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LIME INDUSTRY IN VIRGINIA

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Introduction

The lime industry has developed to a point where it is the backbone of American industry and agriculture. Few people realize that lime enters directly or indirectly into virtually every manufactured product.

Quicklime and hydrated lime are the two types of lime manufactured. Quicklime is produced by burning calcium carbonate at a temperature where the dissociation of carbon dioxide takes place as shown by the formula ($CaCO_3 \rightarrow CaO + CO_2 \uparrow$). This process is also referred to as calcination. Hydrated lime is formed by adding water to quicklime, which gives the following chemical reaction ($CaO + H_2O \rightarrow Ca(OH)_2$ + heat). The term lime is used to refer to both quicklime and hydrated lime. In Virginia, the lime industry is concentrated in the Ridge and Valley province, where there are extensive deposits of high-calcium limestone. Lime is also produced in the Coastal Plain province, where oyster shells, one of the purest forms of calcium carbonate, are used as the raw material.

How lime is manufactured

The first step in lime production is the quarrying or mining of limestone deposits. Where the amount of overburden permits, open pit quarrying is preferred to underground mining which is a more expensive operation. However, in recent years, more and more companies are finding it necessary to shift from open pit quarrying to underground mining in order to obtain high-calcium limestone.

Holes are drilled in the limestone deposits with various types of drills, loaded with explosives, and blasted into sizes that can be loaded by power equipment into trucks. The material is then hauled to a primary crusher where the individual pieces of limestone are reduced to less than 8 inches in diameter and then screened. Shaft and rotary kilns are used to burn limestone and oyster shells. If shaft kilns are used to manufacture the lime, the screened fragments of limestone, ranging from 4 to 8 inches in size, are sent to a secondary crusher to be broken and screened into sizes ranging from three-eighths of an inch to 2-1/2 inches. Oyster shells are added directly to the kiln without any crushing. In either case, the material is heated to a temperature at which carbon dioxide will dissociate from the calcium carbonate. The amount of heat required for this dissociation depends upon the physical and chemical properties of the limestone undergoing calcination. The highest quality lime is obtained by keeping the temperature at the minimum required for calcining.

A shaft or vertical kiln is a large circular or elliptical furnace for the calcination of limestone and oyster shells. Normally, the size of the kiln is governed by the demand for quicklime which can be stored for only a short duration of time. The outer casing of the shaft kiln, constructed from either reinforced concrete, stone or metal, serves the following purposes: it supports the weight of the kiln, protects the inner refractory material from changes in temperature, and reduces the amount of heat lost by conduction and radiation. The inner portion of the shaft kiln is lined with two layers of refractory brick, the second of which serves as a backing. The specifications for the refractory brick depend upon the particular section of the furnace in which it is used. The shaft kiln is divided into three sections: a preheating section, a burning or calcining section, and a cooling section. Brick in the preheating section must withstand the abrasion of rock being added to the kiln; in the burning section, the brick not only must resist abrasion but also corrosion and high temperatures. Finally, in the cooling section, the brick must be capable of withstanding the weight of the overlying brick lining.

The preheating zone, shaped like an inverted cone, serves both as a storage area to insure continuous operation and as a preheating section. The top of this zone may be covered or uncovered, depending upon the type of draft in the kiln. The kiln is loaded or charged at the top with limestone fragments from 4 to 8 inches in size. Limestone from the preheating section passes into the burning zone of the kiln, where calcination takes place. Normally the temperature in the burning zone is somewhere between 1600° and 1800° F., depending upon the physical and chemical properties of the limestone. After the lime has been formed it should be moved into the cooling section of the kiln to prevent overburning which would result in a product of inferior quality.

Natural gas and coal are the two fuels used in shaft kilns by Virginia lime producers. Coal is mixed directly with the limestone or oyster shells in an approximate ratio of 1:5. However, natural gas is a better fuel because it gives the operator a greater degree of control over the heat throughout the kiln. The natural gas and primary air are forced under pressure into a center burner divided into two sections. Separate controls for each section regulate the amount of gas in the center burner. If the temperature on one side of the kiln becomes too high, it can be lowered by reducing the amount of gas in that section of the burner.

The draft from the combustion in the burning zone forces the gases up through the limestone and the top of the kiln. The draft may be natural, forced by a fan at the bottom of the kiln, or induced by an exhaust fan located at the top of the kiln. At several plants hot gases are recirculated through the system in order to reduce fuel consumption. The quicklime from the burning zone falls into a cone-shaped cooling zone, where the heat is removed by radiation, conduction, and outside air passing up through the kiln. The quicklime is taken out through doors at the bottom of the kiln.

Rotary-type kilns are used by two of the largest lime manufacturers in Virginia. These kilns have two major advantages over the shaft-type. Lime plants with large tonnage requirements need several shaft kilns or one large rotary kiln. The cost factor is so much in favor of the rotary kiln that it is used extensively by large-capacity plants. Rotary kilns also permit the use of smaller size fragments than the shaft kiln where small sizes cut off the draft. A rotary kiln is a long (290 to 396 feet), inclined, refractory-lined metal cylinder which is encircled by steel rings, or wheels. A four-speed electric motor, regulated to conform with the amount of rock added, turns the kiln with a series of gears. At the upper end of the rotary kiln is a covered chamber for the collection and removal of dust. A stack, located beyond the chamber, provides a draft through the chamber and kiln. In case of power failure, an auxiliary gasoline engine is kept ready to revolve the heated kiln to prevent it from cracking.

Lime Plants

1. Reliance Fertilizer and Lime Corp., Norfolk, Va.
2. Battery Park Fish and Oyster Co., Battery Park, Va.
3. M. J. Grove Lime Co., Stephens City, Va.
4. Chemstone Corp., Strasburg-Dominion Division, Strasburg, Va.
5. Montgomery Lime Co., Inc., Christiansburg, Va.
6. National Gypsum Co., Kimballton, Va.
7. Standard Lime and Cement Co., Kimballton, Va.
8. Ripplemead Lime Co., Inc., Ripplemead, Va.
9. Perry Lime Co., North Tazewell, Va.
10. Blue Grass Lime Co., Maxwell, Va.

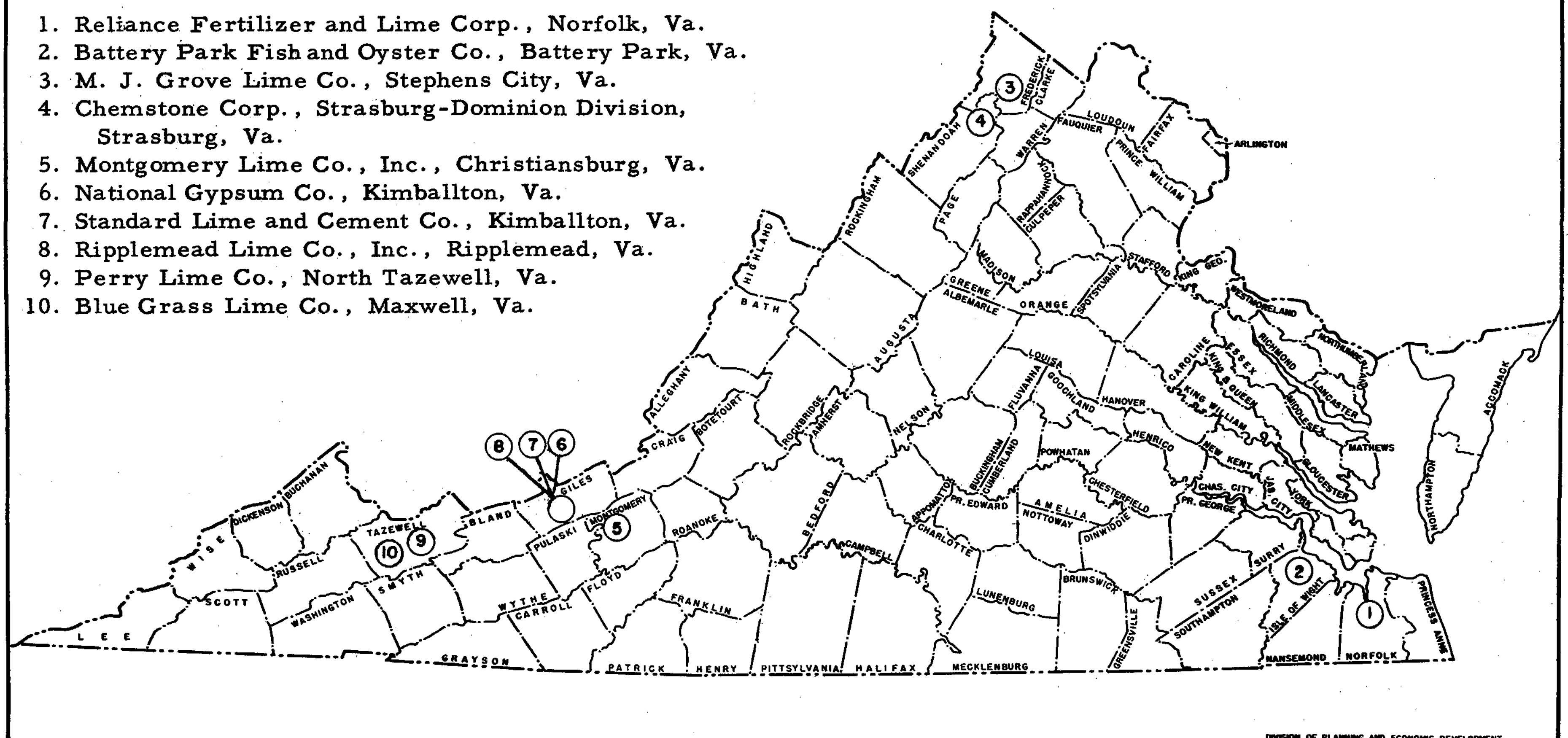

Figure 1. Location of lime plants in Virginia.

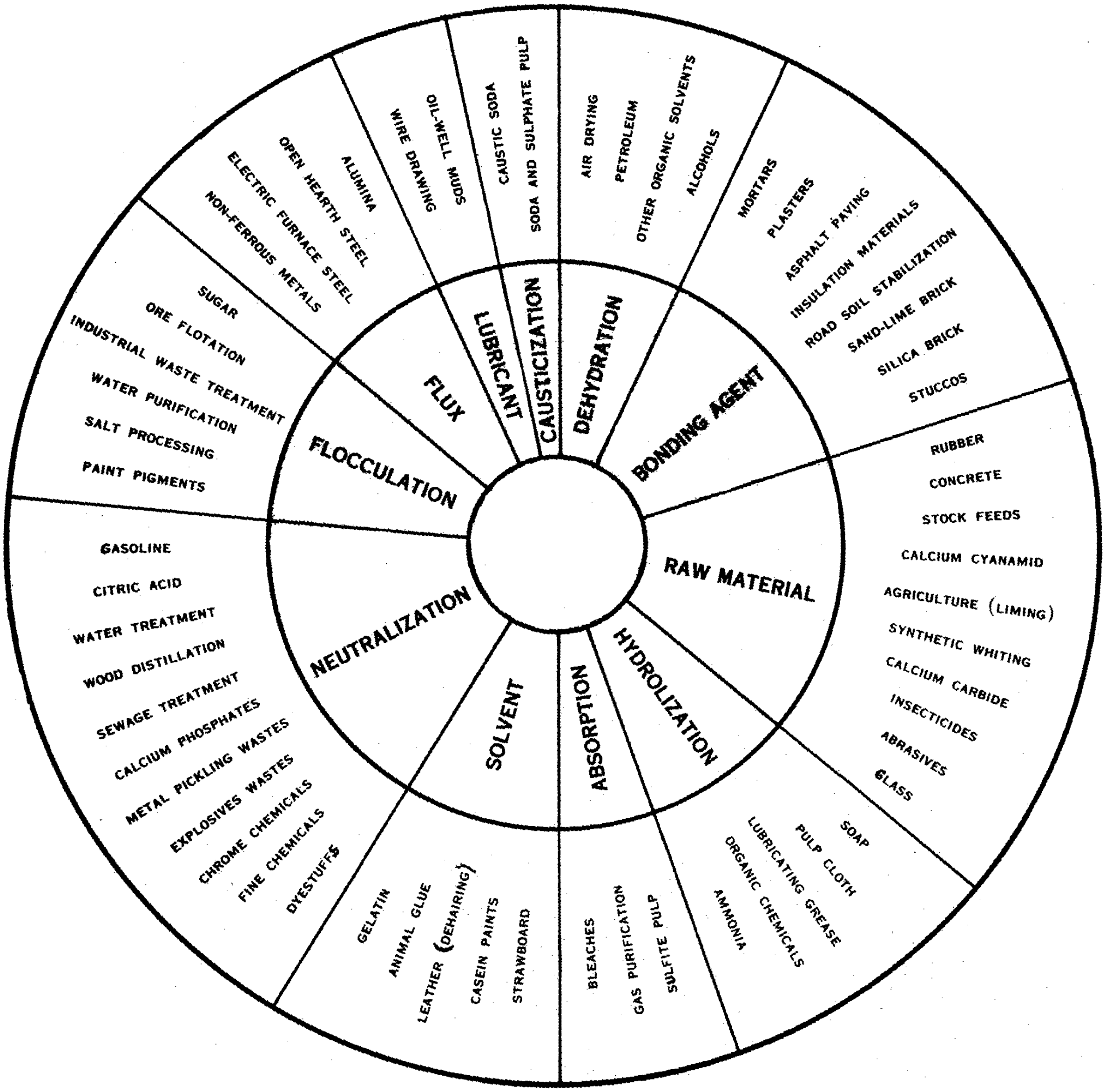

Figure 2. Functions and uses of lime. (Reproduced by courtesy of the Baltimore and Ohio Railroad Company).

Limestone fragments from three-eighths of an inch to 2-1/2 inches in size enter the rotary kiln at the charge end or smallest section of the kiln. An induced draft from an exhaust fan in the flue stack pulls the gases from the burning zone through the kiln, preheating the rock in the feed or charge end. As the rock moves down the kiln by gravity, the diameter of the kiln increases, allowing the rock to be spread over a larger surface area in the burning zone. It is in this zone that the dissociation of CO_2 from $CaCO_3$ takes place. The quicklime from the burning zone moves into coolers. The cooled quicklime from either type of kiln is inspected for underburning and overburning before it moves to a crusher and screens for classification. The quicklime, shipped by the carload, bulk, or in paper bags, is classified as follows:

(a) Lump quicklime - maximum size of 8 inches;

(b) Crushed or pebble quicklime - sizes from one-fourth of an inch to 2-1/2 inches;

(c) Ground quicklime - large-size particles ground so that all will pass a No. 8 sieve and 40 to 60 percent a No. 100 sieve;

(d) Pulverized quicklime - instant grinding so that all will pass a No. 20 sieve and 85 to 95 percent a No. 100 sieve.

Hydrated lime is manufactured from lump quicklime which is ground to a uniform size and thoroughly mixed with water to insure proper hydration. Hydration is carried out in machines called hydrators which are either intermittent or continuous. The intermittent hydrator consists of a revolving drum with stationary paddles mounted on the center shaft to agitate the quicklime and scrape the bottom of the drum. Water is added in the form of a fine spray from a needle valve located in the stack covering the hydrator. This spray recovers the dust which would normally escape through the stack. The quicklime remains in the hydrator until a dry fluffy powder is formed. The continuous hydrator consists of steel tubes, one on top of the other, each of which contains a screw conveyer. Water is added to the quicklime in the upper tube, and a mixture of lime and water is moved from top to bottom through the hydrator by the screw conveyers. When the mixture reaches the bottom of the hydrator, the lime is completely hydrated. The amount of water for hydration is carefully controlled as too much water will result in a wet, sticky lime; too little water will leave an underslaked lime.

Hydrated lime is classified by a cone-shaped Raymond air separator. Hydrated lime, upon entering the classifier, encounters two fans, or "whizzers," that revolve at a high rate of speed. The fans force the hydrated lime out toward the edges of the cone, where a rising current of air is encountered. The light hydrated lime is carried by the rising current of air into dust proof bins for storage, while the heavier material drops down to the bottom of the cone. The classified hydrated lime from the storage bin is packed into 50-lb. bags for shipment.

Uses of Lime

As an industrial chemical, lime ranks second, being surpassed by sulfuric acid. The importance of lime as a chemical can be attributed to its many uses, low cost, and abundant supply. Lime is also widely used in agriculture and to a lesser extent in the building industry.

The wide usage of lime in industry is graphically shown by Fig. 2. Most of the lime produced in Virginia is consumed in the production of steel, calcium carbide, and paper; in agricultural uses; and in water-treatment plants for water purification. A major portion of the lime goes into the steel industry in the form of "pebble" quicklime that is used in electric furnaces, basic Bessemer furnaces, and open-hearth furnaces to form a slag in which impurities such as silicon, phosphorus, and sulfur are removed. The amount and grade of quicklime used depend upon the purity of the iron ore being smelted. In the manufacture of pig iron, a whitewash coating on the molds prevents pig iron from sticking to the mold.

Year	Active Plants	Rank in U. S. in quantity	Building	Chemical	Agriculture	Total
1905		8th				114,221
1910	48	7th				141,257
1915	40	3rd	67,050	138,372	45,149	267,278
1920	35	3rd	63,082	160,996	26,974	251,052
1925	30	8th	86,307	78,069	28,053	192,429
1930	26	7th	50,993	69,455	26,548	146,996
1935		6th	34,486	79,550	19,660	133,696
1940	23	7th	32,638	122,148	23,250	178,036
1945	15	10th	8,867	87,845	21,995	118,707
1950	11	6th	7,258	399,203	21,878	428,339
1955	10	*	4,355	462,993	26,945	494,293
1956	10	*	3,564	483,457	25,125	512,146
1957	10	*	*	*	*	*

* Data unavailable.

Table 1. Distribution of lime production in Virginia by uses in short tons.

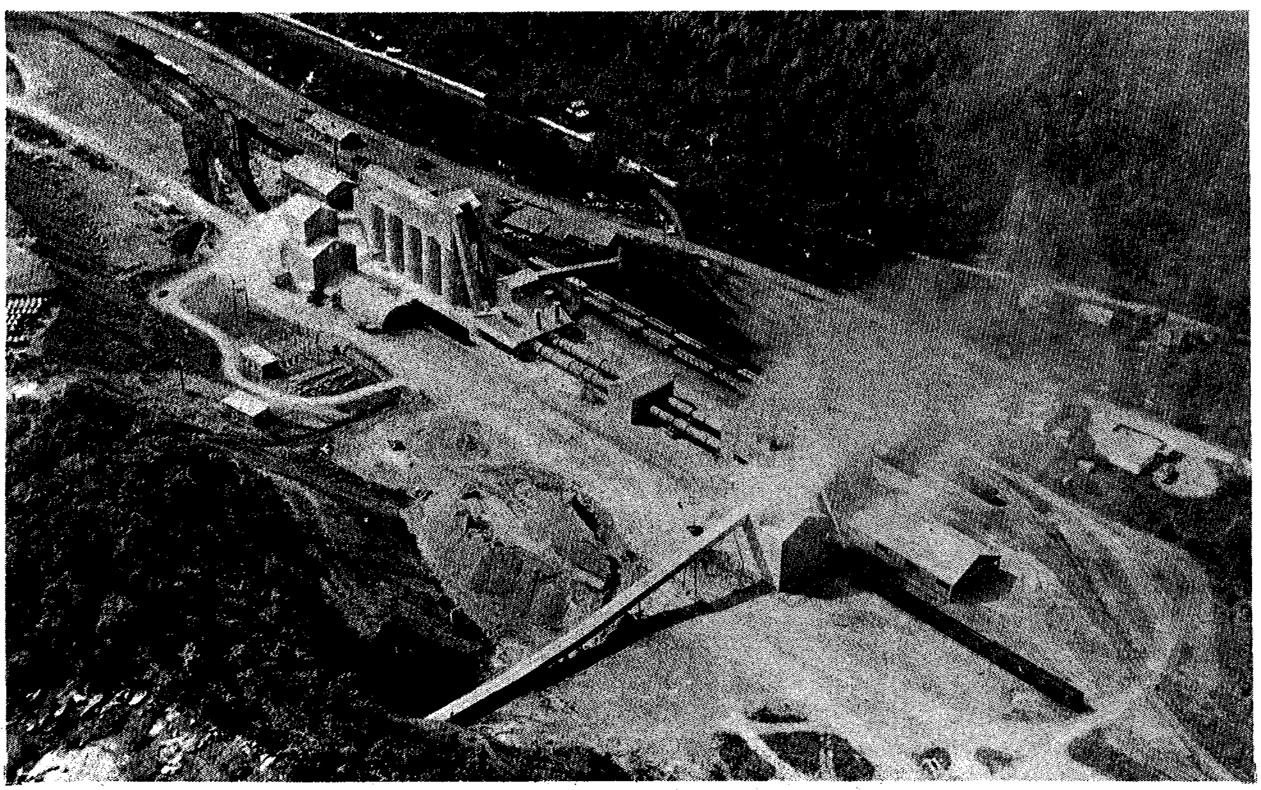

Plate 1. National Gypsum Company lime plant at Kimballton, Giles County. At right, conveyer that feeds limestone from mine to crushing and screening plant; center, two rotary kilns; left, storage bins and hydrating plant.

"Pebble" lime is also used in the manufacture of wire. Lime acts as a lubricant for the dies through which the wire is drawn and as a neutralizer of the pickling acid, and it protects the finished product from oxidation.

An important market for chemical lime is its use in the paper industry. For example, calcium hypochlorite, a bleach liquor, that is formed by the combination of chlorine and lime, is the cheapest and oldest material used to bleach pulp to the desired degree of whiteness. Another use of lime in the paper pulp industry is as a causticizing agent in plants using the Kraft process. In the Kraft process, wood pulp is cooked in a mixture of caustic soda and sodium sulfide. Sodium carbonate solution is recovered from the cooking liquid and reacted with high-calcium quicklime to generate caustic soda which is used again in treating more pulp.

Lime is also used to neutralize pulp-plant waste and to coagulate, such products as yeast, sugar, lignosulfonates, and lactic acid.

High-calcium quicklime is essential in the production of calcium carbide ($CaO + 3C \rightarrow CaC_2 + CO$), the chief source of acetylene. The high-calcium quicklime is mixed with coke and heated in a furnace to a temperature of 2000° C. Molten carbide is removed from the furnace, solidified and later crushed into desired sizes. Acetylene is used in cutting and welding metals and as a raw material in the manufacture of acetaldehyle, alcohol, acetone, rubber, and Lewisite.

In recent years, the use of lime as a stabilizer for the base and subbase modern highway construction has increased considerably. In this use, lime acts as a stabilizing agent in clay soils, and a natural cement is formed by the pozzuolanic reaction between the lime and the available silica and alumina in the clay. Tests have shown lime stabilization has increased the durability of the roads.

Another important application of lime is in the purification of water for industrial and municipal use. Lime is added to the water to coagulate impurities and remove temporary (bicarbonate) hardness. In this reaction, lime combines with the bicarbonates to form insoluble carbonates that are precipitated.

Some types of stream pollution may be stopped by the treatment of industrial waste and sewage with lime. In the chemical industry, acid wastes are neutralized before entering streams. In the textile industry, lime is used to neutralize various acid wastes and precipitate various waste solids.

The chief agricultural use of lime is as a soil corrective and conditioner. The importance of agricultural lime can be appreciated when one realizes that approximately three-fourths of the cultivated land in the Eastern United States is acid or "sour" and needs liming. The application of agricultural lime to the soil is beneficial for the following reasons (Bowles, 1951, p. 25):

"(1) Neutralizing soil acidity;

(2) Replenishing the supply of calcium and magnesium;

(3) Promoting the activity of beneficial bacteria and depressing injurious soil organisms;

(4) Improving the texture and permeability of heavy soils by flocculating the colloids and clay particles;

(5) Hastening decay of organic matter and formation of nitrates;

(6) Rendering iron and aluminum insoluble, thereby preventing the phosphorus in the soil from combining with them in unavailable form, and preventing toxicity;

(7) Combining with nitrogen and phosphorus in easily available form;

(8) Acting as a germicide in certain soil-borne plant disease organisms;

(9) Leaving the soil in a well-balanced, productive condition."

Production

Lime production in Virginia in 1956 reached an all-time high of over one-half million tons valued at nearly six million dollars. The chemical and metallurgical utilization consumed over 94 percent of the total lime produced, while the agricultural utilization consumed only 4 percent. Of the total lime sold in 1956, 95 percent was in the form of quicklime.

Several interesting trends in the Virginia lime industry are shown by Table 1. There has been a sharp decline in the quantity of lime used in the building industry, due to such substitutes as wallboard, gypsum, and mortar mix. The rapid expansion of the chemical uses of lime is shown in the production chart. The number of active plants has decreased from 48 in 1910 to 10 in 1957, but the quantity of lime produced has steadily increased. There has been a gradual transition from small low-cost plants to highly mechanized plants with a greater producing capacity. Smaller companies unable to compete with the larger companies, are forced to rely on local markets for the consumption of their lime.

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PROJECTS OF U. S. GEOLOGICAL SURVEY IN VIRGINIA

Thirteen projects listed below are summarized from information received from Harold M. Bannerman, Acting Chief Geologist, U. S. Geological Survey.

1. Geologic mapping of the Duffield, Stickleyville, Olinger, Keokee, and Pennington Gap 7-1/2-minute quadrangles, with L. D. Harris in charge: The area covers adjoining parts of Scott, Wise, and Lee counties. The objectives are to appraise the oil and gas potential beneath the major overthrusts, to obtain additional knowledge on the major overthrusts, to develop an integrated picture of the mechanism whereby the folds and faults of the southern Appalachians were produced, and to extend the physiographic interpretations previously developed in southwestern and central Lee County. The Duffield quadrangle has been mapped, and it is expected that mapping of the Stickleyville quadrangle will be completed during 1958.

2. Geology and mineral resources of a part of the southern Appalachian folded belt in Virginia, Kentucky, North Carolina, and Tennessee, with J. G. Stephens in charge: This is a long-range project that covers 23 quadrangles, of which parts of four quadrangles are in Virginia. Mapping is in progress in the Ewing (Kentucky-Virginia), Varilla (Kentucky-Virginia), and the Coleman Gap (Virginia-Tennessee) 7-1/2-minute quadrangles. Detailed geologic mapping and subsurface study have been undertaken in order to develop an integrated picture of the tectonic history and subsurface relations of the area. The evaluation of the oil and gas possibilities, as well as such mineral resources as zinc, manganese, limestone, and construction materials, will also be included in the study.

3. Potomac Basin erosion studies, with J. T. Hack in charge: The main objective of this project is a study of the Cen-

ozoic history and development of the Potomac River watershed to provide background for the evaluation of theoretical hydrologic concepts and, in turn, to apply hydrology to the study of geomorphology. The current field work includes reconnaissance mapping of surficial deposits in the Shenandoah Valley.

4. Synthesis of geologic data on the Atlantic Coastal Plain and Continental Shelf, with J. E. Johnston in charge: This study was begun in June 1957, and its purpose is to synthesize and interpret the existing geologic data and to evaluate the petroleum potential of the Atlantic Coastal Plain and the Continental Shelf from northern Florida to the Canadian border.

5. Geology and petrology of the Fairfax, Manassas, Herndon, and Vienna 7-1/2-minute quadrangles, with Charles Milton in charge: Geologic mapping of the area, which is in adjoining parts of Fairfax and Loudoun counties, is in progress.

6. Sedimentary petrology of selected areas in Virginia, with Dorothy Carroll in charge: This project, which is in progress, is a study of the mineralogy of rocks and soils and the mechanical composition of soils and unconsolidated deposits in Augusta and adjacent counties.

7. Correlation between magnetic and areal geology, with W. J. Dempsey in charge: The objectives of this study are to correlate magnetic and geologic data in specific areas throughout the United States, to check and improve techniques of magnetic interpretations, and to determine to what extent magnetic information can be used in the differentiation of rock units and structural features. In Virginia an area near Galax, about the size of two 15-minute quadrangles, has been flown for radioactivity, and the magnetic data will be studied and correlated with the geology and the radioactivity results.

8. Shenandoah Valley dikes, with R. W. Johnson in charge: The primary objective of this study is to obtain knowledge of the surface expression and the extent of a small representative group of dikes, and to correlate this information with data obtained from an aeromagnetic survey, primarily to determine the surface distribution of the dikes. A report on the regional aeromagnetic profiles in central-western Virginia is now available in open files.

9. Southeastern granites, with J. B. Mertie, Jr., in charge: This study is designed to determine relative and absolute ages of granitic rocks in Virginia, North Carolina, South Carolina, and Georgia, and to obtain petrographic and structural data for economic and scientific purposes. The field work has been completed and the report is now being prepared.

10. Southeastern bauxite deposits, with E. F. Overstreet in charge: The main objective is to bring up to date and integrate for publication, reports on war-time exploration and drilling for bauxite in the Gulf Coastal Plain and the southern Appalachian region. The first part of the report, covering work done on bauxite during World War II, is undergoing technical review prior to editing. The second part, consisting of the summary and conclusions, is in preparation.

11. Southeastern monazite exploration, with W. C. Overstreet in charge: This project was started in 1951 to appraise and evaluate the monazite placers in the southeastern Piedmont, including that portion in Virginia. The field work has been completed and the final report is being prepared.

12. Hamme tungsten district, with J. M. Parker, III, in charge: The Henderson, North Carolina, quadrangle, which includes part of the Hamme tungsten district and the extension of the schist-granite contact along which the mineralization occurs, north of Roanoke River in Virginia, have been mapped and the report has been submitted for technical review.

13. Geophysical investigations, southeastern United States, with John Henderson in charge: In 1957 a study was begun to correlate the results of aeromagnetic and gravity surveys with the regional structural geology of parts of the Appalachian and Piedmont provinces of the southeastern United States; to investigate the application of geophysical methods to studies of geol-

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ogy, with particular emphasis on mineral deposits, in selected areas within these provinces; and to conduct experimental tests of the use of new and modified geophysical methods in areas of deep weathering. During the fiscal year field studies will be made in the Appalachian belt in Virginia, Tennessee, and Kentucky.

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NEW QUARRIES

Martinsville Stone Corporation recently opened a quarry in granite gneiss, near Martinsville, Henry County. The corporation produces approximately 2000 tons of crushed stone per day from this operation.

Gainesville Stone Quarry, Inc., plans to open a quarry in diabase, near Gainesville, Prince William County, in the early spring of 1958. The Company is installing a plant which will have a capacity of 200 tons per hour, and is stripping overburden at the quarry site.

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DMEA PROJECTS IN VIRGINIA

The Defense Minerals Exploration Administration projects listed below are summarized from information received from Robert A. Laurence, Executive Officer, DMEA Field Team, Region V, Knoxville, Tennessee.

The following four projects were active in February 1958, with the government's share of exploration costs being $68, 630.00:

Operator	County	Commodity
1. Craven, Shufflebarger and Patteson	Nelson	Rutile
2. The New Jersey Zinc Co.	Louisa	Zinc-lead-copper
3. The New Jersey Zinc Co.	Wythe	Zinc-lead
4. The New Jersey Zinc Co.	Smyth and Wythe	Zinc-lead

The following five projects were completed during 1957, with the government's share of exploration costs being $58, 813.00:

Operator	County	Commodity
1. The New Jersey Zinc Co.	Spotsylvania	Zinc-lead-copper
2. The New Jersey Zinc Co.	Buckingham	Zinc-lead-copper
3. The New Jersey Zinc Co.	Smyth	Zinc-lead
4. The New Jersey Zinc Co.	Smyth	Zinc
5. Roland F. Beers, Inc.	Buckingham	Copper-lead-zinc

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