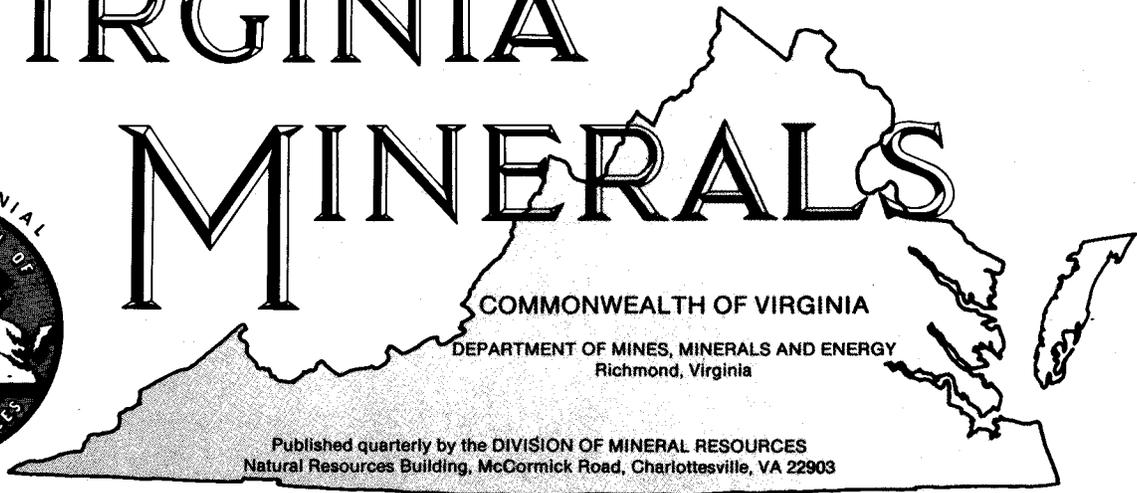
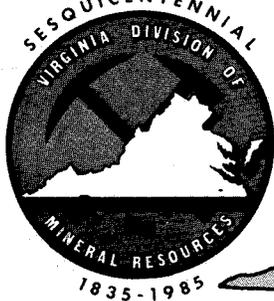


VIRGINIA MINERALS



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No.1

ON RADON

David K. Lasch

It is a capital mistake to theorize without data.

Sherlock Holmes

Radon is thought to be the cause of a large fraction of the lung cancer not caused by smoking (Lafavore, 1987). Although radon, a naturally occurring radioactive gas, has been present since the formation of the Earth, recognition of the possibility of health problems caused by radon is rather recent. In December, 1984, it was discovered that a home in southeastern Pennsylvania contained extremely high concentrations of radon (Lafavore, 1987). This discovery led to the realization that a building could act as a collector of radon.

The problem of radon being concentrated in a home is related to the proximity of a source of the gas to the home and the permeability of the soil surrounding the home's foundation. Permeability is a measure of the relative ease with which a liquid or gas passes through pore spaces or openings in a solid. Since soil permeability can vary widely over a rather short distance, the degree to which a soil containing uranium can affect the radon concentration in a home can vary considerably. Because of this variability, a test for radon at the actual location of a home is required to determine if a radon concentration problem exists. Therefore, there are two important conditions that must be met in order for high levels of radon to exist within a home, that is, a source of radon must be available and the surrounding soil must be permeable. Concentration of radon in a home poses a health problem but one that can usually be corrected through remedial actions for existing homes or proper initial construction designs for new ones.

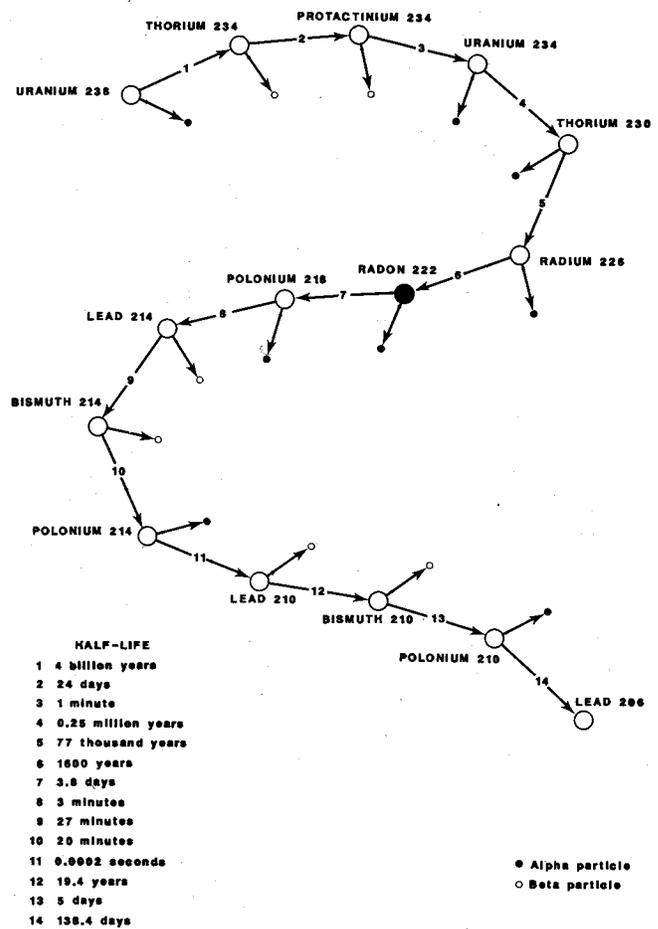


Figure 1. The natural radioactive decay chain of uranium-238 (modified from Hasbrouck, 1986).

Radon is the direct decay product of the element radium (Figure 1). Radium, and therefore radon, is a decay product of uranium-238. Uranium-238, a naturally occurring element, comprises approximately four parts per million of the Earth's crust (Lafavore, 1987). Uranium-238 is known to occur as a trace element, and in greater quantities, in certain types of rocks and sediments found in Virginia. Uranium is not a stable element. Since the creation of the Earth uranium has been constantly decaying into a succession of lighter, but also radioactive, elements until it becomes the stable element lead-206 (Figure 1). During the decay process, three types of radiation are emitted: alpha particles, beta particles, and gamma rays. Alpha particles are of special interest because they provide the method whereby radon decays into its radioactive daughters, or progeny, and are also thought to be responsible for most of the cell damage in human tissue (Hasbrouck, 1986). When a radioactive element decays, the element into which it decays is known as the daughter, progeny, or decay product.

The average length of time that a radioactive element will exist is measured by its half-life, which is the time required for half of the atoms in a given volume of the element to decay. From Figure 1 it can be seen that the range of half-lives for this particular decay series is very large. The radioactive decay time from uranium-238 to thorium-234 is estimated to be 4.5 billion years, about the age of the Earth, whereas the decay time of polonium-214 to lead-210 is only 0.0002 seconds. Radon-222 presents a problem because of its relatively long half-life, 3.8 days. If it had a much shorter half-life, it could not be transported long distances from its source. Therefore, it would present a problem only for those homes built in the immediate vicinity of the source.

Radon, a gas, is primarily transported by the random process of diffusion, that is, Brownian movement, as opposed to convection. It can travel only as far as its 3.8-day half-life will permit. In general this will not be a particularly long distance. But there are three naturally occurring conditions which tend to increase this distance. They are a difference in the temperature between the air and the soil containing the radon, the speed of the wind passing over the soil, and also changes in the barometric pressure. Observations have indicated that falling barometric pressure seems to permit an increase in the amount of radon released from the soil. The weather can also have other effects on the mobility of radon. Rain will fill the pore space in soil and therefore inhibit the flow of radon through the soil. Because the soil has been saturated with rain, the mobility of radon will be decreased; it cannot be transported as far. The radon may not reach an interface where it can be released. A similar decrease in radon release has been observed when the soil freezes (Lafavore, 1987).

CHEMISTRY

When radon decays it emits an alpha particle from its nucleus. This process transforms radon-222 into the element polonium-218, which has a half-life of about 3 minutes. Polonium-218 then decays, by alpha particle emission, into an unstable isotope of lead, lead-214, which has a half-life of almost 27 minutes. This isotope of lead then decays through beta particle emission to bismuth-214 which has a half-life of nearly 20 minutes. Bismuth-214 in turn then decays by beta particle emission into polonium-214 which has an extremely short half-life of 0.0002 seconds. Polonium-214 decays, through alpha particle emission, into another unstable, radioactive, form of the element lead, lead-210, which has a relatively long half-life of 19.4 years. It is important to realize that radon-222, polonium-218, lead-214 and polonium-214 all decay by emitting an alpha particle and that lead-210 has a rather long half-life.

Since radon is rather inert chemically, after it is inhaled it will probably be exhaled. But the progeny of radon, polonium, lead, and bismuth, are chemically active metals. These elements can adhere to most surfaces that they come into contact with, such as dust, pollen or other particles in the air. When inhaled some of these metals may adhere to the inner lining of the lungs. Of the three types of radiation emitted during radioactive decay, alpha particles are the most damaging to human cells. Alpha particles are the largest of the two types of particles emitted and have high levels of energy. They do not penetrate human tissue very deeply, but as they do pass through tissue they knock electrons off molecules which causes the molecules to be altered. These alterations may be harmful to lung tissue. Increased alpha particle radiation appears to correlate with high lung cancer rates. This correlation is suggested by data pertaining to uranium miners and people who work with radium (Hasbrouck, 1986). Both groups of people have been exposed to high levels of radon. The problem is exacerbated by the large volume of air breathed during a day.

GEOLOGY

Because radon is a gas, it can move from its source either as a soil gas or in solution with well water, that is, ground water. Soil gas is a mixture of gases which collects in the pore spaces between soil particles. Because radon is a chemically inert gas, it does not form compounds which might prohibit its ability to diffuse from the soil into a home. The fact that soil gas is a major source of radon in a home has been demonstrated by the fact that airborne radon levels are generally higher in basements than in other parts of a home. But high levels of radon can also be released into a home

by the use of well water during bathing, showering, and washing. All of these processes aerate the well water which causes the radon to separate from it.

The majority of the rocks within Virginia which may contain some uranium are located within the Piedmont Province or the Triassic basins. The remaining occurrences of sediments or rocks which may pose a problem are located on the western margin of the Coastal Plain Province, the Blue Ridge Province at the southern boundary of the State, and along the western margin of the Valley and Ridge Province.

Within the Piedmont Province the source of uranium is thought to be granitoid rocks, gneisses, phyllites, schists, and iron-rich igneous rocks. Within the Triassic basins, the uranium is thought to be associated with diabase, hornfels, and the Triassic sedimentary rocks. The Cranberry gneiss, found within the southern part of the Blue Ridge Province, is believed to be the source of uranium in that region. Various sediments of the Coastal Plain Province are the source for the uranium in that area. Black shale, of Devonian age, found in the Valley and Ridge Province is known to contain uranium.

TESTING

The Environmental Protection Agency (EPA) suggests that tests for indoor radon be performed in two stages. The first stage is a test, of short duration, to determine if a home contains high concentrations of radon. The concentration of a low-level radioactive gas is measured in units of "picocuries per liter." If the initial test indicates that the radon concentration is less than, or equal to, 4 picocuries per liter, the EPA does not recommend further testing. The second stage of testing is required if the initial test results range between 4 and 20 picocuries per liter. They suggest that a second test, of longer duration, be performed. But, if the initial test results range from 20 to 200 picocuries per liter, they definitely recommend that a second, short duration, test be performed as soon as possible to either confirm or refute the results of the first test. The EPA emphasizes the urgency of having a second short duration test because with that concentration of radon in a home the additional time of exposure while a long duration test is being conducted could be harmful. Most importantly, if the initial test results indicate radon concentrations greater than 200 picocuries per liter immediate remedial actions should be taken. Again, because of the extremely high concentration of radon, remedial action should begin before a long duration test is completed.

The initial, or short duration, tests usually measure radon concentrations over a period of a few minutes to a few weeks. The second stage, or long duration, tests measure radon concentrations for a period of a few months to a year. The long duration tests will indicate

what the radon concentrations were over various weather conditions and household environments. Radon concentrations are generally higher during the winter when a house is sealed as opposed to the summer when it is open. An initial test conducted during the winter should indicate the maximum concentration to be expected. Radon concentration measured in the winter may be 60 percent greater than that measured in the summer (Lafavore, 1987).

The best seasons to perform an initial test of a home for radon are in the late fall or early spring when the house is sealed and the heating system is not in use. During these situations natural ventilation, which would dilute the radon concentration, would be at a minimum. Forced-air heating systems increase ventilation and may therefore dilute the concentration of radon. The radon detector should be placed in the basement or lowest room in the house and in a location where it will not be disturbed for the duration of the test. The initial test should be designed to yield an indication of the maximum possible concentration of radon in a home. The results of a test conducted in this manner are not intended to reflect actual day-to-day conditions but to indicate if further testing is necessary.

If further testing is required, it is suggested that two detectors be placed in different locations within the house where they will not be disturbed for a year. To obtain measurements which would indicate the actual radon exposure of inhabitants, the detectors should be placed in living areas preferably on two levels within the house (Figure 2). If it is thought that the source of radon is well water, a detector should be placed in a bathroom or laundry room. These types of locations are preferable to the kitchen, because exhaust fans and particles generated by cooking might affect the outcome of the test. If a particular feature such as a sump pump, toilet, basement wall or floor crack, or a crawl space is suspected as the entry site for the radon a detector should be placed near it.

There are two types of test kits which a home owner can use to determine the radon levels of a home. Activated charcoal monitors can be used to conduct an initial, or short term, test and alpha-track detectors can be used for long term tests of up to one year. Activated charcoal monitors are generally used for periods of no more than a week. They have to be returned to the manufacturer for analysis after they have been exposed to the atmosphere. It is suggested that the house be kept closed as much as possible during the test. Testing for such a short period of time will obviously not yield an accurate measure of the long-term levels of indoor radon. Alpha-track, or track-etch, detectors are used for tests which have a duration of one month to a year. They are most effective if two or more detectors are left in selected locations within a home for a period of up to a year. The results of these measurements give

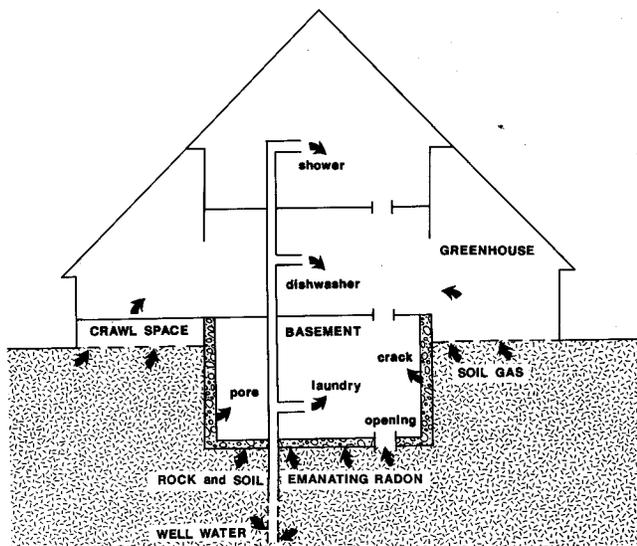


Figure 2. Radon pathways into a home (modified from Hasbrouck, 1986).

an overall indication of the yearly indoor radon concentration through different seasons and indoor environments. After the detector has been exposed for the appropriate amount of time, it must be returned to the manufacturer for analysis.

The Environmental Protection Agency has ten regional offices (Table). They have free booklets which address various aspects of the radon problem and may be able to answer questions specific to their region. The agency also maintains a list of approved radon testing companies which they review twice a year. To be included on the list, which is voluntary, a company that provides radon monitoring services must have measurement and collection techniques compatible with the EPA's standards. Also, the company is required to participate in, and pass, a proficiency test in order to remain on the list. An updated list can be obtained from the EPA regional offices.

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- Hasbrouck, Sherman, 1986, Radon in water and air, health risks and control measures: Cooperative Extension Service, University of Maine at Orono, 8 p.
- Lafavore, Michael, 1987, Radon: the invisible threat: Rodale Press, Emmaus, Pennsylvania, 256 p.
- The U. S. Environmental Protection Agency and the U. S. Centers for Disease Control, 1986, A citizen's guide to radon, what it is and what to do about it: U. S. Government Printing Office, Washington, D. C., 13 p.

Table. Addresses of Environmental Protection Agency offices.

REGION	ADDRESS	STATES COVERED
1	J. F. Kennedy Federal Building Room 2203 Boston, MA 02203 617/223-7210	Conn., Maine, Mass., N. H., R. I., Vt.
2	26 Federal Plaza New York, NY 10278 212/264-2525	N. J., N. Y., P. R., V. I.
3	841 Chestnut Street Philadelphia, PA 19107 215/597-9800	D. C., Del., Md., Pa., Va., W. Va.
4	345 Courtland Street, NE Atlanta, GA 30365 404/881-4727	Ala., Fla., Ga., Ky., Miss., N. C., S. C., Tenn.
5	230 South Dearborn Street 14th Floor Chicago, IL 60604 312/353-2000	Ill., Ind., Mich., Minn., Ohio, Wis.
6	1201 Elm Street Dallas, TX 75270 214/767-2600	Ark., La., N. Mex., Okla., Tex.
7	726 Minnesota Avenue Kansas City, KS 66101 913/236-2800	Iowa, Kans., Mo., Nebr.
8	999 18th Street Suite 1300 Denver, CO 80202-2413 303/293-1603	Colo., Mont., N. Dak., S. Dak., Utah, Wyo.
9	215 Fremont Street San Francisco, CA 94105 415/974-8071	Ariz., Calif., Hawaii, Nev.
10	1200 Sixth Avenue Seattle, WA 98101 206/442-5810	Alaska, Idaho, Oreg., Wash.
Main Office	401 M Street, SW Suite 200, North East Mall Washington, DC 20460 202/475-9605	

CORRECTIONS TO ARTICLE ON HEAVY MINERALS IN HIGH-LEVEL GRAVEL DEPOSITS

The following corrections should be made to the last issue of *Virginia Minerals* (November 1987 — Vol. 33, No. 4) in the article pertaining to minerals in high-level gravel deposits. First, the decimal point should be moved two places to the right for all numbers under the column "WT% ECON" in Table 2. For example, WT% ECON for sample 7051-1 should be 86 percent and read "86," not "0.86." Second, on page 39, THM is determined by adding the calculated amount of heavy minerals in the light mineral fraction (the "lost" or "rejected" fraction from the Humphrey spiral) to RHM.

-C.R. Berquist

MINERAL UPDATE

PLUME AGATE FROM WARREN COUNTY, VIRGINIA

Richard S. Mitchell¹,
William F. Giannini,
and
Oliver M. Fordham, Jr.

Plume agate, a chalcedonic quartz (SiO_2) containing black stains and inclusions resembling ostrich plumes or feathers, occurs at three sites on the west flank of the Blue Ridge Mountains in Warren County (Figure 1). This attractive plume agate was discovered in 1953 by Sterling C. Runion, formerly of Mt. Jackson, Virginia while exploring for manganese and copper deposits along the Blue Ridge Mountains. The agate was very similar to material found in Texas and Oregon. We have named the sites: Runion agate mines 1, 2, and 3. In the early 1960s, specimens were collected by Ray V. Judd

of Luray. Richard L. Runion, Sterling's son, of Harrisonburg, mined a "pickup-truck" load of the material in 1968 from mine 1 and sold most of it to Ray Judd. Specimens were also acquired by Lester Kibler of New Market, who later sold several large blocks of the agate to John C. Crim, owner of the Evergreen Rock Shop, New Market, Virginia. Rough, slabbed, and cabochon-cut specimens of the plume agate have found their way into several rock shops and private collections, especially in the Shenandoah Valley region of Virginia.

Specimens of the agate have been mined at all three

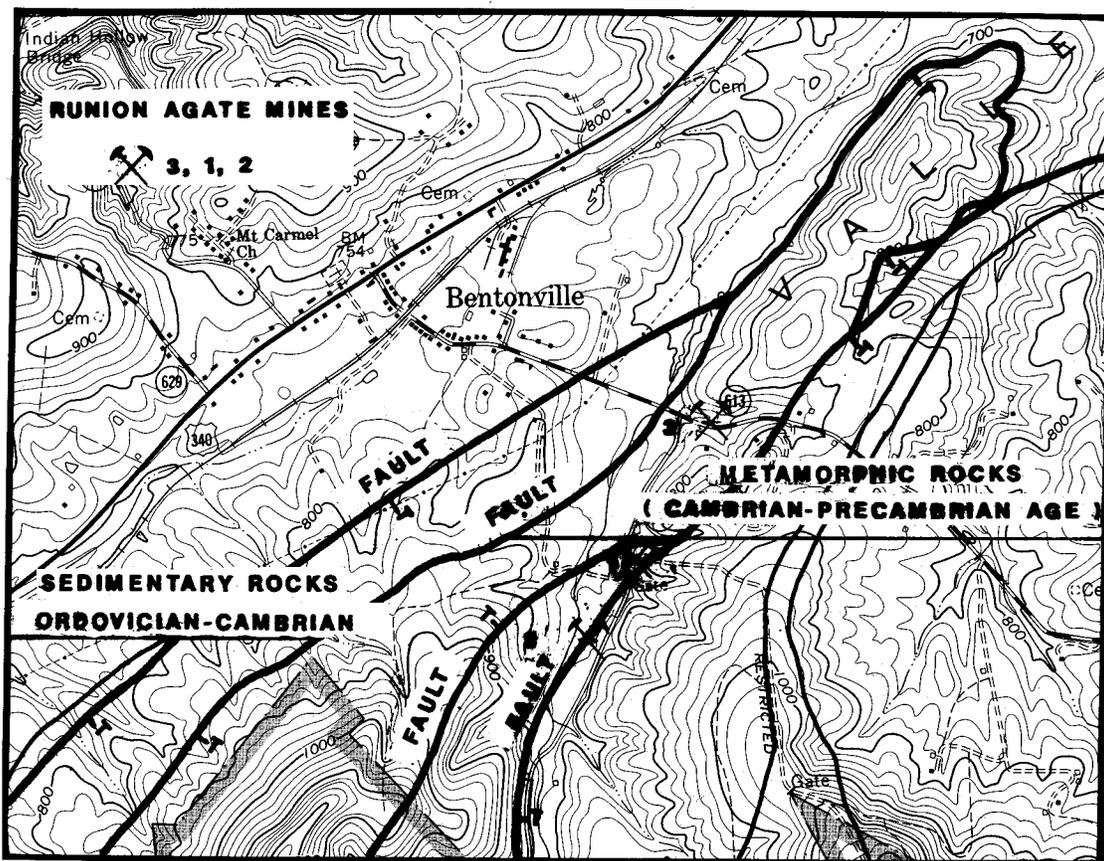


Figure 1. Map showing location of the Runion agate mines and generalized geology (Rader and Webb, 1979) of the surrounding area, Warren County, Virginia; Bentonville 7.5-minute quadrangle.

¹Department of Environmental Sciences,
University of Virginia, Charlottesville, VA

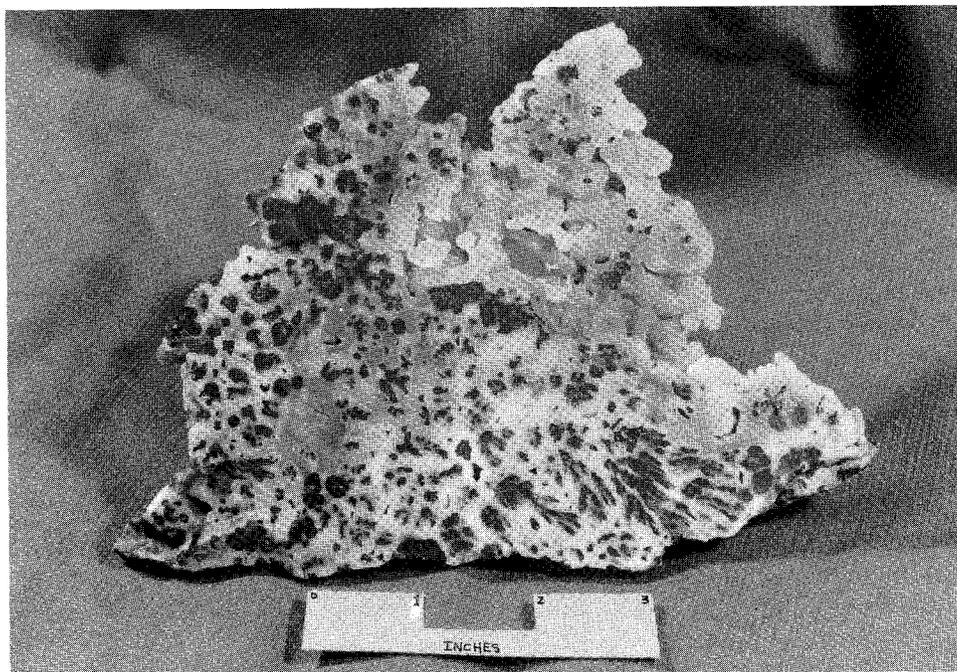


Figure 2. Sawn slab of plume agate from the Runion agate mine 1, Warren County, Virginia (donated by John C. Crim, New Market, Virginia). Dark plumose and masses are the barium-manganese mineral, romanechite, surrounded by lighter chalcidonic quartz (photograph by T. M. Gathright, II).

sites along a major thrust-fault zone from veins to four feet thick, as noted at mine 1, or collected as gray nodules laying loose on the surface around each vein. Loose nodules are very scarce. Mines 2 and 3 have been filled, and number 1 is a round pit approximately 10 feet across and 4 feet deep.

The black plumose mineral has been identified as romanechite. This mineral is one of several manganese-bearing minerals called psilomelane. X-ray diffraction analyses of the plumose zones were made as early as 1963. Although there was some evidence for an impurity in the agate, quartz dominated these earlier analyses and the black mineral was not identified. Recently, specimens became available from John C. Crim, New Market, Virginia, that contain relatively pure brownish-black, submetallic plumose inclusions and small rounded botryoidal masses (Figures 2 and 3). X-ray diffraction studies show the major mineral phase in both the plumose and rounded structures is romanechite, $\text{Ba Mn}^{+2}\text{MnO}_8 \cdot 4\text{H}_2\text{O}$, contaminated by quartz. When heated in air at 600°C ., for one hour, this mineral dehydrates to form hollandite, $\text{Ba}(\text{Mn}^{+4}, \text{Mn}^{+2})_8\text{O}_{16}$, a well-known transformation for the species. X-ray fluorescence analysis verifies the major components as Ba and Mn with Fe, which indicates there is a possibility this is a ferrian romanechite since, upon weathering, it also yields goethite.

We wish to acknowledge John C. Crim, Ray V. Judd, and Richard L. Runion for kindly providing historical

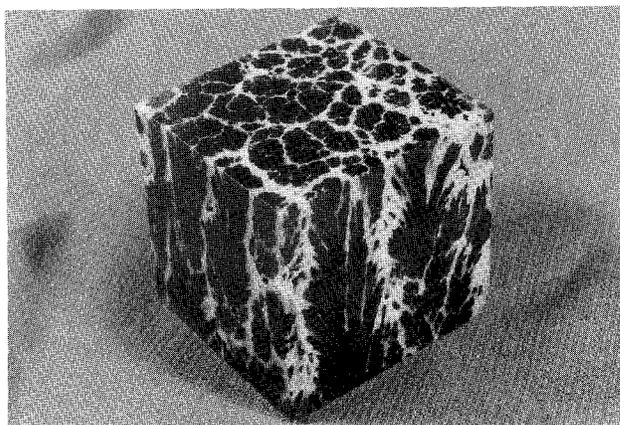


Figure 3. Sawn block of plume agate two inches square, also from the Runion agate mine 1 (donated by John C. Crim, New Market, Virginia — photograph by T. M. Gathright, II).

information about the plume-agate discovery. John C. Crim is also thanked for arranging our first visit to the agate sites with Ray V. Judd and for generously donating specimens for this study.

REFERENCE CITED

- Rader, E. K. and Webb, H. W., 1979, Geologic map of Warren County, Virginia: Virginia Division of Mineral Resources Open File Report 71.

MINERAL AND ENERGY RESOURCES OF SOUTHWEST VIRGINIA

The following abstracts pertain to presentations which will be given in Duffield, Virginia on May 4, 1988.

NON-FUEL MINERAL RESOURCES

Gerald P. Wilkes

Virginia Division of Mineral Resources

There have been many changes with respect to mineral development in Southwest Virginia since earliest activity in the 1700's. Some minerals, once profitably developed, are presently not feasible to mine and conversely, mineral deposits undeveloped at present may become valuable in the future.

Southwest Virginia may be divided into four areas for the purpose of defining these varied mineral resources: the Gossan Lead district (copper, manganese, pyrrhotite); the sulfide area of Floyd County (nickel, gold, arsenopyrite, cobalt); the Cumberland Plateau (sandstone, clay, shale); and the Valley and Ridge province (barite, manganese, iron, lead, zinc, gypsum, halite, sandstone, clay, shale, limestone, dolomite). Each area represents unique geologic conditions that were necessary to create particular mineral deposits.

The Division of Mineral Resources has projects designed to identify and evaluate mineral deposits and make that information accessible to the mineral industry. These projects include the Mineral Resources Data System (MRDS) in cooperation with the U.S. Geological Survey, the high-silica sandstone study, the sandstone aggregate study, and the carbonate analyses study.

VIRGINIA CARBONATE-ROCK SAMPLING PROJECT

William F. Giannini
and

William W. Whitlock

Virginia Division of Mineral Resources

Since the first recorded use of limestone to construct the great Egyptian pyramids about 4,600 years ago, uses of carbonate rocks have realized a continuous growth to the present. These rocks form a large portion

of the surface strata in the Valley and Ridge province of Virginia. Minor occurrences are also found in the Piedmont province as limestone and marble and in the Coastal Plain province as shell deposits.

The carbonate rock sampling project was begun in 1981 to determine the chemistry and reflectance (whiteness-brightness) values of Virginia's carbonate rocks statewide. To date, approximately 3,500 samples have been collected, and 3,300 chemically analyzed. Of those analyzed, 77 qualify as high-reflectance material. This study will provide valuable information to private individuals, companies, consultants, and local and state governments.

Virginia possesses abundant reserves of carbonate rocks, especially along the western portions of the state. Fifty-three quarries and two underground mines are currently extracting these rocks. Production in 1985 was 19,117,000 short tons valued at \$76,395,000.

Major usages for high-purity limestone supplied by Virginia operations include lime production (captive) and lime to treat water and sewage, to use in the paper and steel industries, enhance soil fertility, and to stabilize soil. Other markets utilizing high-purity carbonate-rock products include cement-mortar manufacture, glass and steel industries, fillers and extenders such as in fertilizer, animal feed, wallboard joint compound, paint, rug backing, anti-stick agents, the manufacture of chemicals, and in rubber. Environmentally oriented markets include coal-mine dust and acid-control stone. Major markets not requiring high-purity carbonate rocks include aggregate stone for concrete, asphalt, highway base mix, concrete block, railroad ballast, and soil-fertility enhancement.

SANDSTONE AGGREGATE AND HIGH-SILICA RESOURCES IN SCOTT COUNTY, VIRGINIA

James A. Lovett

Virginia Division of Mineral Resources

Scott County, Virginia, is rich in sandstone and silica resources. Major sandstone-bearing units were examined to identify the potential for use as coarse-aggregate in bituminous surface material (non-polishing surface road stone), as high-silica glass-grade sand and metallurgical-grade material, and for miscellaneous uses such as filter sand and hydraulic fracturing sand.

Eight sandstone units in the Plateau and Valley and Ridge provinces of southwest Virginia were sampled. These include: the upper quartzarenite of the Middlesboro Member of the Lee Formation; the lower quartzarenite of the Middlesboro Member of the Lee Formation; the Tallery Sandstone Member of the Hinton

Formation; the Stony Gap Sandstone Member of the Hinton Formation; and undivided sandstone units in the Pennington Formation, Fido Sandstone, Wildecat Valley Sandstone, and Clinch Sandstone.

Geologic descriptions, physical-properties testing, sieve analyses and chemical analyses for composite samples from selected localities are presented. These data will assist in evaluating the commercial potential of the sandstone resources. Los Angeles-abrasion and soundness testing indicate that selected coarse-aggregate material qualifies for use as bituminous surface material. Chemical analyses of quartzite samples indicate good potential for use as high-silica resources. Silica content of these unbeneficated samples ranges from 95 to 98 percent, but the samples contain alumina and iron compounds. Most samples show the required grain-size range for use in glass sand. Beneficiation would be necessary to wash and size the sand material for use as glass-grade, filter, or hydraulic-fracturing sand.

OVERVIEW OF THE GEOHY GEOLOGIC-MAPPING PROGRAM

Thomas M. Gathright, II
Virginia Division of Mineral Resources

Geologic mapping for the GEOHY project is creating an accurate three-dimensional model of the rock units and coal beds in the southwestern Virginia coalfields. The geologic information, as it becomes available, is being provided as conventional geologic maps and cross sections and as digital data that can be manipulated to provide specific information on selected areas. The completed geologic data base will form a framework in which ground-water potential, coal and rock chemistry, coal resources and non-coal economic deposits may be evaluated.

To date, two-thirds of the project area has been mapped and eleven quadrangles are published or at the printers; three additional quadrangles will be committed for printing this fiscal year. An area equivalent to seven and one-half quadrangles, and comprised of parts of 15 quadrangles largely in Buchanan and Tazewell counties, is yet to be mapped. This mapping will be accomplished within the project period.

The discovery of major fault systems, the lateral pinch-out of rock units, and the recognition of marine "marker" beds and an extensive volcanic ash bed in the Upper Banner coal have led to revision of the stratigraphic detail and coal bed correlation in southwest Virginia.

REMAINING COAL RESOURCE ESTIMATES FOR LEE COUNTY, VIRGINIA AS CALCULATED USING NCRDS COMPUTER PROGRAMS

Elizabeth M. Campbell
Virginia Division of Mineral Resources

The original and remaining coal resources for Lee County, Virginia, were calculated using the PACER and GARNET computer programs written for the National Coal Resources Data System (NCRDS) of the U.S. Geological Survey. This study incorporates data from 111 drill holes and 475 surface locations and utilizes underground mine maps, digitized coal outcrops as mapped by R. L. Miller of the U.S. Geological Survey, and the U.S. Geological Survey Digital Elevation Models (DEM's) of the topographic surface. New stratigraphic correlations developed from drill-hole data and recent geologic mapping in adjacent Wise County have improved the Lee County data base for resource estimates. Coal resources were calculated for categories based on coal thickness, amount of overburden, and occurrence probability.

COAL RESOURCES AVAILABLE FOR DEVELOPMENT:

A NEW STUDY IN SOUTHWEST VIRGINIA
M. Devereux Carter
and
N. K. Gardner
and
J. R. Eggleston
U.S. Geological Survey

The total coal resources of the United States are rather well documented and the amount is large. However, the quality and quantity of coal that will be available for the production of energy in the future are not known with any degree of precision; there has never been a concerted, systematic attempt to determine what percentage of the total coal resources of the conterminous States is actually available for development.

Previously, national and state coal-resource assessments were concerned with the total coal remaining in the ground within certain minimum parameters of bed thickness, data reliability, and depth of burial. The inclusion of additional considerations such as environmental and technologic restrictions to mining coal will enhance present information and provide a more realistic basis for energy policy planning.

Working in cooperation with the Kentucky Geological Survey, the U.S. Geological Survey initiated a pilot study to determine the available coal resources of a 7.5-minute quadrangle in the central Appalachian Basin.

Local mining engineers and state government experts provided information on restrictions and mining practices in the immediate study area. Data were collected, stored, and analyzed in the National Coal Resources Data System of the U.S. Geological Survey.

Environmental and technologic restrictions that affect minability at the surface and at depth for the Matewan quadrangle were analyzed. Environmental factors included as surface restrictions were immovable obstacles such as: (1) major powerlines and pipelines; (2) cemeteries; (3) oil and gas wells; (4) streams; and (5) towns. Technologic factors that influence minability at depth include: (1) minimum bed thickness; (2) maximum overburden; (3) thickness and characteristics of interburden between beds; (4) proximity of mining directly above or below the coal; and (5) the presence of barrier pillars around underground mine workings.

Preliminary estimates of the available resources in the Matewan quadrangle indicate that, of the total resources, only 62 percent of the coal is currently available for mining. Of the available coal, approximately 44 percent meets the standard of compliance coal.

The cooperative program is continuing with the three state geological agencies of Virginia, West Virginia, and Kentucky. A total of five quadrangles will be completed this year, including the Vansant quadrangle in Buchanan County, Virginia. The results of this work will present a new perspective on the coal resources available for development in the central Appalachian region.

NON-FUEL MINERAL INDUSTRY AND PRODUCTS IN SOUTHWEST VIRGINIA

James A. Lovett

Virginia Division of Mineral Resources

Southwest Virginia is most commonly known for abundant coal and gas resources. In addition, the region also has many non-fuel mineral resources and supports a relatively strong and stable minerals industry.

West of 81° longitude, there are nineteen operations which quarry limestone and/or dolomite from formations of Cambrian, Ordovician, Silurian, and Mississippian age. Three operations work Cambrian-age sandstone and sand from recent alluvial deposits. Three operations quarry shale and clay from Cambrian and Ordovician formations. Other operations mine gypsum from Mississippian-age rocks, and quarry Precambrian gneiss.

These operations produce a wide variety of mineral products. Limestone and dolomite are quarried for riprap, for aggregate used in asphalt and highway base mix, and to produce rock dust and agricultural lime.

Sandstone and sand are used as aggregate material and sand is also used in concrete. Shale and clay are worked to produce brick products and clay dummies. Gypsum is mined to produce wallboard and related products. Gneiss is quarried to produce aggregate that is used as asphalt and highway base mix.

AN OVERVIEW OF THE DMME GEOLOGIC DATA SYSTEM

Jan P. Zentmeyer

Virginia Division of Mined Land Reclamation

The Virginia Department of Mines, Minerals and Energy has established a geologic data system aimed at improving mine planning, land reclamation, and development. The building of the data system is a cooperative effort of several state and federal agencies and private interest groups. The system contains a significant amount of stratigraphic information derived from a variety of sources, and a sophisticated mapping package that produces high quality, 2- and 3-dimensional maps and cross sections. Both geologic and geographic data from the southwestern Virginia coalfields are continually being added to the data set. The system enables the user to apply information from many sources to regional problems and studies.

GROUNDWATER OCCURRENCE AND GUIDELINES FOR EXPLORATION IN THE APPALACHIAN PLATEAU OF SOUTHWESTERN VIRGINIA

Anthony S. Scales

Virginia Division of Mined Land Reclamation

Within the Appalachian Plateau of Southwestern Virginia, groundwater occurrence is primarily associated with stress-relief and tectonic fracturing, i.e., the formation of secondary porosity and permeability. Coal seams are the only units that may be considered as aquifers in the sense that they are horizontally continuous, both hold and transmit water, and are underlain by relatively impermeable strata. Artesian conditions can exist on the periphery of the relatively undeformed Pennsylvanian strata. Water quality is a function of contact time with potentially contaminating materials and oxygen.

Groundwater availability increases with decreasing elevation and amount of fracturing. With increasing elevation, wells must be deeper to provide adequate supplies; however, this increases the likelihood of quality problems. Similarly, valley-bottom wells can experience salinity problems with increasing depth. Surface and deep mining operations can increase groundwater recharge and storage. Abandoned underground mines can

act as groundwater collection galleries, and may be significant groundwater sources in the future. A trend to below-average precipitation over the past 17 years has significantly affected marginal supplies.

HISTORICAL PERSPECTIVE OF OIL AND GAS DEVELOPMENT IN SOUTHWEST VIRGINIA

Milford J. Stern

Virginia Division of Gas and Oil

Southwest Virginia has enjoyed an increase in drilling activity and gas production in the past few years. Southwest Virginia, however, is not a newcomer to oil and gas production. The Early Grove Field in Scott and Washington counties commenced gas deliveries to Bristol, Virginia, in the winter of 1937 and in 1942 oil began to flow at the B. C. Fugate #1 well in Lee County, Virginia.

Currently, there are about 700 producing gas wells in the Plateau area of Southwest Virginia and 31 oil wells in Lee County. Along with this production, several companies have located in Southwest Virginia to operate and service the growing oil and gas activity in Virginia. If the past is any indication, Southwest Virginia will receive growing attention by the oil and gas industry.

MISSISSIPPIAN STRUCTURE AND HYDROCARBON POTENTIAL OF BUCHANAN, DICKENSON, AND WISE COUNTIES, VIRGINIA

Frank H. Jacobeen, Jr.

Virginia Division of Mineral Resources

Correlation of Mississippian-age rocks in over 500 petrophysical logs in the interval from the top of the Greenbrier Limestone through the Berea Sandstone and the construction of four structure maps and four isopach maps show that structure is not a prime factor in controlling gas production in Buchanan, Dickenson, and Wise counties, Virginia. A total of 889 wells have tested 26 percent of the acreage in these three counties; operators completed 781 of these as gas wells. Through December, 1986, cumulative gas production from these counties is reported to be 147 billion cubic feet. Remaining proven producible reserves in Mississippian-age horizons are 235 billion cubic feet of gas. The average completed well ultimately should produce over 500 million cubic feet of gas. Based on this record it is estimated that an additional 815 billion cubic feet of recoverable gas is to be found on the undrilled 74 percent of the area of Buchanan, Dickenson, and Wise counties.

POTENTIAL OIL AND GAS PROSPECTS ALONG THE NORTHWEST EDGES OF THE HUNTER VALLEY/CLINCHPORT THRUST SHEETS, SCOTT COUNTY, VIRGINIA

Robert N. Diffenbach

and

William S. Henika

Virginia Division of Mineral Resources

Recent detailed mapping along the northwest edges of the Hunter Valley and Clinchport thrust sheets in the East Stone Gap, Fort Blackmore, and Dungannon 7.5-minute quadrangles suggests the presence of at least two closed structural highs. These highs appear to be located above subsurface tectonic ramps postulated to have developed beneath the overturned limb of the Stone Mountain syncline along the upturned Hunter Valley thrust. Three lines of evidence based on surficial structure along the Hunter Valley thrust point to the presence of structural highs beneath the Stone Mountain structure: (1) anomalously northwest-dipping strata on the upright limb of the Stone Mountain syncline; (2) the locally nearly horizontal axial plane of the syncline; and (3) three linear domains of bedding attitudes on the overturned limb of the syncline that suggest late rotation of bedding by underlying arching. Another high that is incompletely mapped has been recognized as a similar imbricate structure located southeast of the Rye Cove syncline and hidden beneath the upturned Clinchport thrust in the southeastern corner of the East Stone Gap quadrangle.

Structure sections based on deep seismic data indicate that the postulated tectonic ramps beneath the Hunter Valley and the Clinchport thrusts developed above the Pine Mountain fault on detachments in Devonian or Ordovician shale formations.

Devonian shales that underlie and are probably involved in these upper-level detachment structures are of sufficient organic richness and thermal maturity to provide a low source potential for oil and a moderate to high source potential for gas according to J. B. Roen (1983). Potential Mississippian reservoir rocks, including the Greenbrier Limestone and the Berea Sandstone, crop out on the overturned limb of the Stone Mountain syncline and are probably involved in underlying structural highs along the upturned edge of the Hunter Valley thrust sheet. Deeper reservoir objectives may include the Trenton Limestone (Ordovician) and sandstone and dolomite beds in the underlying Copper Ridge and Rome formations (Cambrian) beneath the gently arched Clinchport thrust. The extensive fracturing commonly found at the crest of structural highs presents favorable and relatively shallow hydrocarbon prospects in these formations.

NEW PUBLICATIONS

PUBLICATION 71

Geology of the Virginia Portion of the Flat Gap Quadrangle by J.E. Nolde, W.W. Whitlock, and J.A. Lovett; single sheet, 1988.

\$9.50

PUBLICATION 72

Geology of the Virginia Portion of the Appalachia and Benham Quadrangles by J.E. Nolde, J.A. Henderson, Jr., and R.L. Miller; single sheet, 1988.

\$9.50

PUBLICATION 73

(In Progress)

PUBLICATION 74

Contributions to Virginia Geology – V; 80 p. 1987.

CONTENTS

Pre-Taconian deformation in the Piedmont of the Potomac Valley – Penobscotian, Cadomian, or both? by Avery A. Drake.

Relationships of structure to massive sulfide, deposits in the Chopawamsic Formation of central Virginia, by James F. Conley.

Lithostratigraphy and biostratigraphy of the Martinsburg Formation in southwestern Virginia, with descriptive sections, by Ronald D. Kreisa and Dale A. Springer.

Mafic rocks in the Alligator Back Formation, the upper unit of the Lynchburg Group, in the southwestern Virginia Piedmont: An ophiolite sequence? by James F. Conley.

Geology of the Mobley Mountain granite Piney River quadrangle, Virginia Blue Ridge, by John C. Brock, Norman Herz, Douglas Mose, and Susan Nagel.

\$5.00

PUBLICATION 75

The Quaternary of Virginia – A Symposium Volume edited by J. N. McDonald and S.O. Bird; 137 p. 1986.

CONTENTS

Invited Papers

Quaternary geomorphic processes in Virginia, by John A. Connors.

Late Quaternary vegetational change in the central Atlantic states, by Hazel R. Delcourt and Paul A. Delcourt.

The known herpetofauna of the late Quaternary of Virginia poses a dilemma, by J. Alan Holman.

Quaternary vertebrate localities of Virginia and their avian and mammalian fauna, by Ralph Eshelman and Frederick Grady.

Early man in Virginia, by Ben C. McCary.

Late prehistoric and protohistoric large mammal zoogeography of Virginia, by Robert K. Rose.

On the status of Quaternary vertebrate paleontology and zooarcheology in Virginia, by Jerry N. McDonald.

Embryogenesis dysfunction in the Pleistocene/Holocene transition mammalian extinction, dwarfing, and skeletal abnormality, by Dewey M. McLean.

Abstracts of Poster Papers

Preliminary observations on floodplain, terrace, and fan deposits in the upper Potomac River basin of Virginia and West Virginia, by J. Steven Kite, Alison Bell, and Mark Allamong.

Quaternary alluvial fans in central Virginia, by R. Craig Kochel and David W. Simmons.

Quaternary travertine - marl deposits of Virginia, by David A. Hubbard, Jr., William F. Giannini, and Michelle M. Lorah.

Wisconsinian herpetofaunas of the central Appalachians, by Leslie P. Fay.

Late Pleistocene fauna of the Hollidaysburg fissure, by Shirley S. Fonda and Andrew P. Czebieniak.

The Hot Rain site: A new Pleistocene vertebrate locality in northern Virginia, by James R. Ott and Robert E. Weems.

A Pleistocene legacy: Artic and boreal elements in the contemporary biota of Virginia, by Susan L. Woodward and William F. Ruska, Jr.

Projectile points from a multicomponent site (44Sm51) in the Saltville Valley, Virginia, by Ellen H. White.

Tools and debitage: Cultural debris from a multicomponent site (44Sm51) in the Saltville Valley, Virginia, by Eugene Barfield.

Virginia's first evolutionist: James Lawrence Cabell, by N.T. Boaz.

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TOPOGRAPHIC MAP REVISION

The following 7.5-minute topographic maps have photo-revision, photo-inspection, or bathymetric dates of 1986 or 1987. Thirteen of the bathymetric maps are new and complete the coverage of the Virginia portion of the Chesapeake Bay.

Arvonias	Deltaville	Irvington	Rileyville
Bacons Castle	Dillwyn	Jarratt	Riverdale
Barboursville	Dutch Gap	Kelly	Rochelle
Benns Church	East of Deltaville	Kempsville	Runnymede
Bergton	East of Fleets Bay	Lakeside Village	St. George Island
Bethel Beach	East of Hampton	Linden	Saluda
Bon Air	East of New Point Comfort	Little Creek	Shacklefords
Bowers Hill	East of Poquoson East	Mannboro	Sherando
Boyd Tavern	East of Reedville	Manquin	Singers Glen
Broadway	Eggleston	Massies Corner	Smithfield
Buckhorn	Elkton East	Mathews	Smoky Ordinary
Cape Charles	Elkton West	McGaheysville	Staunton
Cape Henry	Emporia	Metomkin Inlet	Stephens City
Capon Springs	Esmont	Middletown	Stephenson
Charlotte Court House	Fentress	Midlothian	Stony Creek
Cheriton	Fishermans Island	Millboro	Strasburg
Chesapeake Channel	Franklin	Mount Sidney	Studley
Chesconessex	Franktown	Moyock	Sugarloaf Mountain
Chester	Free Union	Mulberry Island	Swift Run Gap
Chesterfield	Front Royal	New Market	Tangier Island
Chincoteague East	Fulks Run	New Point Comfort	Tenth Legion
Chincoteague West	Gladstone	Newport News North	Timberville
Crisfield	Glenmore	Newport News South	Toano
Claremont	Gloucester	Norfolk North	Townsend
Claresville	Goose Island	Norfolk South	Truhart
Clifton Forge	Gore	North Bay	Vicksville
Cobb Island	Great Fox Island	North Virginia Beach	Vienna
Collierstown	Great Machipongo Inlet	Parksley	Virginia Beach
Concord	Gressitt	Parnassus	Ware Neck
Conieville	Grottoes	Pendleton	Warfield
Cornwall	Hampton	Penola	Waynesboro West
Courtland	Harrisonburg	Perkinsville	West of Jamesville
Creeds	Hayfield	Poquoson East	West of Nandua Creek
Crimora	Hebron	Princess Anne	West of Franktown
Cumberland	Holland	Purdy	West Point
Danieltown	Howardsville	Quinby Inlet	Wilton
Deep Creek	Hylas	Quinton	Winchester
		Reedville	Yellow Tavern
		Ridge	Zion Crossroads