VIRGINIA MINERALS

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF MINES, MINERALS AND ENERGY
Richmond, Virginia

Published quarterly by the DIVISION OF MINERAL RESOURCES
Natural Resources Building, McCormick Road, Charlottesville, VA 22903

Sesquicentennial Virginia Division of Mineral Resources 1835-1985

Vol. 35 September 1989 No. 1

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS ABSTRACTS FROM ANNUAL MEETING

The following are abstracts of papers to be presented at the 26th Annual Meeting in Arlington, Virginia October 4-7, 1989.

An Investigation of Factors Influencing Temporal Variations in Radon in a Residential Structure

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A single family home was fitted with monitoring instruments during the winter of 1988-1989. Parameters that were measured include radon every 3 hours in the basement and first floor and weekly average radon on the second floor. Wind speed and direction, outdoor temperature, humidity, and barometric pressure were measured every 12 hours. Household activities such as fireplace use and dryer use were also recorded.

Time series analysis was performed to examine the effect of each potential influence on the radon concentration in the building. A simple algorithm was used to remove periodic variations of 24 hours, and individual two-week periods were analyzed separately to allow seasonal variations to be observed in the regression parameters. While the results do not necessarily imply cause and effect, some interesting effects were observed.

Overview of NOAA's Bathymetric Mapping Program

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In 1983, the President proclaimed the establishment of an Exclusive Economic Zone (EEZ), extending 200 nautical miles seaward of the United States coastline. This proclamation extended the Nation's interests for the purpose of exploring, exploiting, conserving, and managing natural resources in the coastal ocean. NOAA has undertaken a major program to map the seafloor adjacent to the United States using high resolution multibeam mapping systems aboard four of its research survey ships.

Bathymetric maps and data bases with the accuracy and quality being produced from multibeam surveys of the EEZ are essential for planning and carrying our resource exploration, exploitation and management activities. Existing maps do not provide adequate feature definition to meet academic, industrial, and government user needs. The mapping program is essential to any further commercial development and is needed by the nation's scientific community to understand the processes that form continental margins and the mineral deposits in and on the seafloor.

Advances in computer technology, the development of the multibeam sonar systems, and improved methods of obtaining marine positions make it possible for NOAA to respond to these needs.

Since 1984, NOAA has surveyed portions of the outer continental shelf and continental margins of the West Coast, Alaska, Hawaii and the Gulf of Mexico. Results of the surveys are available as detailed contour maps and digital data sets for further analysis. Geomorphic features shown on these seafloor maps have caused considerable re-thinking as to processes and dynamics creating seafloor features and will lead to new understanding regarding continental marine evolution.

Image Maps of the Exclusive Economic Zone

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The U.S. Geological Survey (USGS) started a program in April 1984 to map the U.S. Exclusive Economic Zone (EEZ) at a reconnaissance scale as a first effort to develop a geologic understanding of the new national offshore territory. This effort was in response to President Reagan's EEZ proclamation in March 1983, which extended U.S. jurisdiction over an area extending 200 nautical miles offshore of the United States, the Commonwealths of Puerto Rico and the Northern Mariana Islands, and U.S. territories and possessions. This USGS mapping effort is a cooperative effort with the Institute of Oceanographic Sciences (IOS) of the United Kingdom and uses a unique side-scan sonar system named GLORIA (Geological Long-Range Inclined Asdic) developed by IOS to map the EEZ beyond the continental shelf. To date, over 1.5 million square nautical miles of seafloor have been mapped off the west coast, the east coast, the Island of Hawaii, Puerto Rico, and the U.S. Virgin Islands and in the Gulf of Mexico and the Bering Sea. All of these surveys have been highlighted by discoveries of major geologic features that contribute to our understanding of basic geologic principles and processes, composition and character of marine rocks/sediments, and assessment of nonliving marine resources and geohazards. This program provides "roadmaps" for subsequent, more detailed studies focusing on specific features, area, or topics. A compilation of the processed sonographs, with overlays of bathymetry and geologic interpretations, as well as other types of data (e.g., magnetics and high-resolution seismic data), is published in an atlas for each survey area at a scale of 1:500,000. To date, the west coast and Gulf of Mexico/Puerto Rico/ American Virgin Island data have been published. Results of the Bering Sea and east coast surveys will be published in 1989. The entire digital data set from the Gulf of Mexico is also available on a CD-ROM disk. This technology will be used to make all the GLORIA data available to a broad user community.

Mapping the Radon Potential of Rocks and Soils

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Rocks and soils are the primary source of indoor radon. Radon usually enters a building with soil gas drawn in through the foundation. The availability of radon in the rocks and soils surrounding a foundation is controlled by the radium content and emanating power of the mineral matter (or the radon content of the soil gas), the diffusivity of radon, and the gas permeability. The moisture content of the soil strongly affects both diffusivity and permeability.

Estimating or mapping the radon potential of the rocks and soils requires measurement of these parameters. For small tracts of ground, measuring radon in soil gas, surface radioactivity, and permeability of the soils at several sites and evaluating drainage permits reasonable estimation of radon potential. For larger areas, such measurements are usually impractical, but geologic maps, aeroradioactivity maps, and soil surveys provide indirect bases for characterization. Geologic maps permit estimation of the uranium content of the rocks and soils and the physical properties of the surface materials. Spectral aeroradiometric data show measurements of surface gamma-ray activity from bismuth-214, thallium-208 and potassium-40. Maps of equivalent radium (derived from bismuth-214 data) are available for most of the U.S. Although the coverage of the contiguous U.S. is nearly 100 percent, the broad spacing of the flight lines in most surveys makes those maps best used to estimate the radium content of soils at regional scale (1:1,000,000). Maps showing the total gamma-ray count are available at various scales for many parts of the country. Modern soil surveys describe many of the physical properties of the mapped soils, including permeability and drainage, in good detail. Soils with intrinsic gas permeabilities greater than 10^{-6} to 10^{-7} cm^2 have increasingly high radon availability because soil gas flows readily through such soils. Combining mapped geologic, aeroradiometric, drainage, and permeability data can provide estimates of the radon potential of the rocks and soils for areas from the size of a county up to large regions of the U.S.

None of these approaches has yet given geologists the ability to state unequivocally that a given house will be above 4 pCi/l simply because house construction and other factors control how much radon gets inside. However, in the areas we've studied to date, the geologic probability ranges from near 0 percent to near 100 percent.

Assessing the Radon Potential of the United States

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The Indoor Radon Abatement Act of 1988, signed into law in October, 1988, directs EPA to develop a list of high risk areas for use in school and workplace surveys. The legislation requires EPA to use geological data, available indoor radon measurement data, and structural characteristics in the development of such a list. EPA is approaching this task by incorporating these factors into a radon potential map tentatively scheduled to be completed in fiscal year 1990.

The methodology for radon potential characterizations relies on two assumptions. First, high radioactivity (e.g., radium) indicates high radon potential. Lithologies which have the greatest potential of containing significant amounts of uranium, such as granites and black shales, have a high probability of generating radon problems. In addition, residual soils formed from carbonates can be enriched in radium relative to the bedrock. The second assumption is that high permeability (including high soil matrix permeabilities and fracture permeabilities in soils or rock) can contribute to increased indoor radon concentrations.

Components of the Radon Potential Map of the United States:

1. National Uranium Resource Evaluation (NURE) data. NURE aerial radiometric data can be used to identify areas with potential indoor radon problems due to high surficial radioactivity. Areas with equivalent uranium (eU) concentrations of 2 - 2.5 ppm or greater may have high radon potential.
2. Lithologic data. The NURE data will be compared with geologic data at a scale of 1:2,500,000 for quality control and to aid our understanding of radon occurrence.
3. Soil characteristics as defined in Soil Conservation Service (SCS) reports. Permeabilities 6 in/hr may be considered as the definition of "high" permeability. Other characteristics, such as the potential for fracturing or depth to water table, may also be considered, especially in glaciated regions.
4. Indoor radon concentrations. EPA will have assisted 25 states with conducting indoor radon surveys by the summer of 1989. The data will be separated according to available construction information and compared to NURE, lithologic and soil information and then extrapolated to areas with little or no indoor radon data. Other data from several commercial databases will also be used to identify high radon potential areas.

When combined, these factors will enable us to develop a preliminary map of high radon potential areas in the United States.

Uncertainty vs. Science: the Radon Research Program at the U.S. Department of Energy

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Radon gas, well known to geologists as a decay product of uranium, is certainly less well understood by the general public. The average citizen does not realize that radon (about which one now hears so much) is a naturally occurring substance that has been around as long as the earth's crust. It is not now being discovered for the first time. Indeed, radon has long been a health concern for uranium and other miners.

The discovery in 1984, of a home in Pennsylvania with radon levels greatly exceeding those found in uranium mines, has permanently changed perceptions about this gas. One outcome has been the initiation of major radon programs nationally by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) and also at the state and local levels. These program are designed to identify high radon areas, provide educational information, develop mitigation techniques and to understand the actual health risks to the general public. The low levels, to which the vast majority of U.S. citizens are exposed, represent the area of greatest uncertainty in understanding the potential risks to human health. The enormity of the impacts surrounding this low level risk issue makes this knowledge all the more critical to obtain.

The research contributing to reducing this uncertainty and the design of the radon research program at the U.S. DOE form the basis of this presentation.

Marine Geologic Studies of Hard Mineral Resources in the U.S. Exclusive Economic Zone

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The U.S. Geological Survey (USGS) over the past three decades has carried out a spectrum of geologic surveys and research in marine areas of the Exclusive Economic Zone (EEZ) around the U.S. and its territories, as well as in the Great Lakes region. Regional and topical studies have been undertaken throughout the range of marine environments: estuarine, tidal wetlands, coastal and nearshore, shelf, slope, and the deep ocean basins.

The Survey's marine research program consists of four elements shown in Table 1. The first includes studies using interpretations of bathymetry, seismic-reflection and sidescan sonar data, and analyses of sediment grab samples and cores to develop an understanding of the geologic framework. Information on the geologic setting, as well as the subbottom structure and stratigraphic relationships, and the geologic history and evolution of the areas surveyed is an important part of the program objectives.

A second element entails conducting quantitative studies of the sedimentary processes controlling the origin and evolutionary development of marine sedimentary deposits, and shaping the morphology of the coastlines and seafloor. Oceanographic measurements of waves, currents, and suspended-sediment concentrations, combined with direct observations and acoustic imaging lead to an increased understanding of the erosional and depositional processes.

The third research element is locating, characterizing, and assessing marine non-energy mineral deposits. Information from seismic reflection and coring surveys is displayed in maps and cross sections and used to decipher the three-dimensional geometry of such deposits as well as assess their resource potential. A major focus is on identifying the processes by which mineral deposits originate, how the deposits may be modified or remobilized through time, and what geologic conditions control preservation of mineral deposits.

Each of these three main elements have parts that interrelate with each other. Maximum scientific productivity comes from blending the results as well as interacting closely with other federal agencies, coastal states, and with university scientists.

The last element is that of presenting the scientific results from the various investigations in forms that can be understood and used in an applied manner to address both short and long-term problems.

This talk will summarize results of studies that have been conducted on the inner continental shelves including areas under the jurisdiction of both the state and federal governments. Emphasis is on the shallow subbottom geology, generally Quaternary-age sediments that extend from the seafloor to perhaps 50 m below the seabed, and on the assorted hard minerals (e.g., sand, gravel, shell, placer heavy minerals) present.

The continental shelves have been greatly affected by a combination of glaciofluvial, coastal and estuarine, and marine processes operating over the past several million years. These include four or more major advances of glacial ice sheets in northern latitudes, accompanied by crustal deformation due to ice loading. Also, worldwide fluctuations of sea level in excess of 100 m have been important in modifying the shelf geology.

The combination of rivers transporting large volumes of terrestrial coarse sediment onto exposed shelf areas and the repeated transgressions and regressions of coastal landforms has resulted in the formation and preservation of large sand bodies on the shelf. These sand deposits vary greatly in vertical and horizontal scales: most are 1 to 3 meters in thickness and measure as much as 50 km in length. the most promising targets for sand and gravel are: buried tributary and distributary stream and river channels, shoals (e.g., relict deltas, drowned barrier shorelines, linear shoals) and blanket-like sheet deposits.

The north Atlantic region contains an estimated 340 billion cubic meters of sand and gravel resources, much of which is an admixture of gravel-size and fine-grained material due to its glacial history.

In contrast to northern shelf areas, the middle Atlantic region has an estimated 190 billion cubic meters consisting of largely sand. Gravel in this region is scarce and patchy in occurrence, and is mostly restricted to ancestral fluvial channels and deltas. Linear and ebb-tide shoals, the most promising deposits, are composed generally of medium- to coarse sand and have textural properties similar to sediments on the adjacent shorelines.

In contrast to the Atlantic shelf, little attention has been focused on hard-mineral resources in the Gulf of Mexico until the last several years. Cooperative programs between the USGS and Louisiana Geological Survey have been underway since 1981, resulting in production of detailed isopach maps and cross sections of major sand bodies from seismic profiles and 12-m long vibra-cores. Many of the shoals in the Gulf are composed of fine sand, and the seismic and coring evidence suggests that they originated when barrier islands along the delta plain submerged due to rapid sea-level rise. Sand and gravel resources for the Gulf of Mexico are estimated at 269 billion cubic meters. These estimates are based on only limited studies performed offshore Galveston, Texas, the Louisiana delta plain, and along parts of Florida's western shelf and panhandle.

In conclusion, while much work has been done on shelf areas of the U.S., the EEZ covers vast areas in which existing information on the geologic framework and potential hard mineral resources is sparse and coverage is not nearly adequate. Only through a well coordinated program of mapping and research, involving federal agencies working in close cooperation with the states and universities, can we expect to gain the information needed to assess, manage, and protect the Nation's resources.

Table 1. Main Research Elements of USGS Marine Program.

- o Decipher Geologic Framework of Seafloor and Subbottom
  - bathymetry
  - seismic reflection
  - sidescan sonar
  - sediment samples (grabs, cores)
- o Better Understand and Quantify Sedimentary Processes
  - measure waves, currents, sediment concentrations
  - rates of change in relative sea level
  - effects of storms on the coast and nearshore
  - identify sediment sources
- o Locate, Assess, Characterize Marine Hard Mineral Resources
  - 3-dimensional geometry
  - resource potential
  - processes of origin and preservation
- o Application and Transfer of Results
  - reports
  - maps
  - seminars and workshops

FIELD TRIPS AND CONFERENCES

October 1989

Oct. 1-4 Sinkholes and impacts of karst, mtg., St. Petersburg, Fla. Florida Sinkhole Research Institute, University of Central Florida, Orlando, FL 32816.

Oct. 4-7 American Institute of Professional Geologists, ann. mtg., Arlington, Va. Stan Johnson, Virginia Division of Mineral Resources, Box 3667, Charlottesville, VA 22903. Phone: 804/293-5121.

Oct. 16-18 Ground-water in the Piedmont, mtg., Charlotte, NC. April Smith, 113 McAdams Hall, Clemson University, Clemson, SC 29634-0357. Phone: 803/656-4073.

Oct. 20-22 Applachian Geomorphology, mtg., Carlisle, Pa. W.D.Sevon, Pennsylvania Bureau of Topographic and Geologic Survey, Box 2357, Harrisburg, PA 17120. Phone: 717/787-6029.

Oct. 24-27 Eastern Region, Society of Petroleum Engineers, mtg., Morgantown, W.Va. Sally Goldesberry, Society of Petroleum Engineers, Box 833836, Richardson, TX 75083-3836. Phone: 214/669-3377.

November, 1989

Nov. 6-8 Ground-water and well technology short course, Colunbus, Ohio. National Water Well Association, 6375 Riverside Drive, Dublin, OH 43017. Phone: 614/761-1711.

Nov. 6-9 Geological Society of America, ann. mtg., St. Louis. Vanessa George, GSA, Box 9140, Boulder, CO 80301. Phone 303/447-2020.

Nov. 14-16 Exclusive economic zone, symposium, Reston, Va. USGS-NOAA Joint Office for Mapping and Research, 915 National Center, Reston, VA 22902. Phone: 703/648-6525.

Nov. 15-17 Eastern oil shale, symposium, Lexington, Ky. Geaunita H. Caylor, University of Kentucky, 201 Porter Building, Lexington 40506-0205. Phone: 606/257-2820.

December, 1989

Dec. 4-8 American Geophysical Union, fall mtg., San Francisco. AGU Meetings, 2000 Florida Ave. N.W., Washington, D.C. 20009. Phone: 202/462-6903.

February 1990

Feb. 20-22 Society of Exploration Geophysicists, mtg., New Orleans. SEG, Box 702740, Tulsa, OK 74170-2740. Phone: 918/493-3516.

RECENTLY RELEASED PUBLICATIONS OF THE DIVISION OF MINERAL RESOURCES

Gerald H. Johnson and C. R. Berquist, Jr., 1989, Geology and mineral resources of the Brandon and Norge quadrangles, Virginia: Publication 87, 28 p., color map, $10.50.

The Brandon and Norge 7.5-minute quadrangles are located on the lower Coastal Plain of southeastern Virginia in the counties of Charles City, James City, Prince George, and York. The Norge uplands represents the highly dissected remnants of a marine plain. The lower terrain is dominated by a succession of terraces that are separated from one another by river-parallel scarps.

Formations exposed include the Eastover (Upper Miocene), Yorktown (Lower and Upper Pliocene), Bacons Castle (Upper Pliocene), Moorings (Upper Pliocene (?)), Windsor and Charles City (Lower Pleistocene), Chuckatuck (Lower or Middle Pleistocene), Shirley (Middle Pleistocene), Tabb (Upper Pleistocene), and Holocene deposits. The Tertiary deposits were deposited under marine or marginal marine conditions whereas the Pleistocene and Holocene sediments formed in valleys that had been excavated during preceding glacial lowstands of sea level. The Quaternary deposits, each of which generally exhibits an upward-fining sequence, formed under fluvial-estuarine conditions during periods of relatively higher sea level.

Sand and gravel is the principal economic mineral resource mined. Large quanties of this material are extracted from the Shirley Formation in Charles City County, but less pure, more variable sand and gravel deposits with less utility are present in the lower portions of the Bacons Castle, Windsor, Charles City, and Tabb formations. Clay from the Shirley Formation has numerous structural and utilitarian uses; none is being mined at the present time. Relatively thin, impure lime and glauconite deposits occur beneath a thick cover of Bacons Castle Formation in the Norge uplands.

Groundwater is extracted from aquifers int the Chesapeake, Pamunkey, and Potomac groups and Pleistocene deposits. Geologic hazards include storm flooding in low-lying areas, shoreline recession from stream erosion and mass wastage, land subsidence caused by dissolution of carbonates and groundwater withdrawal (water mining), and groundwater contamination from infiltration of sewage effluents and sanitary landfill leachate. Locally, peat at shallow depth, high surficial groundwater tables, and shrink-swell soils pose problems for construction of buildings and other structures.

N. H. Evans, editor, 1989, Contributions to Virginia Geology - VI: Publication 88, 91 p., $6.00.

Neil E. Johnson, James R. Craig, and J. Donald Rimstidt, Vein copper mineralization of the Virgilina district, Virginia and North Carolina, p. 1-16.

The Virgilina district of the Carolina slate belt of Virginia and North Carolina yielded over 300,000 tons of copper and significant amounts of silver and gold between 1852 and 1916. A detailed examination of the ore and gangue mineralization from the district reveals that the ores display two stages of hypogene deposition and a significant phase of supergene alteration.

Hypogene minerals, in decreasing order of abundance, are bornite, chalcocite/djurleite, anilite, digenite, hematite, chalcopyrite, pyrite, magnetite, ilmenite, rutile, hessite, and gold (fineness approximately 850). Supergene minerals, indecreasing order of abundance, are malachite, covellite, cuprite, digenite, hematite, chalcopyrite, chalcocite/djurleite, azurite, spionkopite, and yarrowite. This represent the first reported occurrence of djurleite, anilite, hessite, spionkopite, and yarrowite in Virginia.

Lamellar intergrowths of anilite and djurleite on their close-packed planes, myrmekitic intergrowths of bornite and chalcocite/djurleite, coexisting chalcocite and djurleite, and gradational transitions from anilite to digenite were determined to have formed by secondary hypogene reactions. These reactions removed iron and sulfur from the bornite and increased the copper to sulfur ratio, which shifted the Cu-S binary phases toward copper-enriched compositions producing delicate textures and intergrowths.

The source of ore fluids and the timing of the mineralization are not known precisely, but fragments of wall rock that are contained within the veins and have schistosity at an angle to the regional schistocity constrain the veins to be post-metamorphic. Metals were probably dervied in part from the metamorphism of mafic volcanic rocks in the area.

Carol Walsh-Stovall, E. S. Robinson, J. D. Rimstidt, and R. L. Stovall, Exploration for magmatic sulfide deposits in the Virginia Blue Ridge, p. 17-21.

The mafic and ultramafic rocks in the Blue Ridge province of Virginia are possible hosts of nickel and cobalt mineralization that might become economic if the present supplies to the United States were cut off. Rugged terrain, dense vegetation, poor rock exposures, and unavailability of detailed geologic maps demand that indirect exploration methods be used to locate areas of mineralization. Coincident geophysical (aeromagnetic) and geochemical (high nickel concentrations in soil) anomalies appear to be good indicators of sulfide-bearing mafic or ultramafic rocks. This concept was tested by performing magnetic and geochemical surveys at the Vest and Lick Fork prospects in Floyd County.

Nora K. Foley and James R. Craig, Mineralogy and geochemistry of the lead-zinc ores of the Austinville-Ivanhoe district, Wythe County, Virginia, p. 23-39.

The Austinville-Ivanhoe mine is the most continuously mined base-metal deposit in North America. The ore bodies of the district are contained within a 400-meter stratigraphic interval of the Patterson and Austinville members of the Cambriab-age Shady Formation. Individual ore bodies are crudely lens-shaped and are situated on the flanks of the Austinville anticline. Sphalerite, pyrite, galena, marcasite, and minor chalcopyrite were deposited during three periods of mineralization separated by intervals of sulfide dissolution and dolomite deposition. The minerals occur as disseminated dolomite replacements and as crustiform coatings along fractures in and around breccia fragments. The banded sphaleritehas a consistent pattern which may be correlated for over 2.7 km across the district. Iron contents of the delicately banded sphalerite range from 0.3 to 3.3 weight percent and appear to be inversely correlated with cadmium contents (0.0 to 0.3 weight percent). The color of the bands is probably not related to variations in iron content but may reflect the presence of inclusion-rich zones. Geothermometry measuremments of fluid inclusions in sphalerite from the middle and late periods of mineralization indicate that ores formed in the temperature range of 100°C to 160°C. Galena from the three generations have progressively high $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{206}Pb/^{204}Pb$ values. In addition, the smaller ore bodies have a wider range in lead values and seem to be more radiogenic than larger bodies.

Ali A. Nowroozi and Arnold Wong, Interpretation of gravity and masgnetic anomalies of the Richmond Triassic basin, p. 41-60

New detailed gravity and magnetic profiles along several State roads and highways which cross the Early Mesozoic age Richmond basin augment existing data for the analysis of the basin.

The gravity profiles display steep gradients across the western border of the basin wher the Triassic lithologies are in fault contact with older metamorphic rocks. The surface geology indicates that this gradient probably marks the southern continuation of the Hylas fault zone. The displacement of this fault may be as much as a few kilometers. A gravity gradient is also apparent along the southern segment of the eastern border of the basin. The eastern edge of the basin is generally bounded by the Petersburg granite of Mississippian age. All available data indicate that the basin is a half graben in which depth decreses toward the east. Theoretical modeling shows that the gravity gradient due to the Hylas fault may be interpreted in the vicinity of Hylas as a thrust fault which dips toward the east from about 26° to 18° to a depth of about 4 km and then becomes nearly horizontal. The eastern block is the Petersburg granite which is thrust over the Goochland complex on the western block. This fault is the source of the dominant gravitational feature of the Richmond basin as far south as the middle of the basin.

A lumped-sum mass model is used to simplify the structure of the basin. The Hylas fault zone and its relation to the basin is model. The results indicate that the basin's western border dips steeply toward the east and reaches a depth of over 2 km whereas its eastern border has a gentle dip toward the west. Several diabase dikes which intrude the Triassic rocks are apparent from the magnetic map. Magnetic modeling of the longest dike, over 12 km long, yields a range of widths of from 15 to 30 meters and a range of depths of from 5 to 35 meters. The dikes also crop out at the surface in many areas.

Robert L. Stovall, Edwin S. Robinson, and Mervin J. Bartholomew, Gravity anomalies and geology in the Blue Ridge province near Floyd, Virginia, p. 61-82.

Bouguer gravity anomalies in the Blue Ridge near Floyd, Virginia can be explained in terms of upper crustal geology and some combination of crustal thickening and anomaly sources at intermediate depths in the crust. Local gravity anomalies were separated from a regional gradient by polynomial filtering of the Bouguer gravity field. Two-dimensional model analysis indicates that these local anomalies could reslut from density differences between steeply dipping rock units truncated by low-angle thrust faults at depth of less than 8 km. Density contrasts in Grenvill rocks could be related to large scale folding.

The regional gravity gradient can be attributed to features of two contrasting crustal models. The study area is situated on the border of an earlier seismic refraction survey that indicates westward crustal thickening from approximately 47 km to 50 km. If this model is correct, then a significant density contrast must exist across a steep boundary at intermediate depth in the crust. An alternate model of norwestward crustal thickening from 30 km to 45 km can account fro the regional gravity gradient without requiring any intermediate crustal anomaly sources.

Edgar W. Spencer, Christopher Bowring, and J. D. Bell, Pillow lavas in the Catoctin Formation of central Virginia, p. 83-91.

Metabasalts of theoleiitic basalt and basaltic andesite composition near Oronoco, Virginia contain pillow structures. The study area is close to the southern end of the Catoctin Formation outcrop belt on the northwestern flank of the Blue Ridge anticlinorium. The flows in this area are interbedded with thick, shallow-water arkosic and conglomeratic metasedimentary rocks. The metabasalts were extruded into a basin now bounded by faults, which is interpreted as an Early Cambrian rift vally. Ti-Zr-Y plts indicate that the rocks are "within-plate" basalts. The plots of the metabasalts from Oronoco, Virginia resemble the plots of the basalts from the Rio Grande Rift.

Richard S. Mitchell and William F. Giannini, 1988, Minerals of Albemarle County, Virginia: Publication 89, 19 p., $3.75.

Scattered references to various minerals found in Albemarle County are found in both published and unpublished geological reports. About 25 years ago an attempt was made to present these data in a comprehensive list. At that time Mitchell and Bland published a three-part paper on this subject. A few years after that, as a result of the discovery of additional minerals, an addendum by Mitchell and Taylor reported these newest discoveries. Now, with many additional mineral localities, a revised publicationof the mineral in Albemarle County was compiled. The minerals in this report are arranged alphabetically, whereas in the older publications they were organized according to a crystal-chemical classification.

Catalogued specimens of most of the 86 mineral species described in this work are stored at the Division of Mineral Resources and some of the outstanding specimens are displayed in Clark Hall at the University of Virgnia, Charlottesville. Others are in private collections.

Michael B. McCollum, 1989, Geologic map of the Rocky Mount and Gladehill quadrangles, Virginia: Publication 90, Part A, $9.50.

James F. Conley, Robert G. Piepul, Gilpin R. Robinson, Jr., Earl M. Lemon, Jr., and C. R. Berquist, Jr., 1989, Geologic map of the Penhook and Mountain Valley quadrangles, Virginia: Publication 90, Part B, $9.50.

James F. Conley, 1989, Geology of the Rocky Mount, Gladehill, Penhook, and Mountain Valley quadrangles, Virginia: Publication 90, Part C, 15 p., one map, $5.00.

The Rocky Mount, Gladehill, Penhook, and Mountain Valley quadrangles are located in the southwestern Piedmont. These four quadrangles are underlain by rocks contained in two major structures: the southeast limb of the Blue Ridge anticlinorium and the northwestern part of the Smith River allochthon. These two structures are separated from each other by the Bowens Creek fault, a southeastward dipping fault that shows both wrench and thrust movement, which has been mapped in reconnaissance

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ISSN 0042-6652

southwestward into the Brevard one and northeastward into the Mountain Run fault.

In the south-central part of the area the Smith River allochthon is truncated by the Bowens Creek fault. The allochthon is preserved in an upright broad gentle synformal warp and is shown by structural data and gravity and magnetic modeling to be a thin, sheet-like structure. The structure was emplaced on an almost flat (now folded) thrust, the Ridgeway fault, that bounds the allochthon on both its southeast and northwestern sides and predates the Bowen Creek fault. The allochthon is composed of metasedimentary rocks subdivided into a lower Bassett Formation and an upper Fork Mountain Formation. These metasedimentary rocks were intruded locally by plutonic rocks of the Martinsvlle igneous complex. In the study area, the complex is a magma series composed of the Rich Acres Formation, a sequence of diorite-gabbro composition; and the Leatherwood Granite.

The southeastern limb of the Blue Ridge anticlinorium is underlain by the rocks of the Lynchburg Group and the Candler Formation. The Lynchburg Group is subdivided into a lower gneiss sequence, Ashe Formation, and an upper schist and gneiss sequence, Alligator Back Formation. The Alligator Back Formation contains ultramafic-gabbro-basalt sequences that are thought to be ophiolites. Chemical analyses of stream sediments indicate anomalously high values for base and precious metals in the vicinity of these mafic and ultramafic rocks. Diabase dikes of Late Triassic-Early Jurassic age intrude rocks of both the SmithRiver allochthon and the Blue Ridge anticlinorium.

Rocks of both the Blue Ridge anticlinorium and the Smith River allochthon have been polydeformed. Rocks of the anticlinorium have been metamorphosed to greenschist and lower amphibolite facies, whereas the metasedimentary rocks of the allochthon have been polymetamorphosed.

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