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VIRGINIA'S LIME INDUSTRY

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Lime production in Virginia continued on the increase in 1985 after a four-year decline from 1980-1983. Production tonnages and values are indicated in the Table; 1985 production was 605,000 short tons at a value of $26.4 million. Virginia's highest ranking in production occurred in 1915 when Virginia was third behind Pennsylvania and Ohio with 267,000 short tons from 40 plants (Wood, 1958, p. 6). High production also occurred during the early 1940's with the increased use in the steel furnaces at that time. The year of most lime production was 1969, when Virginia ranked fifth behind Ohio, Pennsylvania, Texas, and Michigan with 1,072,000 short tons ($13.6 million). Lime production of 824,000 short tons in 1981 yielded a record value of almost 36 million dollars.

Lime (calcium oxide), marketed as quicklime and hydrated lime, is produced from a variety of calcareous materials such as limestone, dolomite, marble, chalk, shell, coral, aragonite or by-product sludge from paper mills, carbide plants, and other industrial plants. Quicklime is made by calcining (burning) such calcareous materials in a kiln at temperatures ranging from 1900° to 2400°F ($CaCO_3$ + heat$\rightarrow$$CaO$ + CO_2). Hydrated lime, a more stable lime, is produced by uniting quicklime chemically with water ($CaO + H_2O \rightarrow Ca(OH)_2$ + heat). Two basic materials used for lime manufacture are high-calcium limestone (minimum 97 percent $CaCO_3$) and dolomitic limestone (minimum of 20 percent $MgCO_3$). Raw materials that contain at least 97 percent combined calcium and magnesium carbonate content are considered necessary for salable lime.

PROCESSING

For calcining (burning) of the limestone, several types of kilns are utilized depending on capacity of operation, fuel costs, market requirements, and air pollution regulations. Increasingly important is the amount and cost of fuel required to convert each ton of limestone to lime.

Vertical (shaft) kilns are elliptical or circular and may be of stone, reinforced concrete, or boiler plate construction. The kilns are lined, usually with two layers of refractory brick, and are divided into three sections: preheating, calcining, and cooling. The limestone is put in the kiln at the top of the preheating section. In the calcining section, the temperature control is dependent upon the physical and chemical properties of the limestone. If coal is the fuel, it is mixed in directly with the limestone, usually in a ratio of 1:5. Energy requirements are usually under 5 million BTU per ton of lime. Generally, large stone (3 to 12 inches in size) was fed into the older kilns, but the more modern vertical kilns handle smaller (1-to 3-inch sizes of stone to produce a more reactive lime. Advantages of vertical kilns include lower fuel cost through higher efficiency, less wear on the refractories, easier starting and stopping of kilns, and lower pollution-control

Table. Lime production in Virginia[1]

	Short Tons	Value (in $)
1888	170,000 Bbls.	
1905	114,221	393,434
1910	141,257	563,567
1915	267,278	840,969
1920	251,052	2,201,724
1925	192,429	1,491,568
1930	146,996	960,219
1935	133,696	850,444
1940	178,036	1,044,229
1945	118,707	835,575
1950	428,339	3,861,932
1955	494,293	5,048,697
1960	711,000	8,028,000
1965	847,000	10,584,000
1969[2]	1,072,000	13,653,000
1970	1,046,000	14,090,000
1975	705,000	20,192,000
1976	878,000	25,993,000
1977	846,000	28,767,000
1978	832,000	30,578,000
1979	872,000	34,935,000
1980	824,000	33,872,000
1981	804,000	35,984,000
1982	641,000	31,721,000
1983	557,000	24,637,000
1984	562,000	24,799,000
1985	605,000	26,426,000

[1]Production from annual edition of the U.S. Bureau of Mines *Minerals Yearbook*; Roberts, 1942.
[2]Fifth in production behind Ohio, Pennsylvania, Texas, and Michigan

costs. Figure 1 depicts vertical kilns presently in operation at Riverton Corporation, Warren County.

Calcimatic-kilns were developed to utilize smaller sizes of stone. These kilns are used to further burn the incompletely calcined fines produced by other kilns. Their circular hearths have stationary beds of lime that are exposed to multiple burners which are usually gas-fired. The lime is usually carried in a thin layer; one revolution through the many burners constitutes a calcining cycle.

Rotary-kilns were developed and utilized for plants needing greater capacity and to also burn small stone readily, use less manpower, create a wider range of burn, and produce a more uniform quality product. Longer rotaries were developed in the early nineteen sixties. They are able to burn smaller size material because a draft is not needed. Stone as small as ¼ inch can be burned as successfully as 2¼-inch material; however, a 1:3 ratio of small to large feed is best. In contrast to vertical kilns that operate fully charged, the rotary has 90% of its volume filled with flame and hot gases; new surfaces of the stone are exposed as the kiln slowly rotates. As the area of solids exposed is small, this type of kiln has a lower efficiency than a vertical kiln. A rotary kiln utilized by W. S. Frey Company, Inc. is shown in Figure 2.

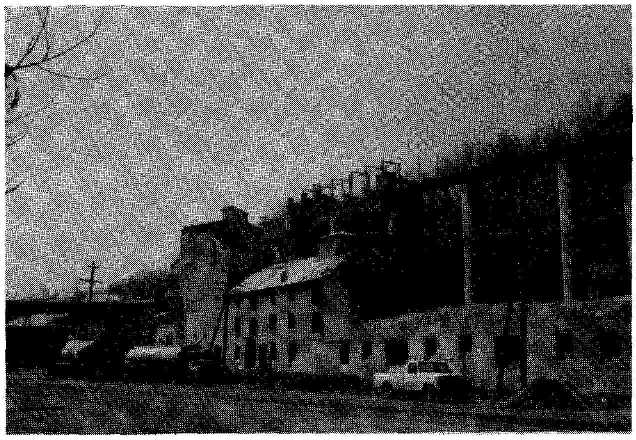

Figure 1. Vertical kilns at Riverton Corporation, Warren County.

Rotaries vary in size; most typically they are 8 to 10 feet in diameter, 150-200 feet long, and produce 200-500 (ton per day). All types of fuel can be used, but powdered coal is the popular choice today. Coal can be pulverized more effectively by putting more crusher balls in the mill. The hot gases are returned through coolers to the kiln as secondary air in order to increase fuel efficiency. Trends today are toward shorter kilns with preheaters in which exhaust gases preheat the stone. Finely pulverized limestone is spread over coarser material as it is calcined. This allows the finer material to be calcined as it is shifted with the kiln load.

After calcination, the lime is inspected for underburning or overburning and it is crushed and/or screened and classified as follows (Boynton, 1966, p. 263-264):

lump quicklime	2 ½ to 8 inches
pebble quicklime	¼ to 2 ½ inches
ground quicklime	100% passing 8 mesh and 2-4% passing 100 mesh
pulverized quicklime	100% passing 20 mesh and 85-90% passing 100 mesh

Fines are used to produce hydrated lime. They are accumulated in a hydrator, which consists of a revolving drum with stationary paddles to agitate the lime. A fine measured spray of water from a needle valve is added to lime until a hydrated product is produced. A continuous hydrator contains a screw conveyor which mixes the water with the lime. Water is controlled, as too much of it will result in a wet, sticky lime, and too little yields an underslaked lime. The hydrated lime is usually separated out by an air separator. At plants where lime is not hydrated, fines usually end up in settling ponds.

USES

An average of 150 pounds of pebble quicklime is used as a flux to produce a ton of steel in a basic oxygen furnace. Impurities such as silica, alumina, phosphorus, and sulfur are removed in a slag that forms during the fluxing process. For greater refractory life, steel companies substitute high-dolomitic lime for 10-30 percent of the high-calcium lime. Refractory lime (dead-burned dolomite) is used to line the bottoms of open-hearth steel furnaces to extend life of brick linings. With the advent of basic oxygen furnaces, use of this lime declined until development of tar-bonded refractory bricks, which are made from the dead-burned dolomite.

Lime is used in beneficiation of copper ores to neutralize the acidic effects of pyrite and other iron sulfides and maintain the proper pH in the flotation process. It is also used to recover uranium from gold slimes in a flotation process, to neutralize sulfuric acid waste in ore extractive plants, control pH and curtail cyanide loss in gold and silver recovery, and as a flux in the recovery of nickel by precipitation.

Municipal potable water is treated with lime to remove turbidity. In sewage treatment, lime is used to control pH in the sludge digester. This removes dissolved and suspended solids that contain phosphates and nitrogen compounds. Lime neutralizes the acidic waste water in coal washing plants, wastes from sulfuric acid pickling plants, and plating wastes. Lime is also used in large quantities to recover ammonia for recyclical use in the manufacture of soda ash and bicarbonate of soda. Fourteen hundred pounds of quicklime are required to produce a ton of soda ash.

The fusion of coke and quicklime produces calcium carbide ($CaO + 3C \rightarrow CaC_2 + CO$), which is the chief source of acetylene. The ingredients are heated to 2000°C; molten carbide is removed from the furnace, solidified, and crushed into desired sizes. Treatment of the fused carbide with nitrogen, which is obtained by liquefying air, produces calcium cyanamide, a nitrogen fertilizer. Introduction of chlorine and hydrated lime produces calcium hypochlorite and chloride of lime, which are dry sources of bleach.

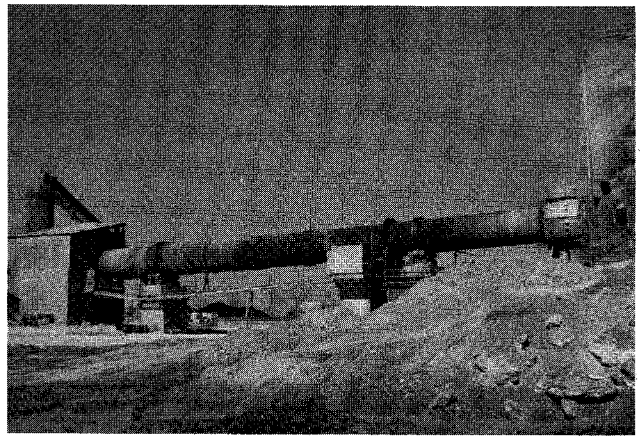

Figure 2. Rotary kiln at W. S. Frey Company, inc., Clear Brook in Frederick County.

The paper industry uses lime in combination with chlorine in bleaching paper pulp to obtain a desired degree of whiteness. Lime is also used when wood pulp is cooked in caustic soda (sodium hydroxide) and sodium sulfide. Sodium carbonate solution is recovered and reacted with quicklime to generate sodium hydroxide which is recycled to treat wood pulp again. Lime is also used in the clarification and color removal of paper mill wastes.

Dolomitic quicklime granules are used as a flux raw material in the mix for the manufacture of glass. Lime is used to make calcium silicate building products (sand-lime brick) and hydrated lime is used to produce silica refractory brick.

Lime, necessary in manufacturing refined sugar, helps purify the sugar juices from both cane and beets. It removes phosphatic and organic acid compounds as insoluble calcium compounds that are then removed by filtration. Most beet-sugar plants make their own lime as they use about 500 pounds of quicklime per ton of sugar. They also use CO_2, which is available from the lime kiln stack gases in their process. Lime is used as a CO_2 absorbent for fresh fruit and vegetables to extend the freshness of the produce.

Hydrated lime with about 10% pebble quicklime is used for soil stabilization for highway and off-highway purposes. Hydrated lime is also used with fly ash in the preparation of base material at mix plants, in asphalt mix (1.2%) to act as an antistripping agent, in exterior plaster or stucco in warm climates, and as a dependable plasticizer that makes mortar more workable. Since air-slaked lime reacts faster than pulverized limestone, it is often used in agricultural liming. Dolomitic lime is used in a sandy soil that is magnesium deficient.

To reduce air pollution, the use of lime has increased for the removal of sulfur dioxide from stack gases of coal-fired electrical utilities, and metallurgical and chemical plants. Flue-gas desulfurization is becoming a larger issue and may lead to an expanded market for lime. Lime has a potential use in the neutralization of the effects of acid rain.

GEOLOGY

There are several formations in the Shenandoah Valley area that contain high-calcium limestones. The unit with the most potential is the high-calcium New Market Limestone and its approximate equivalent, the Mosheim Limestone of Ordovician age, which is bluish to dove gray, compact, and fine grained. They have glossy textures and fracture conchoidally. In most places in the Shenandoah Valley of Virginia, each of these limestones may be divided into two parts. The upper part, which is thick bedded to massive and nearly free of insoluble matter, contains 97 to 98 percent calcium carbonate and has chalk-like weathered surfaces. The lower part contains some thin-bedded, shaly and dolomitic, buff limestones and dolomite pebble conglomerate at the base and overlie the irregular surface of the Beekmantown dolomite.

In the Shenandoah Valley, the thickness of the New Market Limestone is greater west of the Massanutten synclinorium (70 to 120 feet) than in the eastern belts, where measurements range from less than 15 feet to about 50 feet with localized exceptions. Western belts of New Market Limestone in the northern and central Shenandoah Valley contain a basal dolomitic limestone and a pebble conglomerate that are similar in appearance to the Blackford Formation of southwestern Virginia.

The lower unit of the New Market closely resembles and occupies the stratigraphic position of the dolomitic, shaly, cherty beds of the Blackford Formation in southwestern Virginia (Cooper and Cooper, 1946). The New Market in northern Virginia was identified as Mosheim as was also the Five Oaks Limestone in southwest Virginia (Butts, 1933). The black, cherty Lincolnshire Limestone overlies the New Market in the central and northern Shenandoah Valley, and the high-calcium Five Oaks Limestone overlies the light-gray, black cherty, limestone beds of the Blackford Formation (Cooper, 1944, p. 24) (Figure 3).

SELECTED AREAS OF POTENTIAL RESOURCES

Clarke County

The New Market Limestone is 67 feet thick about a mile south of Wadesville, east of Opequon Creek (Edmundson and Nunan, 1973, p. 42). The unit has a similar thickness near the nose of several anticlines, north of Virginia Highway 7 and also south of the West Virginia state line near Swimley (Figure 4).

Frederick County

Both northeast and southwest of Winchester, the New Market Limestone ranges from 80 feet to a maximum of 200 feet thick (Butts and Edmundson, 1966, p. 28); around Stephenson it is 120 feet thick. It is 125 feet thick on the east limb of an anticline at W. S. Frey's Clear Brook operation. The unit becomes thinner toward the axis and western limb of the structure.

Shenandoah County

There is a 218-foot section of New Market Limestone along Swover Creek, 2.5 miles north of Hamburg (Figure 4) near the central part of the county; a composite sample from the top 116 feet was analyzed as containing 98.56% $CaCO_3$

Figure 3. Cherty limestone beds of the Blackford Formation, near Klotz, Giles County.

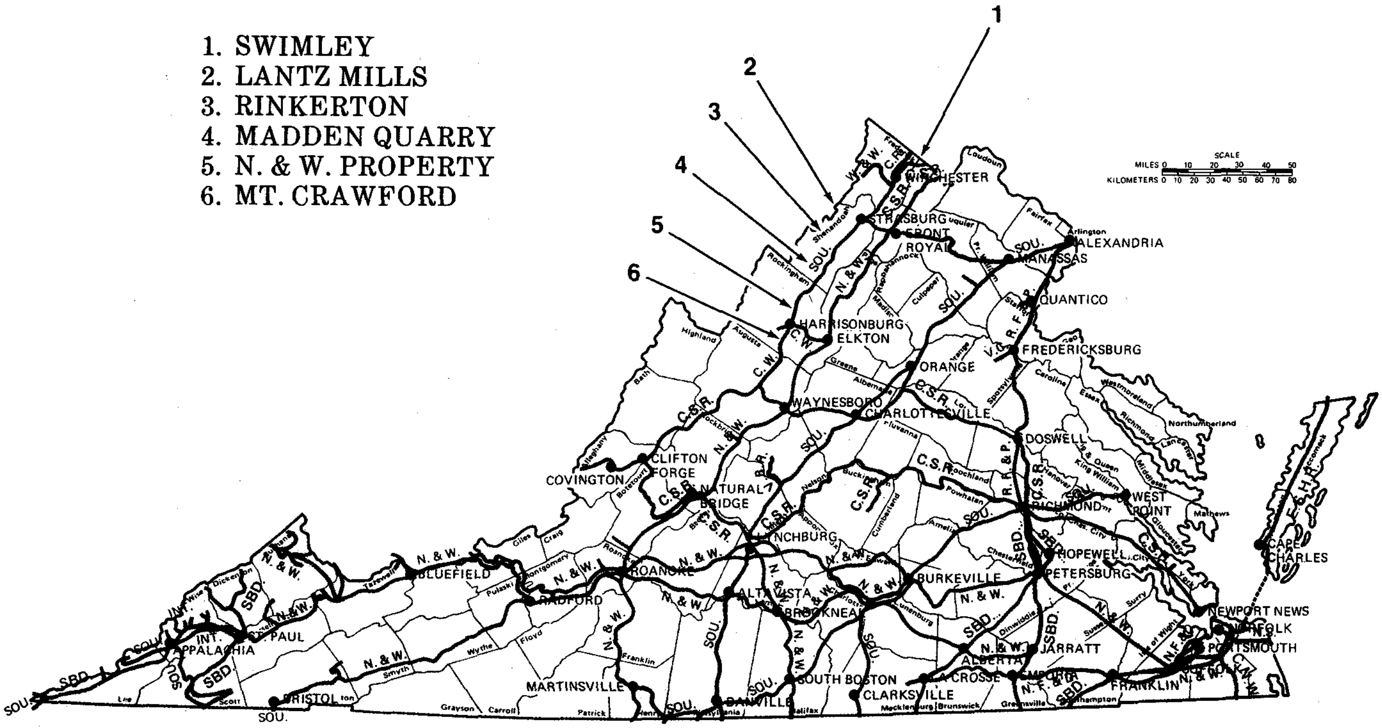

Figure 4. Exposures of New Market Limestone for potential resources.

(Edmundson, 1945, p. 59). This is the same location referred to by Cooper and Cooper (1946, Geologic Section 12) as being 4 miles west of Edinburg. A thick exposure of New Market (Figure 4) is present in an abandoned quarry northwest of Mt. Jackson and just southeast of Rinkerton (Young and Rader, 1974, p. 15). Because of the low dip in the northeast-plunging syncline, approximate thickness of 100 feet and railroad accessibility, this may be a favorable deposit. Another location is about 1.5 miles southwest of Lantz Mills (Figure 4) off State Road 693 in the nose of a shallow synclinal structure. Edmundson (1945, p. 55) reports an average analysis of 96.65% $CaCO_3$ from the 141-foot-thick section in the eastern limb of the syncline; in the western limb, the section is about 180 feet thick. In northern Shenandoah County, Chemstone Corporation is quarrying this limestone where it has a thickness of almost 150 feet just north of Strasburg. Fifty-five feet of high-calcium limestone is exposed along Tumbling Run, just southwest of Strasburg (Figure 5).

A continuous section (80+ feet) of the New Market is present in the abandoned Madden quarry (Figures 4 and 6) just west of Interstate 81 west of New Market. Analyses of the top 38 feet of the unit indicate an average of 98.15% $CaCO_3$ (Edmundson 1945, p. 52).

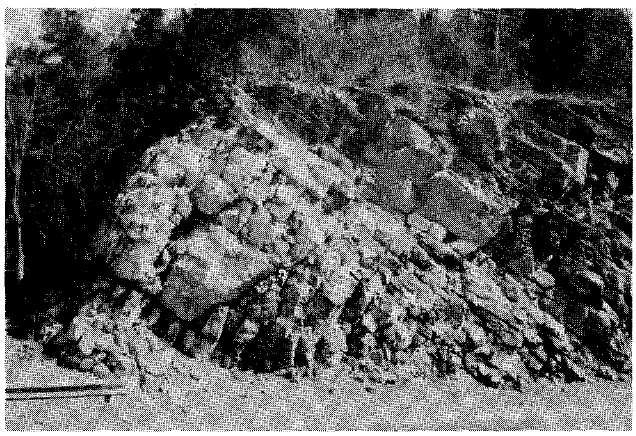

Figure 5. New Market Limestone along Tumbling Run, southwest of Strasburg.

Rockingham County

Other exposures of New Market Limestone that may have a potential for commercial development are present in Rockingham County both north and south of Harrisonburg. The site (Cedar Grove Church deposit) located northeast of Harrisonburg is presently owned by Norfolk Southern Corporation. (Figure 7). The New Market at this site is as much as 300 feet thick and averages 100 feet thick; it was quarried in the past for

Figure 6. Inactive Madden quarry, New Market.

roadstone. The high-calcium limestone contains solution channels and tension fractures that have some mud, shaly interbeds with small amounts of silica, and negligible amounts of pyrite. The black, cherty Lincolnshire Limestone overlies the New Market and dips toward the west-northwest at this locality (Figures 4 and 7). The outcrop belt along the ridge continues for 3.5 miles and reserves are noted in a company report to be about 500 million tons of high calcium limestone. Analyses of chip samples taken across a 12-foot interval near the top of the unit in the northwest wall indiate 98.02% $CaCO_3$ (W. F. Giannini, 1985, personal communication). The southern exposure is located east of Mount Crawford (Figure 4) along Pleasant Run. The unit there is approximately 200 feet thick and dips to the east with very little overburden (Gathright and others, 1978).

Giles County

Five Oaks Limestone of the Cliffield Formation is being mined underground by USG Industries, Inc. and Virginia Lime Company in Giles County. The dove-gray, dense, hard, high-calcium limestone ranges in thickness from 40 to 100 feet and has a general dip of 15° to the southeast. In the area of Kimballton, the Five Oaks has been contorted by a regional thrust from the east-southeast (Eilertsen, 1964, p. 5). Tension fractures may be filled with calcite or open with linings of red clay or silt.

CARBONATE PROJECT

The Division of Mineral Resources is conducting a long-term project that will provide new quantitative data on the location, thickness, and composition of limestone, dolomite, and other carbonate-rock units in Virginia. Acquisition of up-to-date location information and chemical, reflectance, and other data will lead toward a better understanding of the economic potential of the carbonate materials in Virginia. Almost 3000 samples have been taken in the last five years.

As a part of this project, several dolomite units between Clarke County, in the northeastern part of the Valley and Ridge province, and Lee County, in the extreme southwestern part of the State, were sampled to determine possible sources of refractory-grade dolomite. Samples were taken at six different locations from three different rock units (Figure 8). Chemical analyses and differential thermal analyses (DTA) performed on the six samples by the U. S. Bureau of Mines, Albany Research Center in Albany, Oregon are published in Sweet and Giannini (1985). Samples 135-C and 135-D meet specifications for materials having a maximum of 0.75 percent SiO_2, less than 0.4 percent Fe_2O_3, and less than 0.3 percent Al_2O_3.

Figure 7. Lincolnshire Limestone overlying New Market Limestone, inactive Cedar Grove Church deposit, Rockingham County.

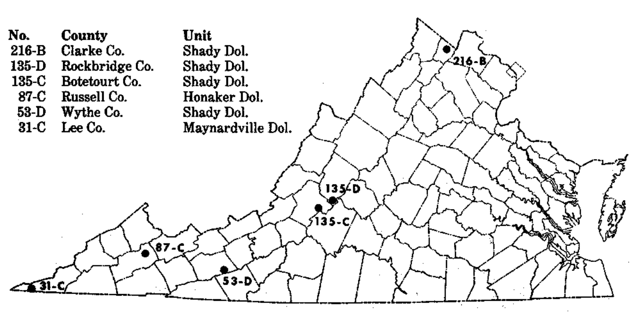

Figure 8. Dolomite sample locations.

VIRGINIA LIME PRODUCERS

Six companies (Figure 9) in Virginia produce quicklime and/or hydrated lime (Sweet, 1985) for a variety of markets. Both USG Industries, Inc. and Virginia Lime Company, Subsidiary of the Rangaire Corporation, operate underground mines in the Five Oaks Limestone (high-calcium limestone) of Ordovician age at Kimballton, Giles County. Both quicklime and hydrated lime are produced at each of the operations. In northern Virginia the Chemstone Corporation, Shenandoah County, and the W. S. Frey Company, Inc., Frederick County, quarry high-calcium New Market and Mosheim, limestones of Ordovician age. These limestones are presently being calcined in rotary kilns by both companies; however, only the Chemstone Corporation produces a hydrated lime. The Shen-Valley Lime Corporation in Stephens City, Frederick County, hydrates purchased quicklime. The Riverton Corporation, located in Warren Cuonty north of Front Royal, calcines limestone from the Edinburg Formation of Ordovician age. This limestone is calcined in coal-fired vertical kilns, hydrated and mixed with portland cement to produce masonary cement.

W. S. Frey Company, Inc.

W. S. Frey Company, Inc., located about 7 miles north of Winchester in Frederick County, just east of Clear Brook, has been in operation at this site since 1961. Underground mining began south of State Road 672 in 1964; five tunnels were developed eastward down dip from the quarry. This underground mine was closed in the fall of 1967; the mine is now flooded with water. An abandoned quarry north of the road reopened in the early 1960's but is now full of water (Figures 10 and 11).

The company is presently quarrying the high-calcium New Market Limestone of Ordovician age on the eastern limb of a south-southwest plunging anticline. The limestone is approximately 125 feet thick and becomes thinner toward the axis and nose of the anticline. The overlying Lincolnshire Limestone is being stripped toward the south; rock from both it and the underlying Beekmantown Formation is being crushed for marketing as crushed stone.

Stone is trucked to the crusher located east of the quarry. After crushing, the stone is calcined in a 165-foot rotary kiln fired with bituminous coal. The kiln is fired at a temperature higher

1. W. S. FREY CO., INC.
2. SHEN-VALLEY LIME CORP.
3. CHEMSTONE CORP.
4. RIVERTON CORP.
5. USG INDUSTRIES, INC.
6. VIRGINIA LIME CO.

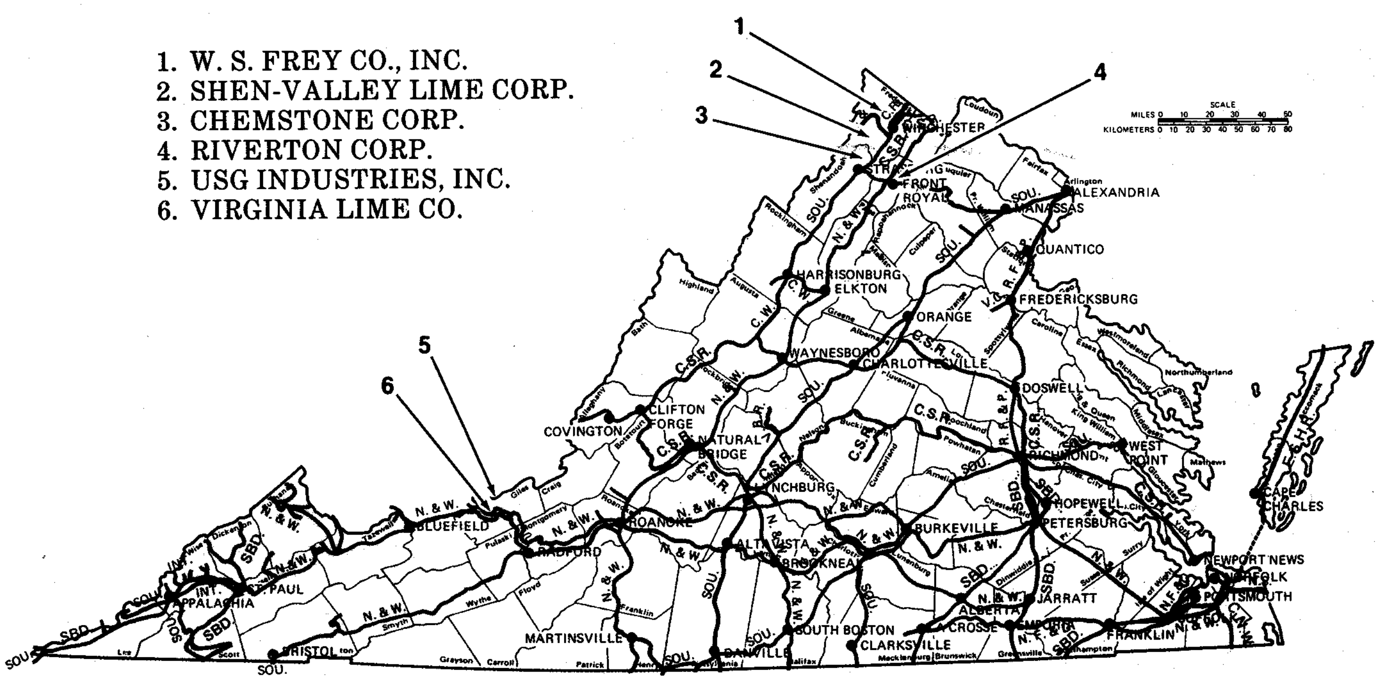

Figure 9. Lime Producers in Virginia.

Figure 10. Abandoned quarry of W. S. Frey Co., Inc.; note sharp contact of New Market Limestone with the overlying Lincolnshire Limestone and underlying Beekmantown Formation.

Figure 11. Abandoned quarry of W. S. Frey Co., Inc., showing Lincolnshire Limestone overlying New Market Limestone in nose of northeast-plunging anticline.

than normal to drive off a significant amount of volatiles.

The calcined stone is marketed as fluxstone for the steel industry, filler and feed ingredients, glass-industry sand, and as an agricultural lime.

Shen-Valley Lime Corporation

Shen-Valley Lime Corporation is located in Frederick County, just west of Stephens City. The company has taken over the former operation of Genstar Stone Products and produces hydrated lime, utilizing purchased quicklime. Lime comes to the plant (Figure 12) by dump truck and is crushed and then put into a storage bin.

Material is fed into the hydrator where water is added from the top; agitation during the process helps to hydrate the lime. Since the water supply is municipal, varying pressure can be a problem. From the hydrator, material is sent by a screw conveyor into the air separator. Here the powdery finished hydraulic lime is separated out; some coarse and some waste material are separated out and recycled. Dust collectors are used to control some of the fines.

The hydrated lime is marketed in bulk and also sold in 10-, 20-, and 50-pound bags for water purification and sewage treatment and for resale by other retail outlets.

Chemstone Corporation

Chemstone Corporation is located in Shenandoah County just north of Strasburg. The company quarries the high-calcium New Market Limestone of Ordovician age. The high-calcium unit is underlain by the Beekmantown Formation and overlain by the Lincolnshire Limestone (Figure 13). Present mining extends both north and south from the center of the quarry. The limestone dips an average of 35 degrees to the east and is as much as 150 feet thick at this locality. There tends to be more pyrite in the stone toward the north end of the quarry. The rock is shot, loaded, and transported to the primary crusher at the plant site (Figure 14).

Some of the limestone is crushed into several sizes for roadstone as well as for introduction into a preheater, where the raw material is heated

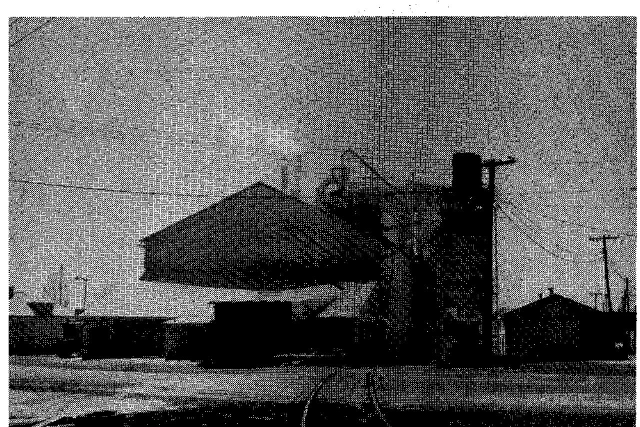

Figure 12. Plant of Shen-Valley Lime Corporation, Stephens City.

Figure 13. Quarry of Chemstone Corporation, Strasburg, looking northeast with dip-slope of the underlying Beekmantown Formation to left.

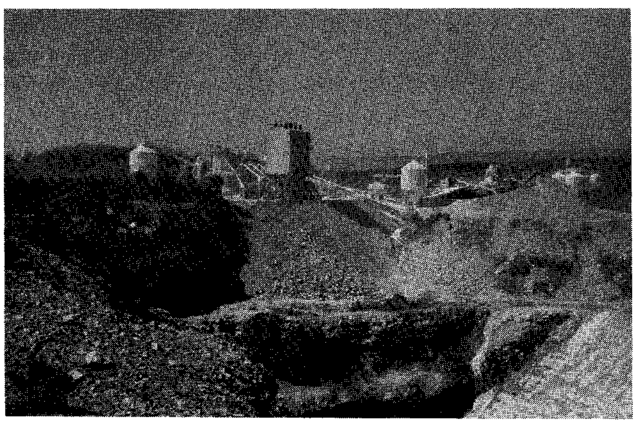

Figure 14. Plant site of Chemstone Corporation, looking southwest from east rim of quarry.

by exhaust gases in a refractory-lined box, before it is fed into the rotary kiln (Figure 15). Bituminous coal, which is stored across State Road 629, travels by conveyor to a Raymond mill where it is pulverized to minus 200 mesh before it goes into the kiln. There are also 5 vertical (shaft) kilns as well as one calcimatic kiln on the property; all of which are gas-fired. The calcimatic kiln is presently in use by the company. Hydrated lime is also produced from some of the quicklime.

Markets for the quicklime and hydrated lime include water purification, sewage treatment, the steel industry, and various chemical uses.

Riverton Corporation

Riverton Corporation, located in Warren County just north of the North Fork of the Shenandoah River, began production in 1868. The company quarries black limestone from the Edinburg Formation of Ordovician age. This limestone is calcined in vertical kilns, hydrated, and added to portland cement to produce masonry cement. The limestone, with shale interbeds, overlies the Lincolnshire Limestone in the quarry. The impure limestone is crushed to ½-inch to 4-inch size, transported in small rail cars, and dumped into the top of the vertical kilns. Pea-size, low volatile anthracite coal is placed both below and above stone in the kilns. Vertical kilns are used at this operation because of their effectiveness relative to capacity and low energy requirement of less than 4 million BTU per ton of lime produced. There is a continuous feed into the kilns which have a processing time of 72 hours.

After the material is calcined it is pulverized and then hydrated with a controlled amount of water and sulfuric acid to produce a hydrated hydraulic lime. The sulfuric acid produces a cemental quality to the batch. The proprietary masonry cements produced by the portland cement industry reach their approximate ultimate strength in 28 days. Hydraulic lime grows in compressive and bonding strength for an indeterminate number of years at a faster rate than portland cement and eventually may exceed a portland cement type mortar in compressive strength.

The company utilizes 8 to 10 million pounds of pigments per year to produce many different colors of masonry cement. Several types of cement are manufactured by varying the percentage of portland cement versus hydrated lime.

USG Industries, Inc.

USG Industries, Inc. is located in Giles County, near Kimballton (Figure 16). The operation was acquired from Gold Bond Building Products of National Gypsum Company in early 1984. The "slope-entry" underground mine is developed in the high-calcium Five Oaks Limestone of Ordovician age, which here averages about 80 feet in thickness. Dips of 15°to 45° to the east may reflect the presence of local faults. The mine has been developed on twelve levels in the past, with the top six levels having been mined out. Stone fed from the ninth and tenth levels is presently crushed on the tenth level of the mine.

After the stone is crushed, it is transported on a 36-inch conveyor to the surface where it goes to the screen house. Material has three potential routes from here: additional crushing, size grind-

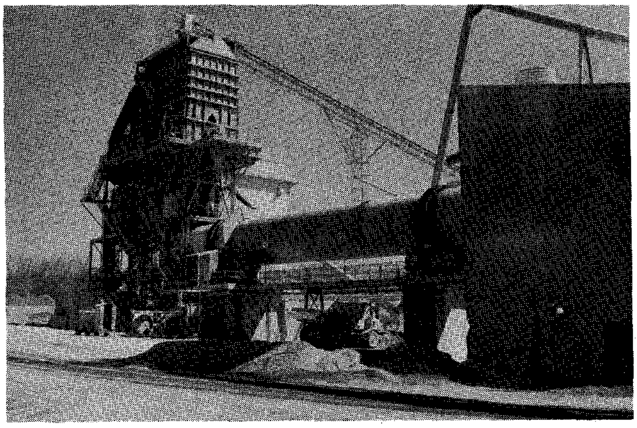

Figure 15. Rotary kiln at Chemstone Corporation, Strasburg.

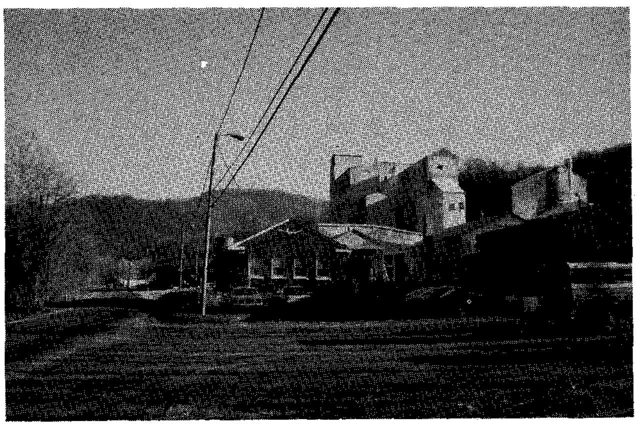

Figure 16. USG Industries, Inc., Kimballton, Giles County.

ing, and calcining. Material for calcining is fed into three rotary kilns fired with bituminous coal. Over the last year or so, the company has added dust collectors for air-pollution control.

Limestone fines are pulverized and sold for agricultural use. Quicklime is also hydrated at this plant. Products are marketed to the pulp and paper industry, steel industry, and for water purification and agricultural purposes.

Virginia Lime Company

Virginia Lime Company, Subsidiary of the Rangaire Corporation (Figure 17), is located in Giles County at Kimballton. This "slope-entry" underground mine (Figure 18) is developed in the high-calcium Five Oaks Limestone, which occurs on both limbs of a northeast plunging syncline. The unit has an average thickness of about 40 feet.

A thrust fault has created minor folds and also open joints, some of which have been filled with mud. The company is presently mining on the 240- and 300-foot levels, under the western slope of Butt Mountain; the mining plan calls for 50-foot rooms and pillars. Mining is now about 500 feet below the surface; future mining to the east will extend to about 1500 feet below the surface.

Limestone is shot and trucked to the plant on the surface. After being crushed, the stone (¼ inch to 2 ½ inches) is fed into kilns which use bituminous coal; two kilns, one 396 feet long, are presently (September, 1986) in use at the plant. Finer-size material that is not used in the rotaries is considered waste and put into settling ponds. Lime is sent to market in rail cars and tank trucks.

Quicklime is hydrated with water, air separated, and sold in bulk and in bags for municipal water purification and sewage treatment plants. The ratio of quicklime to hydrated lime production is 5:1.

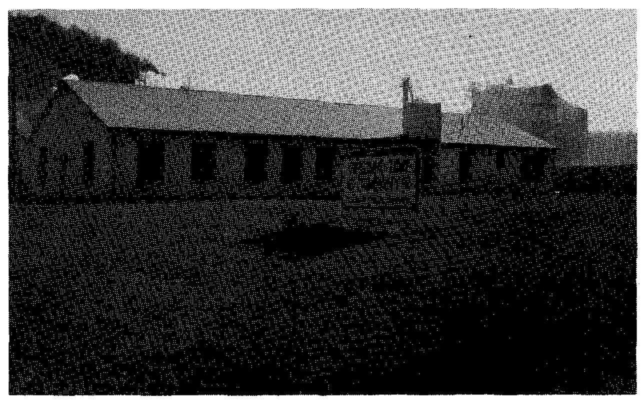

Figure 17. Office of Virginia Lime Company at Kimballton, Giles County.

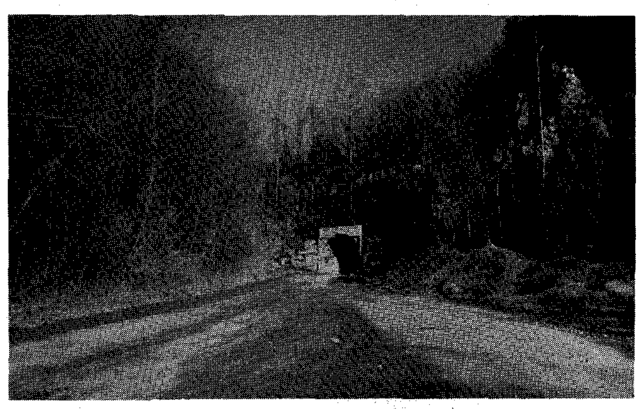

Figure 18. Entrance to "slope-entry" underground mine, Virginia Lime Company, Kimballton.

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MINERAL UPDATE

LARGE ANDALUSITE CRYSTALS FROM VIRGINIA

William F. Giannini, D. Allen Penick, Jr.,
and
Richard S. Mitchell[1]

Exceptionally large reddish to flesh-colored andalusite crystals and pseudomorphs (paramorphs) of kyanite and sillimanite after these crystals have recently been discovered in Campbell County, Virginia. The crystals, collected in clusters weighing up to approximately 150 pounds, are nearly square in cross-section and consist of prism faces bounded by the basal pinacoidal face (Figure 1). Single crystals measure to 4.6 inches wide (prism face width) and 10 inches long (Figure 2). There is a strong possibility that these andalusite crystals are of record

Figure 1. Cluster of kyanite-sillimanite pseudomorphs after andalusite, Campbell County (1-inch scale — photograph by T.M. Gathright, II).

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size. Many of the crystals contain small blue corundum crystals to 0.2 inch long which exist as aggregates to 1.5 inches across. Many of the larger andalusite crystals are now replaced, either by bluish to white, long prismatic kyanite crystals and fibers, or by bluish, dense fibrous masses of sillimanite. Andalusite, kyanite, and sillimanite each have the same chemical composition of Al_2OSiO_4 but form in different temperature-pressure environments. The coexistence of these minerals gives evidence that the immediate geologic physical environment changed considerably after the original andalusite crystals were formed. All minerals mentioned have been identified by X-ray diffraction analyses.

The andalusite crystals were initially formed along both sides of a quartz vein through contact metamorphism with a staurolite-rich muscovite schist. The vein can be traced northeast-southwest for approximately 200 feet and may exceed 10 feet in width near the northeastern end.

Kyanite, sillimanite, and andalusite are used primarily for the production of synthetic mullite for the manufacture of refractories used as linings in metallurgical and glassmaking furnaces and in cement and lime kilns. These minerals are also used for glassmaking and ceramics. It remains to be determined if this new occurrence will be of economic value or only of scientific interest. Additional work and research on the deposit are underway and detailed information will be published.

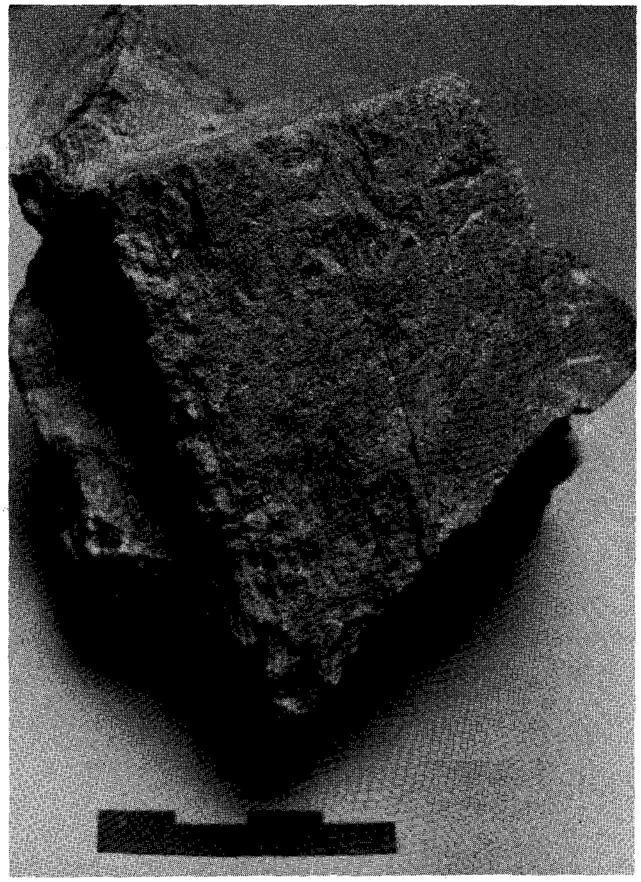

Figure 2. Large pseudomorph of kyanite-sillimanite after andalusite, Campbell County. Prism face measures 4.6 inches across (1-inch scale — photograph by T.M. Gathright, II).