geologic mapping. All of the coal-bearing portions of 36 quadrangles were mapped and printed. This project created a detailed data base of the geology and mineral resources for the coal-bearing portion of seven counties. The project was a cooperative effort between Office of Surface Mining, Division of Mineral Resources, Division of Mined Land Reclamation, and the Powell River Project.
- o Geologic Map of the Coastal Plain of Virginia (1:250,000 scale). This project was done in cooperation with the U.S. Geological Survey. The resultant map is usable for planning, development, or regulatory purposes and as a base for groundwater, environmental, and mineral resources investigations. The field mapping for this project led to the discovery by a Division geologist of a world class mineral sand deposit south of Petersburg.

- o Detailed Geologic Maps (1:24,000 scale) Published
  - Brandon and Norge quadrangles (Publication 87).
  - Rocky Mount and Gladehill quadrangles (Publication 90).
  - Penhook and Mountain Valley quadrangles (Publication 90).
  - Haysi quadrangle (Publication 91).
  - Nora quadrangle (Publication 92).
  - Keen Mountain quadrangle (Publication 96).
  - Grundy quadrangle (Publication 97).
  - Harman and Jamboree quadrangles (Virginia part) (Publication 98).
  - St. Paul and Carbo quadrangles (Publication 106).
  - Boswells Tavern and Keswick quadrangles (Publication 107).
  - Richlands quadrangle (coal-bearing part) (Publication 109).
  - Tazewell North, Tip Top, and Gary quadrangles (coal bearing part) (Publication 110).
  - Hurley, Panther, Wharncliffe, and Majestic quadrangles (Virginia part) (Publication 121).
  - Geologic map of Clarke County, Virginia (1:50,000 scale) (Publication 102).

ENGINEERING AND ENVIRONMENTAL APPLICATIONS

The geologic data obtained from numerous mapping projects can be interpreted to assist in the identification of potential problems related to the construction of highways, dams, power plants, high-rise buildings, and waste-disposal sites (Figure 6). In addition, the geologic data is useful in identifying and protecting groundwater resources.

Studies include: locating areas with sinkhole and solution activity which may render land less suitable for foundations or waste disposal facilities; and locating and characterizing geologic units with groundwater potential. A geologic map of Giles County, which shows the type of rock units, slope steepness, and locations of sinkholes and landslide deposits, is available for land-use planning in this earthquake prone area of western Virginia.

Some of the major projects and significant investigations that the Division has been involved in and have completed since 1989 follow:

- o Karst Mapping Project (1:250,000 scale). These maps

illustrate the concentration of sinkholes and caves in carbonate rocks. The maps are invaluable for planners, developers, and regulatory agencies in decision making related to groundwater and pollution potential and engineering considerations. Two maps have been printed (Publications 44 and 83) and the third project (Southwestern Virginia) is in progress.

- o Geochemistry and radioactivity in the Powhatan area, Virginia (Publication 78).
- o NURE data - geochemical data for stream sediments and surface and groundwater (computer database - U.S. Department of Energy and U.S. Geological Survey).

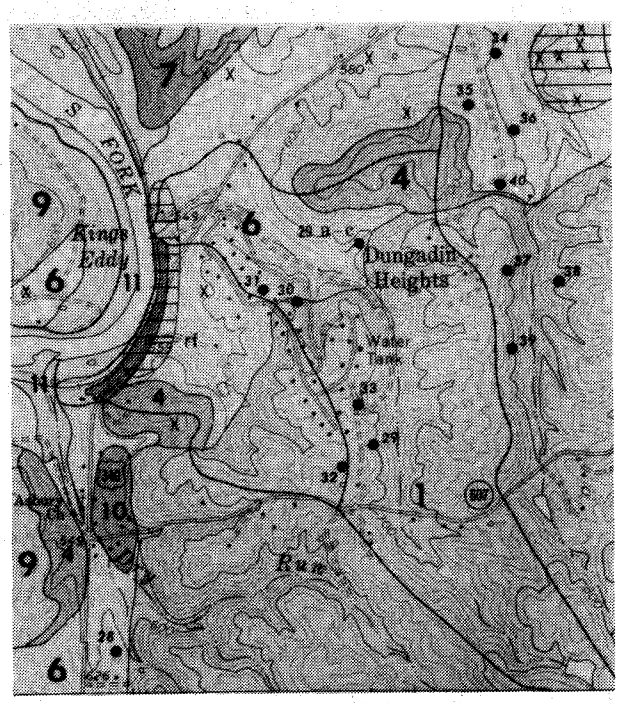

Figure 6. Map of the southwest corner of the Front Royal quadrangle showing units with similar environmental response factors (Rader and Biggs, 1975).

EARTH SCIENCE INFORMATION

The Division provides information on all aspects of the state's geology, topography and mineral wealth to a wide range of clients. The staff makes presentations to scientific groups, conducts field trips for colleges and universities, and presents displays at geological meetings and meetings of engineers, surveyors, and teacher associations for educational purposes. A quarterly publication," Virginia Minerals", has a variety of articles about geology and mineral resources, publications, and associated activities.

Geologic maps, reports, and topographic maps may be purchased from the Division's Sales Office (Figure 1). The Division can supply information on mineral museums, clubs, shops, and mineral and fossil collecting areas. Staff geologists identify rocks and minerals collected in Virginia as a service to the public. The Division library has geological publications, historical maps, and information on remote sensing products from the National Cartographic Information Center that is especially tailored for Virginia.

Some of the general items that pertain to this major aspect of Division activities since 1989 are:

- o Contributions to Virginia Geology (6 papers) (Publication 88).
- o Coal, oil and gas, and industrial and metallic minerals industries in Virginia - 1986-87 (Publication 95).
- o Coal, oil and gas, and industrial and metallic minerals industries in Virginia - 1988-89 (Publication 114).
- o Coal, oil and gas, and industrial and metallic minerals industries in Virginia - 1990 (Publication 125).
- o Coal, oil and gas, and industrial and metallic minerals industries in Virginia - 1991 (Publication 128).
- o Directory of the Mineral Industry in Virginia - 1993 (Publication 129).
- o Proceedings - 26th Forum on the Geology of Industrial Minerals (Publication 119).
- o Bibliography of Virginia Geology and Mineral Resources 1970-1979 (Publication 120).
- o Bibliography and Index of Virginia Geology, 1980-1989 (Publication 123).
- o Minerals of Albemarle County (Publication 89).
- o Travertine-Marl: Stream Deposits in Virginia (Publication 101).
- o Physiographic Diagram of Virginia (Publication 105).

Current Geology Projects

The Division's current investigations cover a large area of important subjects, some are listed below:

- o Geologic mapping (1:24,000 and 1:100,000 scales).
- o Waste material resources in Virginia.
- o Gas Atlas, Southwestern Virginia.
- o Oil and gas well data and geology - Dickenson and Russell Counties.
- o Oil and gas well data and geology - Wise County.
- o Epithermal Hot Spring Deposits.
- o Barite resources in Southwestern Virginia.
- o Cadmian, gallian, and germanian resources.
- o Offshore sand study - Virginia Beach.
- o Virginia Coal Quality Assessment.
- o Minerals of Rockbridge County.

TOPOGRAPHIC MAPS AND PRODUCTS

The Division, in cooperation with the U.S. Geological Survey, maintains a jointly funded federal program to prepare and revise a variety of topographic maps and other map products. The topographic maps show roads, buildings, streams, lakes, mountains, valleys, and woodland. Map products include orthophotoquads, which are inexpensive black and white aerial photographs of corresponding topographic map areas, and orthophoto maps, such as the multicolor depictions of the Great Dismal Swamp that combine the characteristics of topographic maps and aerial photographs. Availability of these maps and their products are indicated in an index map, at conferences, during office visits, and mail-outs to agencies and organizations.

These maps and orthophotoquads are essential to geo-

logic mapping and resource studies of all kinds. They are used for general land-use planning, including recreation and agriculture, and for the siting of industrial and commercial activities, including the locating of transmission lines, pipelines, and communication towers. Other uses include evaluation of real estate, determination of historical boundaries, and the location of political boundaries.

The Division completed its 7.5-minute topographic mapping program in 1972. The Division and the Virginia Department of Transportation have provided funds on a yearly basis to revise the maps. In addition to the standard 7.5-minute quadrangle maps, the Division provides funding for the preparation and printing of county base maps at a 1:50,000 scale. As of July, 1993, twenty-one county maps have been printed, and twelve others are in preparation.

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MINERAL UPDATE

GOYAZITE

Lance E. Kearns

The rare phosphate goyazite, $SrAl_3(PO_4)_2(OH)_8 \cdot H_2O$, has been identified from the Willis Mountain mineKyanite of Kyanite Mining Corporation, 4 miles south of Dillwyn, Buckingham County, Virginia. Identification was made by X-ray powder diffraction and further substantiated by EDAX analysis. SEM photograph (Figure 1) shows small (0.1 to 0.15 mm), hexagonal-R crystals. The specimens were submitted for study by David Woolley of Lynchburg, Virginia. This is the second reported occurrance of goyazite in Virginia. Mitchell and Knowlton (1971) previously reported an occurrence at the Virginia Glass Sand Corporation (now Unimin Corp.) near Gore, Frederick County, Virginia, where it was found as white chalky coatings and spherulites on joint planes.

Mitchell and Fordham (1987) reported on a suite of unusual phosphate minerals from Willis Mountain. Included are trolleite (Giannini and others, 1986), lazulite, variscite, and apatite which occur in kyanite-rich quartzite with accessory paragonite, rutile, and pyrite. In their study, Mitchell and Fordham (1987) refer to an unknown mineral as "...tiny (fraction of a mm) grayish orange, sparkling crystals in small cellular cavities ... usually in the same specimens as the iron-poor lazulite." X-ray diffraction patterns were reported to be similar to those of the beudantite and crandallite group phosphates. Hexagonal unit cell dimensions were a = 7.02 angstroms and c = 16.27 angstroms refined for either $R\bar{3}m$ or R3m space groups. Indexing and refinement of 36 diffraction peaks obtained in this study yield dimensions of a = 7.01 angstroms and c = 16.59 angstroms for the R3m space group (a = 6.97; c = 16.51 reported in Palache and others, 1951). It is believed that the material described by Mitchell and Fordham (1987) was goyazite.

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Figure 1. Goyazite crystals from the Willis Mountain mine of Kyanite Mining Corporation, SEM photograph.

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NEW PUBLICATION RELEASES

Publication 127. Pliocene molluscs from the Yorktown and Chowan River Formations in Virginia, by Lyle D. Campbell, 259 pages, 43 plates, 3 figures, 5 tables, 1993. **Price $12.50**

Publication 128. Coal, oil, and gas, and industrial and metallic minerals industries in Virginia, 1991, by Palmer C. Sweet and Jack E. Nolde, 18 pages, 4 figures, 12 tables, 1 map, 1993. **Price $5.50**

Publication 129. Directory of the mineral industry in Virginia - 1993, by Palmer C. Sweet, 29 pages, 1 map, 1993. **Price $6.00**

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