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LIGHTWEIGHT-AGGREGATE INDUSTRY IN VIRGINIA

Carroll E. Smith

Virginia raw materials used in the manufacture of lightweight aggregates are quarried from rock strata containing shale, slate, and schist. Perlite, another raw material, is shipped from out-of-state sources. These aggregates are marketed under the trade names *Clinchlite, Lynlite, Permalite, Solite,* and *Weblite* by five producers who operate six plants in Virginia (Figure 1). Lightweight aggregates are formed by heating the shale, slate, schist, and perlite almost to their melting points. This causes expansion, or bloating, that results in a reduction of weight per unit volume. More lightweight aggregate is used in the manufacture of lightweight concrete masonry units than for any other purpose. A standard 8- by 8- by 16-inch concrete building block weighs about 45 pounds, but a similar block made with lightweight aggregate weighs only 26 to 28 pounds. Lightweight structural concrete is used in precast building units such as tilt-up wall panels, floor and roof slabs, and superstructures for bridges. Lightweight concrete is poured for bridge decks, for airplane runways and aprons, as fill for roofs and floors, and as fireproofing and insulating material. Concrete made with sand and gravel weighs approximately 150 pounds per cubic foot, whereas lightweight structural concrete made with expanded shale or slate aggregates weighs approximately 100 pounds per cubic foot. Lightweight structural concrete has a greater density and a higher compressive strength than lightweight insulating concrete, such as that made with expanded perlite. Perlite concrete, used for insulating purposes, weighs only 20 to 40 pounds per cubic foot. Construction projects in Virginia that have utilized *Solite* lightweight aggregate include the 4-mile-long Chesapeake Bay Bridge, the 14-story Virginia State Office Building in Richmond, and the Reynolds Metals Building in Richmond; projects that have utilized *Weblite* include a multistory addition to the University Hospital in Charlottesville, the Roanoke Rehabilitation Center, the Lynchburg Airport Building, and the Virginia State Highway Building Annex in Richmond.

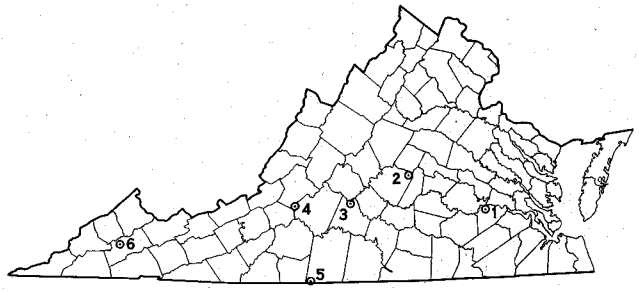

Figure 1. Location of lightweight-aggregate plants in Virginia: 1) Virginia Perlite Corporation, 2) Solite Corporation, 3) Lynlite Materials Company, 4) Virginia Lightweight Aggregate Corporation, 5) Virginia Solite Company, 6) Clinchfield Coal Company.

Properties of Lightweight Aggregate

The light-weight property of the aggregate is of primary importance. Such aggregate contributes less weight to the dead loads encountered in construction projects, and consequently less structural and supporting steel is needed. Their cellular structure makes them excellent insulators

to temperature and sound. High strength, chemical inertness, low shrinkage, good elasticity, low water absorption, durability, and uniform particle size and shape are desirable properties of lightweight aggregates.

Specification standards of lightweight aggregates for concrete were published in 1955 by the American Society for Testing Materials (Code No. C 330-53T). Lightweight aggregate used in concrete may consist of pumice, lava, tuff, slag, burned clay, shale or slate, cinders, or other particles that are strong and durable. Unit weight of coarse lightweight aggregate cannot exceed 55 pounds per cubic foot, and the weight of fine lightweight aggregate cannot exceed 70 pounds per cubic foot. In 1960 the ASTM wrote specifications (Code No. C 330-60T) to cover lightweight aggregates intended for use in structural concrete for which the desirable properties are lightness in weight and high compressive strength.

Processing of Lightweight Aggregate

The expansion or bloating process involves two simultaneous reactions. When the prepared raw material reaches its bloating temperature, a point between its initial and complete vitrification temperatures, it softens to a viscous or pyroplastic mass. This softened condition is accompanied by the evolution of gases that are entrapped in the viscous mass; these gases cause the material to expand and produce a thin-walled cellular structure. Substances contained in the raw materials which are responsible for the release of these gases include iron, sulfur, silica, alkalis and alkaline earth minerals, carbon, and water. Commercial production of lightweight aggregates is accomplished by either the rotary kiln method or the sintering process.

Rotary Kiln Method

A rotary kiln is a rotating cylindrical furnace that is slightly inclined from the horizontal. The raw material, crushed to a specified size, is fed into the higher end of the kiln. During its passage to the lower end, the raw material becomes progressively hotter until it reaches the temperature at which bloating occurs. The kiln is fired with either coal, gas, or oil near the lower end. After undergoing the bloating process the material is discharged from the lower end of the kiln and cooled by exposure to air. When sufficiently cool the material is crushed to specified sizes according to usage. Rotary kilns are kept in continuous operation so that the proper temperature can be maintained and no time and fuel are lost in reheating.

Sintering Process

The down-draft sintering process accomplishes incipient fusion of the raw material without melting and transforms it into a porous agglomerate. The process provides intimate contact of extreme heat (2200°F) with the raw material and insures uniformity of product and maximum bloating or expansion. The fuel, finely divided coal, is mixed with the raw material, and a thin layer of this mixture is placed on a moving grate that passes under a combustion chamber where high temperatures ignite the coal. Combustion, maintained by suction fans pulling air downward, continues in a thin horizontal layer that moves downward through the mixture. The resulting agglomerate is discharged from the grate, cooled and crushed to specified size.

Producers of Lightweight Aggregate in Virginia

Solite Corporation

The Solite Corporation established the first rotary kiln plant in Virginia near Bremo Bluff in northeastern Buckingham County in 1947 (Figure 2). The raw material, Arvonia slate, is excavated from a quarry about 0.5 mile west of the Solite Corporation plant. Both the weathered and unweathered slate expand easily, but the weathered rock is preferred because its friable and brittle nature makes it easier to quarry and crush. It also gives a finished material of higher structural quality.

The quarried slate is trucked to the plant where it is crushed to 1½-inch to dust size and placed in stockpiles. From the stockpiles the slate goes to the kilns for firing. The company has seven rotary kilns, including two that are 6.5 feet in diameter and 100 feet long, four that are 8 feet in diameter on the firing end and 100 feet long, and one that is 9 feet in diameter on the firing end and 125 feet long. The five smaller

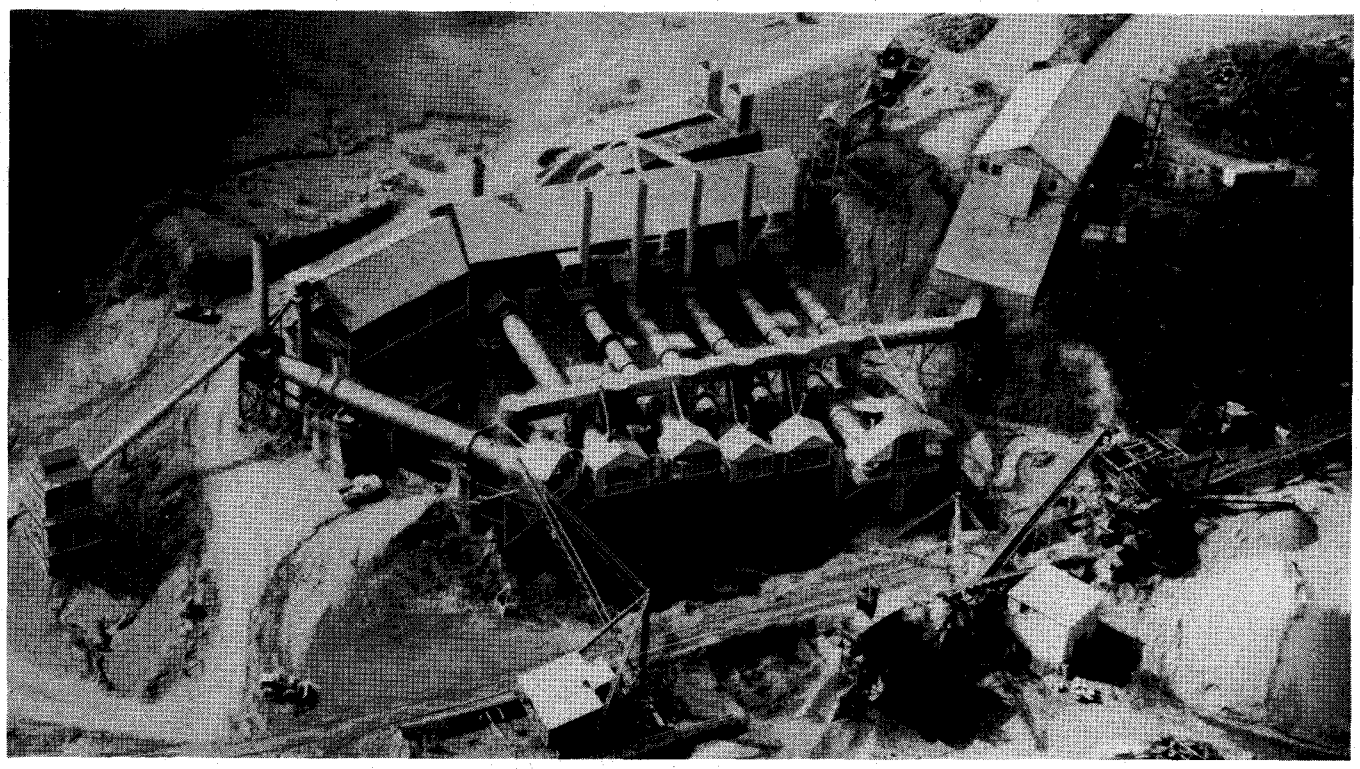

Figure 2. Solite Corporation plant at Bremo Bluff.

kilns slope 7/8 inch per foot, and the two larger ones slope 3/4 inch per foot. They rotate at a speed of 1.5 rpm and are fired by pulverized coal that produces a temperature ranging from 2150° to 2200°F at the firing end. The firing cycle requires approximately 30 minutes. The expanded slate is discharged as large clinkers that are allowed to cool before being crushed to specified sizes.

Aggregates produced by the Solite Corporation for use in lightweight structural concrete are 1/8-inch to dust size and 3/4-inch to 1/4-inch size. A third size, 3/8 inch to dust, is used in the manufacture of lightweight concrete blocks. Two weights of the largest size aggregate are produced; one of these will float on water and is used in making a lighter concrete. The finished product is marketed under the trade name of *Solite*. It is shipped from the plant by railroad car and truck.

The Virginia Solite Company

The plant of the Virginia Solite Company, a subsidary of the Solite Corporation, is located near Leaksville Junction in southwestern Pittsylvania County just north of the Virginia-North Carolina state line (Figure 3). The company obtains its raw material, a hard, gray Triassic shale, from nearby quarries in both Virginia and North Carolina; at present the shale is being quarried in Virginia. It is carried to the plant by truck, and crushed to 1 1/2-inch to dust size.

The shale is fired in three rotary kilns, each 8 feet in diameter and 125 feet long, which use pulverized coal as a fuel in winter and gas during the rest of the year. The rotary kilns slope 3/4 inch per foot and rotate at 1.5 rpm. Temperatures range from 350°F at the feed end of the kiln to 2200°F, the bloating temperature, at the firing end. After being discharged from the kiln and allowed to cool, the expanded shale is crushed to minus 3/8-inch size. The finished product, *Solite*, is used in the manufacture of lightweight concrete blocks.

Clinchfield Coal Company

The Lightweight Aggregate Division of Clinchfield Coal Company at South Clinchfield in northwestern Russell County began operation in May 1959 (Figure 4). The operation utilizes

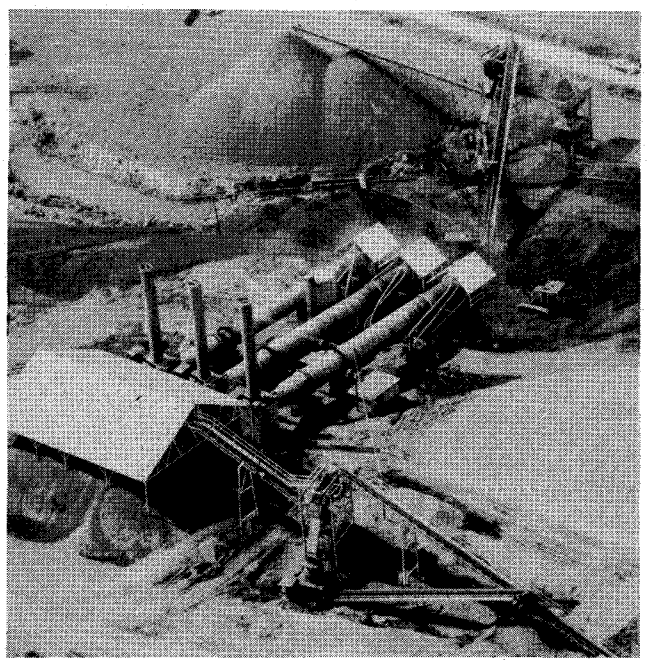

Figure 3. Virginia Solite Company plant at Leaksville Junction.

shale that is separated from coal at the company's adjacent Moss No. 3 coal-preparation plant. The coal is mined from the Jawbone and Tiller seams at Duty about 8 miles north of the plant. The shale is washed and crushed during the process of separation from the coal. The 1½- to ¼-inch shale is then carried by railroad cars to the aggregate plant where it is stored in a 5000-ton-capacity concrete silo until needed. No crushing is necessary at the lightweight aggregate plant before the shale is fed into the kilns. The aggregate, sold commercially as *Clinchlite,* is produced in two rotary kilns that use pulverized coal as fuel. One kiln is 9 feet in diameter and 151 feet long, and the other is 11 feet in diameter and 151 feet long. The kilns slope ¾ inch per foot and rotate at either 1 or 1.5 rpm. The bloated shale is discharged from the kilns into two rotary coolers that are 8 feet in diameter and 125 feet long. The coolers rotate at 3 rpm and expose the aggregate to air by a tumbling action. When discharged from the coolers the product is cool enough to be held in the hand. The aggregate is then crushed to specified sizes and stockpiled. Three sizes, ¼ inch to dust, ⅜ to 3/16 inch, and ¾ to ⅜ inch, are produced. *Clinchlite* is used for the manufacture of lightweight concrete masonry units, for structural, insulating, and fill concretes, and for precast concrete products.

Lynlite Materials Company

The most recent addition to the lightweight-aggregate industry in the State is the Lynlite Materials Company, located near Lynchburg in Campbell County. The plant began operating in February 1963. At present the plant has one oil-fired rotary kiln that is 9 feet in diameter and 90 feet long. In the future two similar kilns will be installed. The raw material used by the company is hard, fine-grained, blue-gray schist of the Joshua formation. The schist is quarried at the plant site and crushed to 1¾- to ¾-inch size. It bloats at about 2100°F. The kiln discharges the expanded schist into a horizontal rotary cooler that exposes the aggregate to air. The expanded schist, sold under the trade name of *Lynlite,* is crushed to minus ⅜-inch size and used in the manufacture of lightweight concrete blocks.

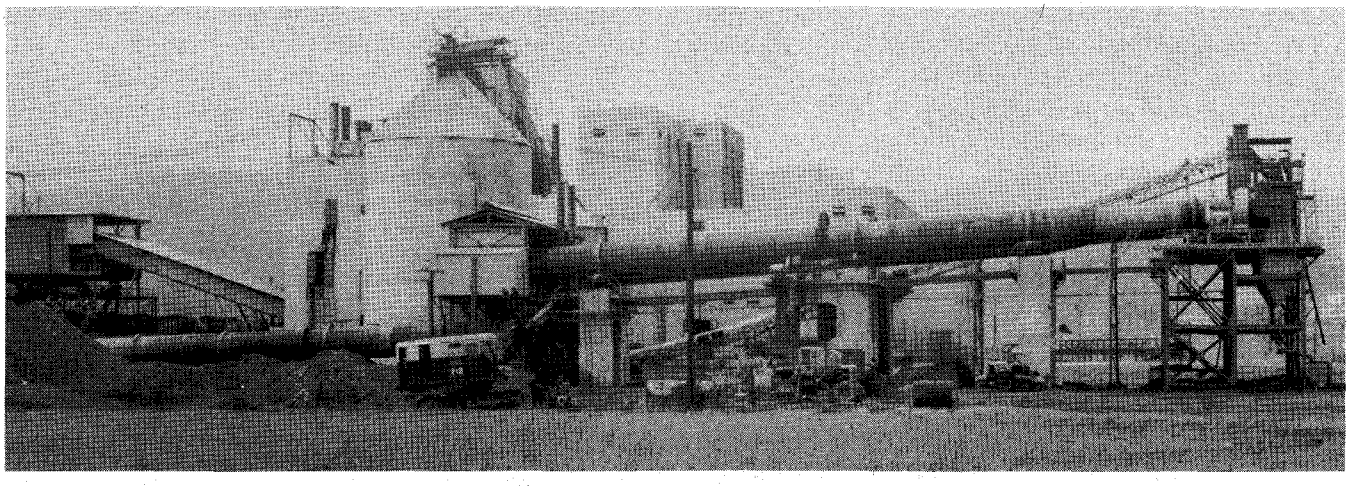

Figure 4. Lightweight Aggregate Division of the Clinchfield Coal Company plant at South Clinchfield.

Table 1. Data on lightweight-aggregate producers in Virginia.

Company	Location	Raw Material	Process	Fuel	Product	Uses
Lightweight Aggregate Division Clinchfield Coal Co.	South Clinchfield	Pennsylvanian shale	Rotary kiln	Coal	Clinchlite	Lightweight concrete masonry units and lightweight concrete
Lynlite Materials Co.	Lynchburg	Joshua schist	Rotary kiln	Oil	Lynlite	Lightweight concrete blocks and roofing fill
Solite Corp.	Bremo Bluff	Arvonia slate	Rotary kiln	Coal	Solite	Lightweight concrete blocks and lightweight concrete
Virginia Lightweight Aggregate Corp.	Webster	Rome shale	Sintering	Coal	Weblite	Lightweight concrete masonry units and lightweight structural concrete
Virginia Perlite Corp.	Hopewell	Perlite	Rotary kiln	Gas or oil	Permalite	Lightweight insulating concrete, plaster aggregate, soil conditioner, and insulating material
Virginia Solite Co.	Leaksville Junction	Triassic shale	Rotary kiln	Gas or oil	Solite	Lightweight concrete blocks

Virginia Perlite Corporation

The Virginia Perlite Corporation expands perlite, a raw material not native to Virginia. The perlite, already crushed and sized, is shipped by rail from Mexico, New Mexico, and Colorado to the company's plant at Hopewell. Perlite is essentially a volcanic glass of rhyolitic composition that contains 2 to 5 percent of chemically combined water. After the perlite is heated to above 1500°F in a small rotary kiln fired by gas or oil, it expands and undergoes a change in color from gray to white. It "pops" much like popcorn as the trapped water vaporizes to form microscopic cells or voids in the heat-softened glass. The result is a honey-comb structure that accounts for the light weight and excellent thermal- and acoustical-insulating properties of expanded perlite. Three sizes of expanded perlite, sold commercially under the trade name *Permalite*, are produced. One size is used as aggregate in lightweight insulating concrete; another is used as a substitute for sand in lightweight insulating plaster, and a third is used as a soil conditioner that lightens and aerates the soil and increases its water-holding properties.

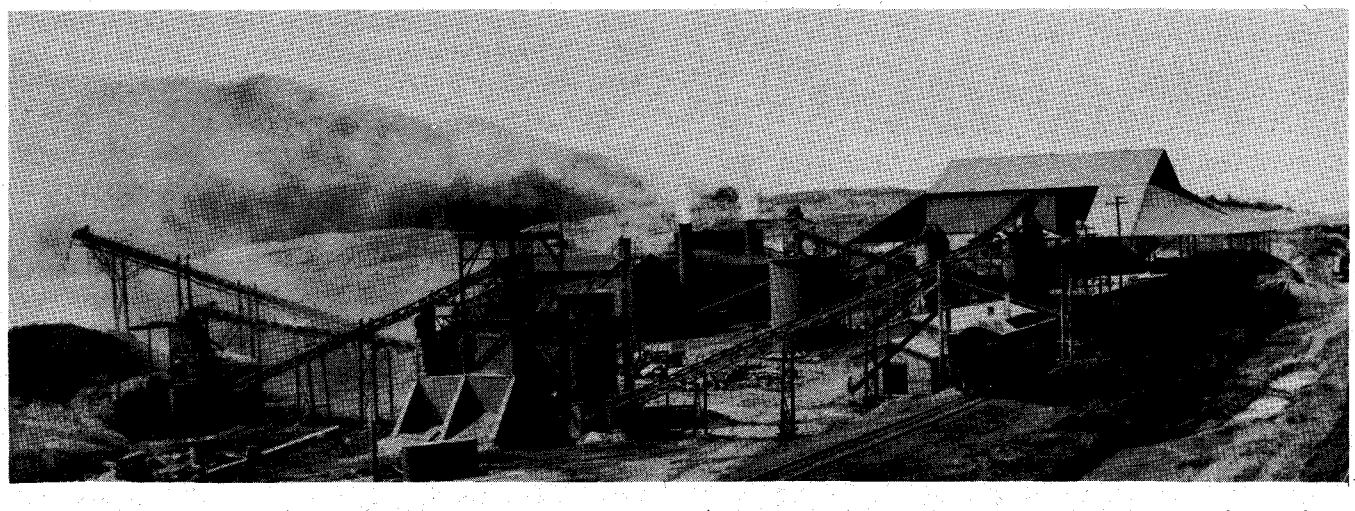

Figure 5. Virginia Lightweight Aggregate Corporation plant at Webster. Sintering equipment is located in building flanked by smoke stacks in center background.

Virginia Lightweight Aggregate Corporation

The Virginia Lightweight Aggregate Corporation is the only producer in the State that uses the sintering process for manufacturing lightweight aggregate. The plant, which began operation in 1951, is located at Webster in southern Botetourt County (Figure 5). The raw material utilized by the plant is obtained from an adjacent quarry in the gray to greenish Rome shale. Coal mixed with the raw material is of semi-anthracite rank and is transported by truck from near Blacksburg. The shale is crushed to minus ⅜-inch size and blended with approximately 10 percent coal (minus ⅛ inch in size) and a small percentage of pre-sintered material. This mixture is blended in a drum-type pelletizer where a small amount of water is added to give stability to the mix.

A layer of raw material, 9 inches thick, is placed on the grate of the sintering machine, and the grate passes under a gas-fired combustion chamber where the temperature reaches 2700°F. As the material passes under the combustion chamber, the coal is ignited. Fans draw air downward through the layer of material; this induced downward flow of air supports combustion of the coal in the mixture, cools the shale as it reaches the pyroplastic state causing the evolving gases to be entrapped, and acts to preheat the lower portion of the layer. The bloated shale tends to restrict the passage of air through the mass during the firing phase, but this condition is minimized by adding a small amount of previously bloated material to the system.

After leaving the grate the expanded shale is cooled, crushed to specified size, and stockpiled. Three sizes of sintered aggregate, sold commercially as *Weblite*, are produced by Virginia Lightweight Aggregate Corporation; they are ¾ to 3/16 inch, and ⅜ to 3/16 inch, and 3/16 inch to dust. The main uses of *Weblite* aggregates are in the manufacture of lightweight concrete masonry units and lightweight structural concrete.

New Publications

Bulletin 78. GEOLOGY AND MINERAL RESOURCES OF GREENE AND MADISON COUNTIES by Rhesa M. Allen, Jr. 102 p., with geologic map in color. Price $3.75.

Greene and Madison counties are in north central Virginia and are located in the Blue Ridge and Piedmont physiographic provinces. Their boundaries enclose an area of 470 square miles which extends from the crest of the Blue Ridge Mountains in the northwest to Orange County on the southeast.

Bedrock of the counties consists predominantly of Precambrian to early Cambrian igneous and metamorphosed sedimentary and igneous rocks. A small exposure of Lower Cambrian sedimentary rocks is in the extreme southwest corner of Greene County. Triassic sedimentary and igneous rocks occur in eastern Madison County. Quaternary alluvial deposits are in the lower valleys of the major streams of the area. The oldest Precambrian formations consist of gneissic and granitoid rocks of the Virginia Blue Ridge complex which are overlain in part by metamorphosed sedimentary rocks of a schistose, phyllitic and quartzitic nature. Age relations of the rocks of the complex have not been definitely established, although in this area the Lovingston formation appears to be the oldest core unit and the Robertson River formation the youngest.

The major structure of the Greene-Madison area consists of the broad upwarp of the Blue Ridge-Catoctin Mountain anticlinorium. Gravity faults displace rocks of the complex and Catoctin formation along northeasterly and northwesterly trends. Minor strike-slip faults, small thrust faults, and shear zones are also present in the rocks of the complex and the Lynchburg formation. The northeastward-trending Mechum River formation appears to represent a downfaulted, and later thrust-faulted, wedge in the Lovingston formation. Thoroughfare Mountain is a synclinal complex composed of a coarse clastic facies of the Lynchburg formation. A series of northeastward-trending gravity faults, offset by northwestward-trending transverse faults, are present along the west margin of the Triassic area.

The mineral resources of Greene and Madison counties consist in part of gneissic and granitic rock along with sand and gravel for construction uses, unakite (a facies of the Pedlar formation) for use as a gem stone, and an ultramafic "soapstone-like" rock which may have potential value. The copper ores of the Blue Ridge have been worked in the past but appear to be of poor quality and limited quantity, and it is doubtful that they will receive attention in the future. Small amounts of pyrite occur at several places in the area. Clays are present, especially in association with Triassic sediments.

Report of Investigations 5. GEOLOGY OF THE CLINCHPORT QUADRANGLE, VIRGINIA by William B. Brent. 47 p., with geologic map in color. Price $2.25.

The Clinchport quadrangle is in Scott County in southwestern Virginia. Clinch River flows through the center of the area, that extends from the south margin of the coal fields to just north of the Virginia-Tennessee border. All of the bedrock is sedimentary and ranges in age from Cambrian to Devonian. Total thickness of exposed formations is approximately 10,000 feet. The rocks are chiefly Cambrian and Ordovician limestones, dolomites, and shales.

The structure consists largely of northeastward-trending reverse faults and formations that dip southward. A notable exception is the Rye Cove syncline that contains many small folds and faults. Three low-angle thrust faults trend to the northeast across the area; they are the Copper Creek, Clinchport, and Hunter Valley faults. A previously unmapped southeastward-trending high-angle reverse fault is described.

Mineral resources of economic importance include deposits of limestone and dolomite. High-calcium limestone for cement manufacture is quarried at Speers Ferry, and dolomite for use as crushed and broken stone is quarried at Glenita. Tests conducted on samples of Rogersville shale indicate that it has potential economic value.

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Report of Investigations 6. TRIASSIC FORMATIONS OF THE DANVILLE BASIN by Carl T. Meyertons. 65 p., with geologic map. Price $1.50.

The Danville basin in south-central Virginia contains about 15,000 feet of continental sediments and at least 60 diabase and gabbro dikes. Three new formations, the Leakesville, Dry Fork, and the Cedar Forest formations, are proposed.

Sporadic movement on the Chatham border fault and subsidence of the basin initiated and accompanied sedimentation. Later, basement movements caused tilting of sedimentary blocks and oblique faulting and raised a quartz monzonite basement block to the surface.

The uppermost Triassic sediments were derived from exposures of these blocks. Intrusive magmas then were forced into some of the earlier fault-plane fractures, and in some places the earlier sediments were altered.

Rocks suitable for brick and ceramic-ware manufacture and for the production of lightweight aggregate are described. Localities favorable for crushed-stone quarry sites are noted.

Changes in Staff

Dr. John H. Yoe, who served on the faculty of the University of Virginia for 44 years and on the staff of the Virginia Division of Mineral Resources for 38 years, retired on June 30, 1963. He provided consultation on chemical problems that were related to geology. Dr. Yoe was director of the John Lee Pratt Trace Analysis Laboratory.

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Mr. Charles J. Waag joined the Division staff on May 1, 1963, to direct work in transferring geologic data to newly compiled topographic maps. He has earned two degrees in geology at the University of Pittsburgh, a B.S. in 1954 and a M.S. in 1958. In June 1954 he was called into service and was assigned to the 10th Tactical Reconnaissance Wing at Spangdahlen, Germany after attending the Officers Photo-radar Intelligence School at Lowry Air Force Base in Denver, Colorado. Mr. Waag recently returned from Venezuela where, for five years, he was a geologist with the Orinoco Mining Company at Cerro Bolivar. He is married and has one son.

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Mr. Roger C. Wilkenloh was employed by the Division on May 1, 1963, to collect data for ground-water studies. He received his B.A. degree from the University of Virginia in 1957. Mr. Wilkenloh served with the U. S. Army Corps of Engineers at Fort Belvoir, Virginia where he attended their Multiplex Map Compiling School. From 1960 to 1963 he did graduate work at the University of Virginia.

Doctor Arthur August Pegau passed away at the age of 69 on May 26, 1963. He obtained his Ph.D. at Cornell University in 1924 and was a member of the University of Virginia faculty from 1924 to 1948. He was also employed by the Virginia Geological Survey from 1926 to 1948 at which time he accepted full-time employment with the Survey as a mineralogist. He retired from the Virginia Division of Mineral Resources on June 30, 1960.

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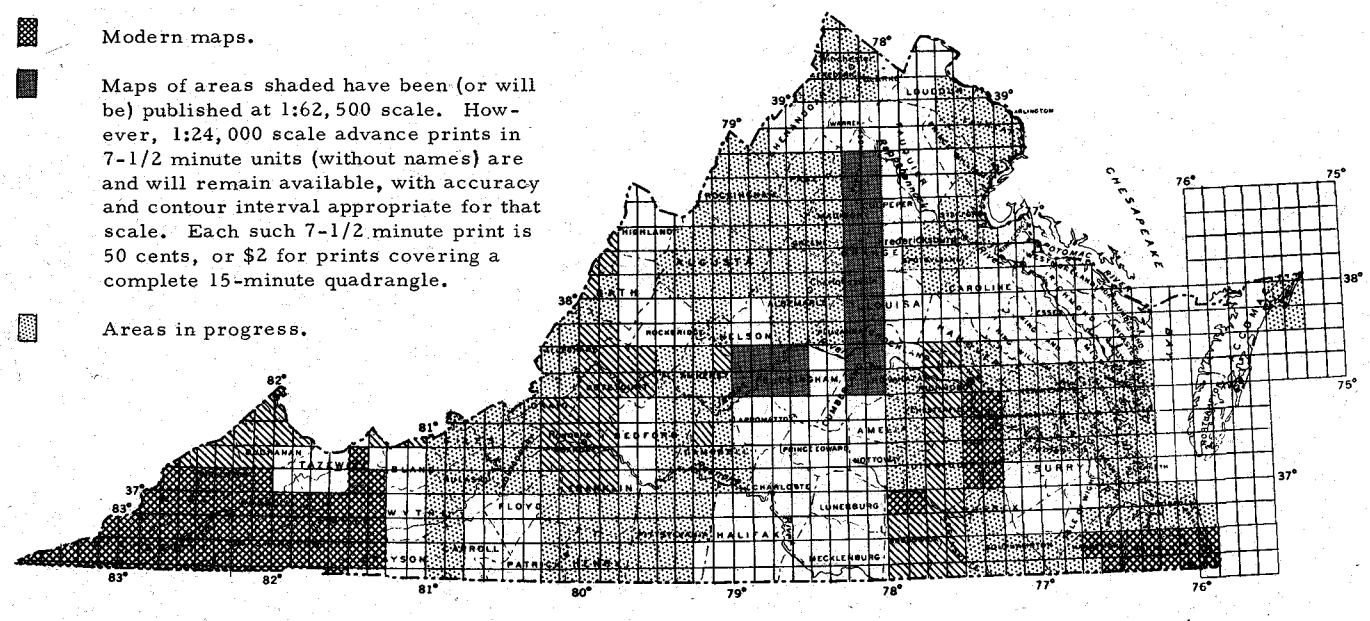
Areas in progress.



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