REPORT

OF THE

STATE GEOLOGIST

ON THE

MINERAL INDUSTRIES

OF

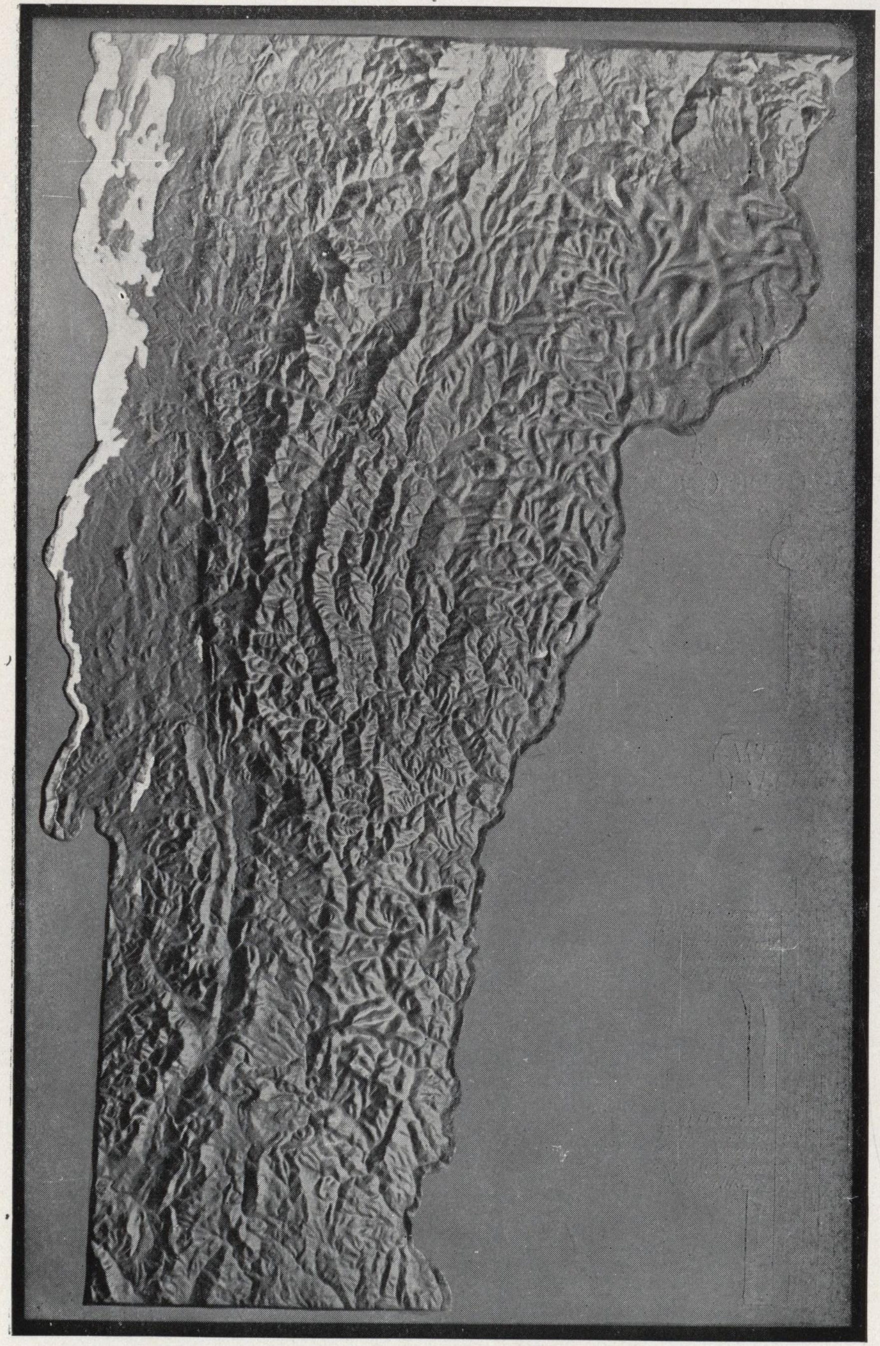
VERMONT

1939-1940

TWENTY-SECOND OF THIS SERIES

ELBRIDGE C. JACOBS
State Geologist

The Printcraft Shop, Barre, Vt.



RELIEF MAP OF VERMONT

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STATE OF VERMONT
OFFICE OF STATE GEOLOGIST
BURLINGTON

To the Board of Conservation and Development,
Montpelier, Vermont,

Gentlemen:

I herewith present my biennial Report, as State Geologist, for 1939-'40.

In this Report I have gone very thoroughly into the mineral industries of the State, in all their aspects, and have endeavored to show the value of our mineral products and the number of men engaged.

The present status of topographical mapping in the State is shown.

I have also given an account of the efforts of the New Products Committee of the New England Council to locate new mineral deposits and to deveolp new mineral products in Vermont.

Visits to many mineral localities have been made, an unusually large correspondence has been carried on, and many consultations have been held with persons and companies interested in our minerals.

Respectfully submitted,
Elbridge C. Jacobs,
State Geologist

Fleming Museum,
University of Vermont.
December, 1940.

FOREWORD

Fom many years Vermont stood first among the States of the Union in the value of her granite and marble production but, in 1939, she yielded first place in marble to Tennessee on account of the latter's large contracts for the National Gallery of Arts, in Washington, D. C. Vermont produces more asbestos fiber than all other States combined. She stands second only to Pennsylvania in the value of her slate production and third in the value of her talc products. Besides these minerals and rocks, she produces a great deal of limestone and lime, and will soon be an important producer of China clay of which she has very large deposits. Heat-resisting products, fire clay, mica, garnet, bricks, jasper, sand, gravel, and crushed stone make up the balance of her mineral products.

In 1939 the total value of Vermont's mineral products exceeded twelve million dollars and over four thousand men were employed in her mineral industries.

In the following pages each of these industries is considered in its various aspects.

The value of Vermont's mineral wealth lies in her nonmetallic resources. Although there are many small occurrences of metallic minerals—gold, copper, manganese, and iron ores, molybdenum. and others—they are not believed to be of economic importance and so have not been discussed.

An account is given of the New Products Committee, of the New England Council and its activities in seeking to discover new economic minerals and new uses.

CONTENTS

ILLUSTRATIONS

Asbestos

The Minerals Yearbook, for 1940, of the U. S. Bureau of Mines, will state that the sales of domestic asbestos, in 1939, attained an all-time high of 15,459 tons, which was an increase of 48 per cent over 1938. Imports of asbestos also greatly increased. Consumption was 37 percent greater than in 1938 but was far below the high point of 1937. The United States led all countries in the manufacture of asbestos products but, in 1939, produced only six percent of its requirements, the remainder being imported, chiefly from Canada.

The Vermont asbestos industry reached a new high point in 1939 and is in a highly prosperous condition. Vermont produced more asbestos than all the other states of the Union combined.

Uses

Asbestos is a mineral remarkable for its finely-fibrous, flexible nature and for its resistance to heat. The choicest variety is the beautiful amianthus, which is seen chiefly in museum and laboratory displays. Besides this there are the long, "cross", spinning fiber, often several inches in length, which is used in the manufacture of fire-proof curtains, gloves, etc.; and the short, "slip," fiber which finds many uses, such as brake linings for automobiles, trucks, and other transport, in asbestos shingles (made of Portland cement and about 15 percent of asbestos), wall-board, asphalt roofing, corrugated paper for insulation, pipe and boiler covering, and in other products. It is for such purposes that the short-fibered Vermont mineral is finding increased markets. The Army and Navy Munitions Board classes asbestos as a strategic mineral on account of its use in brake-bands and clutch-facings. (It is of interest to note that other "strategic" substances are aluminum, antimony, chromium, manganese, mercury, mica, molybdenum, nickel, rubber, tin, and tungsten.)

Occurrence

Two varieties of asbestos occur: (1) the fibrous forms of the amphibole group of minerals, chiefly tremolite and actinolie, which gives rise of the stiffly-fibrous agalite of Gouverneur, N. Y., and (2) chrysotile, which is the chief asbestos of commerce, and is the fibrous, flexible variety of the hydrous magnesian silicate, serpentine ($H_4Mg_3Si_2O_9$). This, in turn, is an alteration product of ultra-basic rocks, such as peridotite, dunite, or pyroxenite, ingeous rocks which have come up from the depths of the earth and solidified in the crustal rocks.

The Vermont asbestos deposits are of the chrysotile variety. They are being quarried only on Mt. Belvidere, in Eden and Lowell townships, Lamoille County. (See the Jay Peak quadrangle of the U. S. Topographical Survey). These deposits belong to a broken chain of asbesticized serpentine lenses that runs somewhat east of north, from Moretown, Vermont, into southern Quebec where, in the Thetford, Black Lake, and Danville districts, the largest asbestos workings in North America are found.

On Belvidere Mountain quarrying operations have been carried on by various companies for forty years, but it was only with the advent of the Vermont Asbestos Corporation, in 1929, that commercial success was attained. This corporation was taken over, in 1936, as a subsidiary, by the Ruberoid Company of New Jersey and is now in highly successful operation.

The company has acquired nearly all the asbestos-containing properties on the southern and eastern flanks of the mountain—the old New England, Gospel Right, University of Vermont, Rivers, and Gallager lots— and now owns some 1800 acres of mineralized land. Quarrying operations on a large scale are being carried on, on the south side of Belvidere at the 2150-foot level. The asbestos-bearing serpentine lies beneath a capping of the rock, amphibolite, which extends down from the summit (3360 feet above sea-level) for about a thousand feet. The geological relationship of the amphibolite to the serpentine has not been accurately determined but is generally regarded as a fault contact.

Genesis of the Asbestos

The ultra-basic igneous bodies have been intruded into the metamorphic country rocks of the region: slates, phyllites, quartzites, schists, and gneisses, of Pre-Cambrian and Cambrian ages. These ultra-basic rocks have been altered to serpentine and this, in turn, to chrysotile asbestos. The asbestos occurs chiefly as "slip fiber", lying generally parallel to the serpentine surfaces, but some "cross" fiber also occurs, lying at about right angles to fractures in the serpentine, which it has, so to speak, healed.

Plate 1.

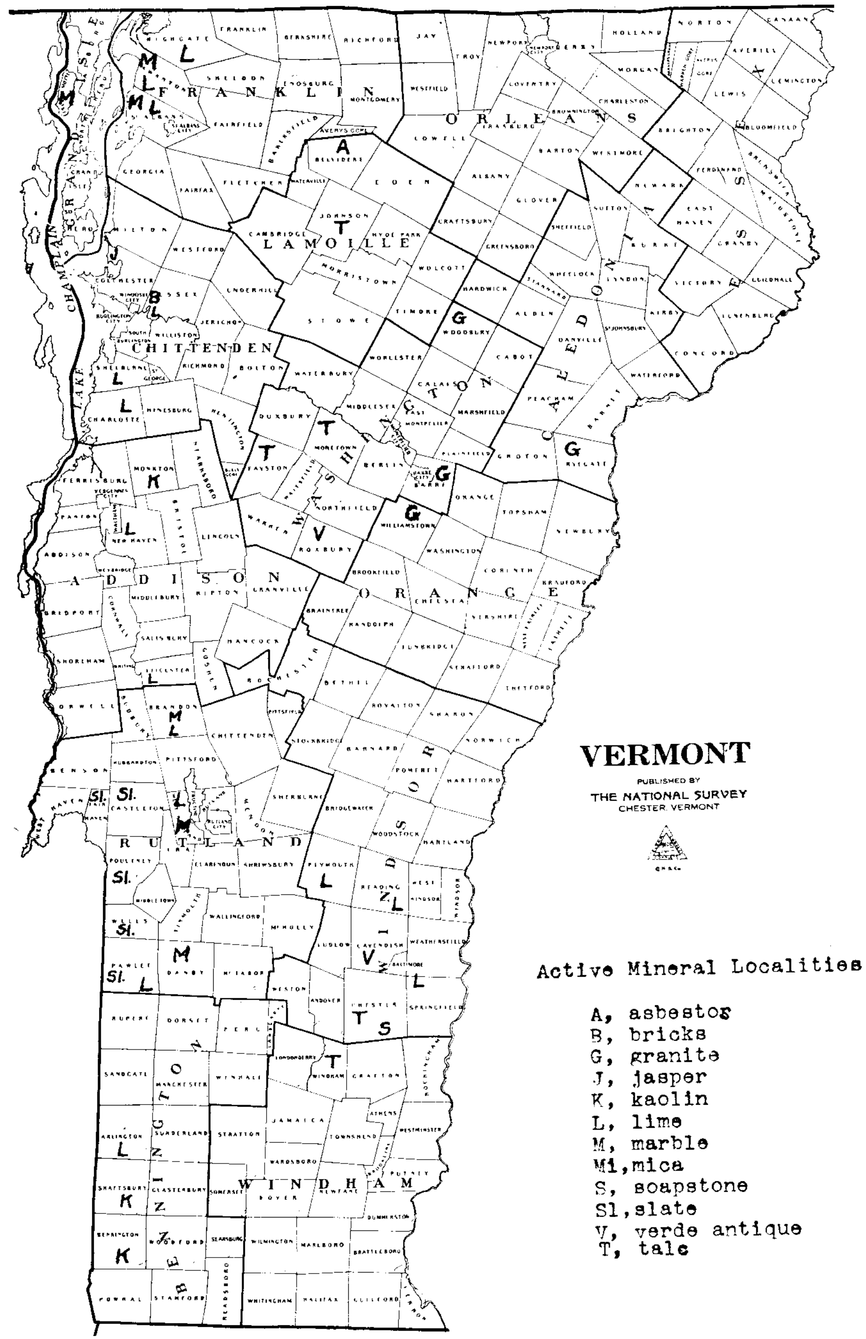
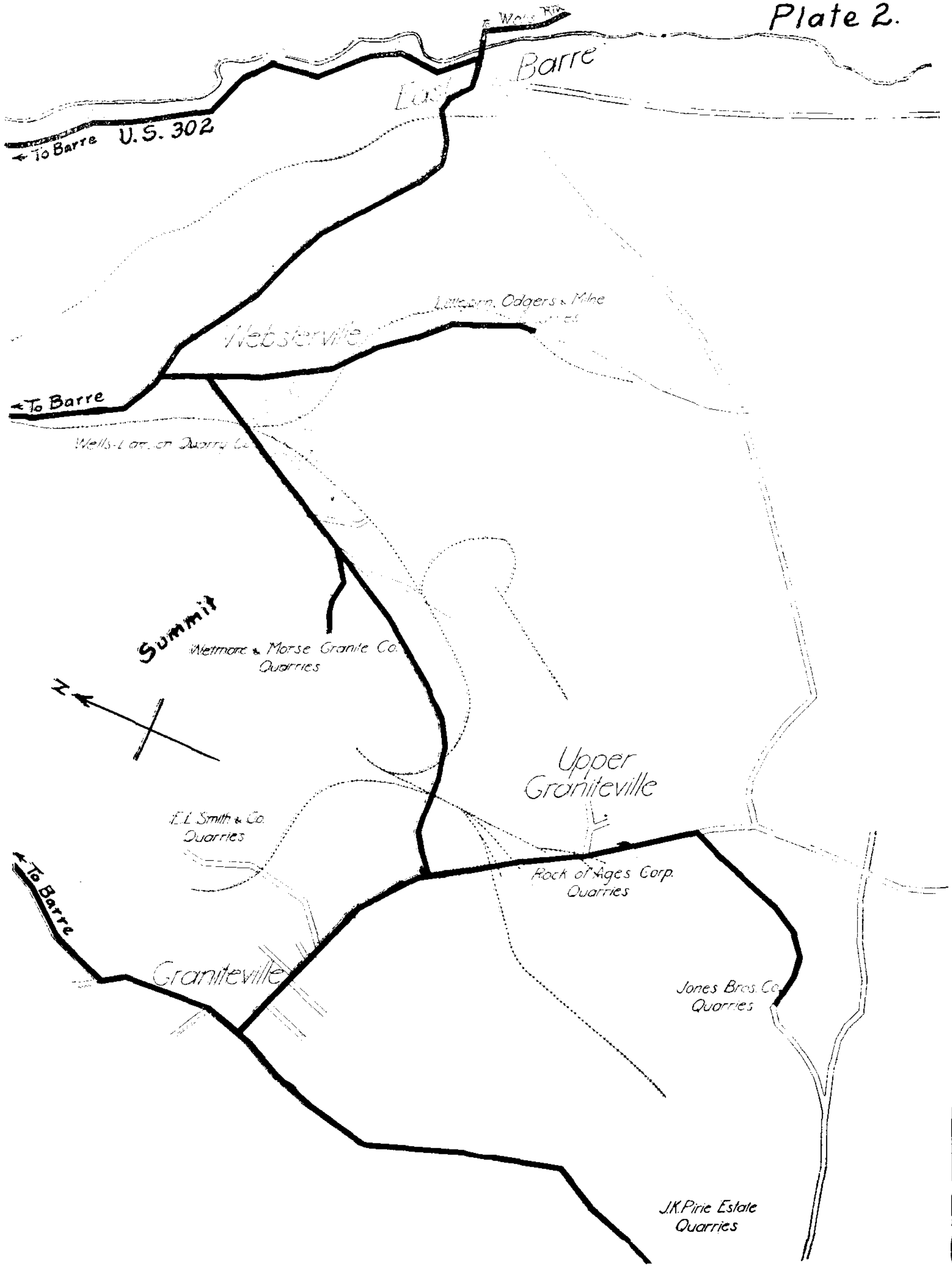


Plate 2.



Various theories have been proposed by writers for the formation of the asbestos but probably the most accurate is that of Keith and Bain[1].

They find that the asbestos has been formed in cracks in the serpentine, produced by earth movements; that the asbestos has resulted from the action of acids of silicon (of which there are several) on the serpentine, at some distance from the fiber; and that these acids have probably been derived from granitic intrusions.

Small amounts of magnetite (Fe_3O_4) and chromite ($FeCr_2O_4$) occur in the serpentine and go to the tailings dump, which now contains millions of tons. A concentration test, made to determine if the chromite could be profitably recovered, showed about one percent chromite, an amount too small for economic recovery.

Asbestos Production

The Minerals Yearbook for 1940 will give the following data of world production and consumption for 1939 in metric tons[2].

	Production	Imports	Exports	Apparent Consumption
North America	272,365	162,830	152,883	282,312
Europe	98,812	150,177	20,648	228,341
Africa	74,377	181	73,110	1,448
Asia	11,375	44,206	5,590	49,591
Australia	176	11,358	....	11,534
So. America	141	328	21	448
Totals	457,246	369,080	252,652	573,674

From this table it is calculated that North America consumes 59.6 percent and Europe, 21.6 percent, of the whole.

In North America, Canada is by far the greatest producer, with 264,894 short tons, in 1938, of which 223,840 short tons, valued at \$7,577,198, were exported to the United States, in the form of mill fibers, short fibers, and crude material.

The United States produced 12,901 short tons, in 1938, and 15,459 tons in 1939; for these, values are not given. Our dependence on Canadian asbestos is evident.

Asbestos is quarried in Arizona by several companies, in Montana, and Vermont; while, Georgia, Maryland, South Car-

1 Chrysotile Asbestos; S. B. Keith and G. W. Bain, Economic Geology, vol. 27 (1932), pp. 169 and 281.

2 A metric ton weighs 2205 pounds.

olina, and Virginia produce fibrous anthophyllite [(Mg,Fe) SiO3] which is used as a substitute. As already noted, Vermont produces more asbestos than all the other States together. She is steadily increasing her production.

Producing Company

Vermont Asbestos Mines, Division of the Ruberoid Company, of Bound Brook, N. J.

Officers: President, W. B. Harris, 500 Fifth Avenue, New York City; vice-presidents, L. C. Rugen, F. E. Byrnes, Bound Brook, N. J.; treasurer, S. D. Van Vleet, New York City; mine manager, C. T. Limerick, Hyde Park, Vt.

Quarries and mill at Eden, Vermont; shipping point, Hyde Park.

Products: fiber for brake-linings and clutch-facings, asbestos shingles, wall-board, asphalt roofing, corrugated paper for insulation, boiler coverings, etc.

One hundred and sixty men are employed.

Clay

With the reduction in imports of English China clay, due to the war, the question of domestic production assumes increased importance. In the Bennington region Vermont has enormous deposits of China clay (kaolin) on which researches are being conducted which, it is believed, will render them fit for paper and other trades.

Definitions and Properties

Clay may be defined as a hydrous aluminum silicate ($H_4Al_2Si_2O_9$), occurring in fine, flake-like particles and possessing the property of plasticity; that is, capable of being molded into desired shape which it will retain when dry. The stickiness of wet clay is common knowledge, especially to autoists.

For ceramic uses the clay particles must be exceedingly fine. The sizes of English clays, to which Vermont clays are comparable, are as follows: all particles finer than 60 microns[1]; 50 percent finer than three microns; 10 percent finer than 0.5 microns. It is said that, in order to possess the property of plasticity, clay must be finer than 3.9 microns.

Clay belongs to several groups of minerals: kaolin, montmorillonite, talc, mica, schist, as well as gibbsite and diaspore. Of these the kaolin group is probably the most common and it includes kaolinite, anauxite, dickite, illite, nacrite, halloysite, and allophane.

Kaolin, or kaolinite, is derived largely from the natural alteration of feldspar according to the equation:

$$\underset{\text{orthoclase}}{2KAlSi_3O_8} + \underset{\text{water}}{2H_2O} + \underset{\text{carbonic oxide}}{CO_2} = \underset{\text{kaolin}}{H_4Al_2Si_2O_9} + \underset{\text{potash carbonate}}{K_2CO_3} + \underset{\text{silica}}{4SiO_2}$$

This feldspar occurs most abundantly in pegmatite bodies (Pegmatite is a coarse development of feldspar, quartz, mica, and other minerals) but also in granite, syenite, rhyolite, schists, shales, and quartzites.

Naturally clay is contaminated with many other minerals such as mica, quartz, metallic sulphides, oxides of iron, graphite, and organic material. In order to obtain pure, white kaolin, these substances must be removed as far as possible by washing, bleaching, and treatment with various chemicals. The process of purification is known as beneficiation.

1 A micron is one millionth of a meter, or 0.00003937 inch.

Physical Properties

In addition to its plastic property, pure kaolin is white, soft, has a typical clay (argillaceous) odor when breathed upon (any clay or clay-bearing rock, has this odor), and a cubic foot weighs from about 100 to 140 pounds. Exceedingly plastic clays are called "fat"; those of low plasticity are called "lean".

Clay, when dried or fired, shrinks. According to Ries[1], shrinkage is of two kinds: air shrinkage and fire shrinkage. The former is due to the evaporation of water and the drawing together of the clay particles. "The latter occurs during firing and is due to the compacting of the mass as the particles soften under heat. Both are variable. In the manufacture of most clay products an average total shrinkage of about eight or nine percent is commonly desired. Excessive air or fire shrinkage causes cracking or warping of the clay. To prevent this a mixture of clays is often used."

"Fusibility is one of the most important properties of clays. When subjected to rising temperatures, clays, unlike metals, soften slowly and hence fusion takes place gradually." The softening points of clays are determined by forming them into small cones or pyramids, of standard dimensions, and comparing their behaviors with those of standard cones or pyramids (Segar or Orton cones) of known softening points, when exposed to the same temperatures and under standard conditions.

Chemical Properties

Pure kaolin contains 39.5 percent of alumina (Al_2O_3), 46.5 percent of silica (SiO_2) and 14 percent of water (H_2O), but commercial clays contain many impurities which affect their physical properties, as will be shown in the analyses to follow.

Classification of Clays

RESIDUAL CLAYS

Under this heading are included those clays which are found in contact with the rock from which they were derived by the natural process called kaolinization. Such clays give us kaolin or white-burning clay, which is very refractory.

COLLUVIAL CLAYS

These are sedimentary deposits derived from residual clays by erosion and transportation.

1 Economic Geology; H. Ries, Macmillan Co., N. Y.

TRANSPORTED CLAYS

Here are included those clay sediments which bear no direct relation to the underlying rocks, but have been transported, mixed, and deposited by the agency of running water. They include esturine clays, lake and pond clays, flood-plain and terrace clays, and glacial drift or boulder clays. Such clays are likely to be very impure and generally contain iron compounds which turn red on firing. They give us our brick and tile material.

CLAY CONCRETIONS

Besides stones and boulders which are associated with glacial clay deposits, there are found, deep within the clay itself and derived from it, various mineral substances, such as limonite, siderite, pyrite, and calcium carbonate. The calcium carbonate manifests itself in curiuos shapes and forms which the brick-maker calls "clay dogs". They are interesting curiosities.

Uses of Clays

The uses of clays are many and varied. The following partial list is taken from Ries[1].

Domestic: Porcelain, stone ware, yellow ware, Rockingham ware for table service and cooking, fire-kindlers.

Structural: Bricks, common, pressed, faced, paving, glazed; terra-cotta, roofing tile, drain tile, door knobs.

Refractories: Fire-brick, saggers, stove and furnace brick, furnace cement.

Engineering: Portland cement, electrical conduits, road "metal".

Decorative: Ornamental pottery (Parian ware).

Minor uses: Paint and paper fillers, electric insulators, scouring soap, chemical apparatus, smoking pipes, filter tubes, plaster, alum, etc.

Vermont glacial clays, of which there are enormous deposits, are used in brick-and tile-making; some are fit for pottery. Kaolin is, at present, used in a small way in the manufacture of stove cements and linings. When the great deposits around Bennington are properly beneficiated, they will be available for the best uses of porcelain, pottery, paper filling, and others.

1 *Op. cit.*

Occurrence

TRANSPORTED (GLACIAL) CLAYS

In the 15th Report of the Vermont State Geologist (1925-'26) the writer located glacial clay deposits in the various counties of the State, and especially along the Connecticut River. He noted former brick-making companies and individuals. Some of the deposits are enormous and would provide more material for brick- and tile-making than will ever be used. At present only the deposits at Essex Junction and Bennington are being worked.

Several glacial clays have been submitted to the writer, and by him to Professor F. H. Norton, of the Massachusetts Institute of Technology, who reports that they could probably be used for modeling purposes, although not comparable with the best French clays.

KAOLIN

Along the Green Mountain Border Thrust Fault there is a broken chain of kaolin deposits, extending from Monkton to Pownal and including outcroppings at Monkton, Brandon (Forestdale), Rutland, North Clarendon, South Wallingford, Tinmouth, North Dorset, Shaftsbury, and Bennington. These deposits are more or less associated with iron ores and manganese minerals. Some of them were formerly worked for iron and manganese; notably the Kinney Kobble mine at So. Wallingford, which was operated by the Carnegie Steel Company between 1888 and 1890.

FORESTDALE

At Forestdale, near Brandon, the Horn-Crockett Company worked a deposit of kaolin, associated with iron ores and manganese minerals, as early as 1902. The mine was operated for twenty years and produced some 80,000 tons of kaolin, which found a market as a paper filler. The mine reached a depth of 200 feet. The kaolin body was some 200 feet along the strike and was about 150 feet wide. It caved in, in 1922, and was abandoned.

MONKTON RIDGE

Kaolin is being quarried in a small way at Monkton Ridge by Leon V. Bushey, who owns several acres of clay-bearing land and produces a few hundred tons yearly. The product is sold to the Rutland Fire Clay Company.

The clay is a residual deposit, derived from feldspar. Much of it is of good color and has been used as a paper filler. The clay has recently been examined by Professor F. H. Norton, of the Massachusetts Institute of Technology, who reports that it is of excellent quality. The drying-shrinkage is 6.3 percent and the firing-shrinkage, at 1100° Centigrade, is 4.8 percent, at which temperature it possesses a fair amount of strength. The fired specimens showed some trace of cream-color. Prof. Norton thinks that the clay should have commercial value as a paper filler and possibly as a refractory material. Much more extensive tests would be necessary in order properly to evaluate it.

Adjoining the Bushey property is a tract of some twenty acres of land underlain by kaolin and owned by the North American Clay Company, of which Mr. R. T. Vanderbilt, 230 Park Avenue, New York City, is the president. A 60-foot shaft, and drifts, opened the deposit, which is said to be of the same general quality as the Bushey clay. The property was formerly operated by Otis M. Williams, who worked it for several years, shipping his product to paper mills. It has been idle for some years.

Both of these properties appear to be good prospects.

BENNINGTON AND SHAFTSBURY

Kaolin has been mined at East Bennington, intermittently, for over a century. In his chapters on The Potters of Bennington, Dyer[1] records that "In 1793 Capt. John Norton and his son, William, moved from Sharon, Connecticut, and settled in Bennington, where they started an earthenware kiln and, in 1800, added the manufacture of stoneware". They also made fire brick. At the Mass. Institute of Technology there is displayed a fire brick made at Bennington in 1836. Mr. John Spargo, in his book[2], traces in detail the history of this enterprise which was carried on by the Norton family for 101 years, till the death of Edward L. Norton, in 1894.

In the southeastern part of Shaftsbury and the northeastern part of Bennington, lying somewhat east of Furnace Brook, there is a chain of kaolin deposits which strikes approximately north and south and extends for a distance of about three miles. In three places on this chain kaolin has been mined, at intervals, for many years.

1 Early American Craftsmen; Walter A. Dyer.
2 The Potters and Potteries of Bennington.

In East Shaftsbury the clay was worked by Booth and Lyons before 1865. Later it was operated by H. N. Elwell and then by Lafayette Lyons till 1889 when it passed into the hands of S. C. Lyons, who mined the clay till 1915, when operations were suspended for several years. In 1923 the Vermont Kaolin Corporation was formed and took over the property, which it holds in reserve.

Lying next south in the chain is the Stratton property on which clay was mined by Homer Lyons in the eighteen-seventies. In 1926 the mineral rights were sold to the Vermont Kaolin Corporation. Drilling operations by the corporation have located a very large deposit of kaolin, covering more than twenty acres in area and ranging in depth from fifty to more than 150 feet.

The third location, which has proved to be the most important, lies about two miles south of the Stratton property. It was operated by the U. S. Pottery Company in the eighteen-fifties and sixties. The property passed into the possession of the Vermont Kaolin Corporation in 1923, since when it has been operated intermittently. The Merrimac Chemical Company, of Boston, held the property under option for several years, during which they made extensive explorations, by drilling, and proved the existence of over three million tons of kaolin, underlying a tract of land 1,100 feet long by 600 feet wide. This company experimented with the kaolin as a basis for the manufacture of aluminum sulphate. The experiments were evidently unsuccessful and the property was returned to the Corporation in 1929.

During 1930-'31 the Corporation operated very successfully, shipping over 15,000 tons of kaolin to Montreal, where it was made into cream-colored faced bricks for some of the large buildings of the city.

In 1936 the two largest kaolin producers in Georgia, the Georgia Kaolin Corporation and Edgar Brothers, jointly undertook a study of the deposits and, by core-drilling, proved the existence of some three million tons of crude clay, in addition to the three million tons already revealed by former drilling. These six million tons constitute the largest deposit of kaolin north of the Carolinas.

An experimental mill for the beneficiation of the clay, which is very variable in color, has been built and it is believed that, in time, the obstacles will be overcome and a first-class clay will be produced.

CHEMICAL ANALYSES OF BENNINGTON CLAYS

	Crude White	Crude Buff	Crude Red	Crude Mixed
SiO_2	56.98%	57.10	53.96	58.96
Al_2O_3	28.52	28.17	27.16	26.03
Fe_2O_3	0.76	1.19	4.93	1.72
TiO_2	1.67	1.35	1.23	1.39
CaO	0.10	0.09	0.09	1.12
MgO	0.77	0.67	0.96	0.86
K_2O	1.41	1.10	2.63	1.64
Loss on ignition	9.25	9.43	8.26	8.46

FIRING PROPERTIES OF BENNINGTON KAOLIN

Cone (20 rate)	Temperature	Burned Porosity	Burned Vol. Shrinkage	Linear Shrinkage
06	1000°C.	45.0%	6.06	2.2
01	1100	37.4	20.1	7.3
7	1200	21.2	37.6	14.6
9	1250	15.3	40.1	15.7
12	1300	13.0	40.8	16.0
13	1350	5.4	43.7	17.5
15	1400	2.4	43.8	17.5
16	1450	1.4	44.8	18.0
19	1500	2.0	43.0	17.1
20.5	1550	7.0	37.5	14.5

MIXED CRUDE BENNINGTON KAOLIN

06	(same as	41.0	3.7	1.3
01	above)	33.0	15.4	5.4
7		21.5	26.3	9.7
9		16.8	29.8	11.1
12		13.2	31.3	11.8
13		7.0	33.1	12.5
15		3.9	33.3	12.6
16		6.8	27.7	10.3
19		12.8	21.7	7.9
20.5		14.9	22.1	8.0

	Washed Kaolin	Crude Kaolin
Pyrometric Cone-Equivalent	32-33	30-31
Water of Plasticity	40.5%	30.2%
Drying shrinkage	20.2%	15.8%
Bulk specific gravity	1.47	1.64
Linear Drying Shrinkage	7.3%	5.6%

(Above data by American Refractories Institute)

Fired Modulus of Rupture—(Cone No. 11; absorbtion, 7.2%) 2985 lbs. sq. inch.

The above data are believed to be fairly representative of the kaolins of Bennington and Shaftsbury and should furnish interested persons a reasonably comprehensive idea of their chemical and physical properties.

Geology

F. A. Burt[1] made an extensive study of the geology of the Bennington and Shaftsbury kaolin deposits. As a result of his investigations he arrived at the following conclusions:

1. "The deposits are residual rather than of the transported type."

2. "The kaolin has been developed by normal weathering processes. The parent rocks are primarily the Pre-Cambrian gneisses of the area, and to a less extent of the feldspathic and argillaceous phases of the (Cheshire) quartzite". This quartzite forms the front of the Green Mountain Thrust, near the base of which the kaolin deposits are found."

3. "The kaolin, associated sands, and iron-manganese ores represent different members of the same formation."

4. "The formation is of Tertiary age and was protected from glacial erosion by its topographical position at the base of cliffs against which the glacier impinged."

5. "The known deposits do not form a continuous belt, but there is some evidence that their continuity is more nearly complete than the surface conditions indicate, and that originally it was complete."

Clay Companies

FRANK E. BUSHEY AND SONS

Office and quarry at East Monkton, Vt.

Post Office address, Bristol, Vt.

Mr. Frank E. Bushey has deceased and the business is carried on by his son, Leon V. Bushey.

Product: Crude kaolin, which at present is used by the Rutland Fire Clay Company.

THE VERMONT KAOLIN CORPORATION, INC.

President, Sanford C. Lyons; address, 133 Lowell Street, Arlington Heights, Mass.

The corporation is not at present in production but is working on the beneficiation of its clay.

1 The Origin of the Bennington Kaolins; Frederick A. Burt, 16th. R'p't. Vt. State Geologist (1927-'28).

Fire-Clay

Holmes[1] defines fire-clays as "refractory clays which resist exposure to high temperatures without disintegrating or becoming soft and pasty by melting. They are characterized, chemically, by a low content of alkalies and lime".

As far as is known, there are no true fire-clays in Vermont.

The Rutland Fire Clay Company produces an artificial clay which serves many high-temperature purposes admirably. The company has built up a large and prosperous business.

THE RUTLAND FIRE CLAY COMPANY

Office, Rutland, Vermont.

Officers: President, C. A. Perkins; Secretary, C. S. Perkins; Treasurer, J. C. Flynn.

Products: Roof coating, roofing cement, patching plaster, furnace cement, boiler covering, pipe-joint cement, stove lining, asphalt paint, asbestos cement.

Production:

1936, 10,195 tons; sales value, $834,156.
1937, 10,267 tons; sales value, 815,450.
1938, 9,602 tons; sales value, 791,515.
1939, 9,171 tons; sales value, 791,032.

The Company employs sixty men.

Bricks

As far as the writer knows, only one company is manufacturing bricks in the State.

THE DRURY BRICK AND TILE COMPANY

Office, Essex Junction.

Officers: President, H. D. Drury; vice-president, H. K. Drury; Treasurer, M. W. Drury.

Quarries and kilns at Essex Junction.

Products: Sand-struck and water-struck bricks.

Capacity, six million sand-struck and one and one-half million water-struck bricks annually.

The company is furnishing bricks for the new Waterman building at the University of Vermont.

1 The Nomenclature of Petrology; Arthur Holmes.

Granite

Granite is Vermont's largest mineral industry and, measured in dollar value, constitutes about 60 percent of her mineral production.

Although the granite industry, in 1939, showed a few percent increase over 1938, it is still in a depressed condition. Quarry men estimate that the industry is operating at about 60 percent of normal. By far the greatest use of Vermont granite is for monumental purposes which of course has been restricted by the long-continued depression. The structural granite business shows some improvement.

With the abandonment of the West River Railroad, the Presbrey-Leland Company closed its quarries at West Dummerston.

John B. Hall and Associates, quarriers of structural granite at Hardwick, has been succeeded by Granite Incorporated, under the same management. C. E. Gibson, of South Ryegate, who also produced structural granite and monumental bases, has formed the Winchester-Gibson Company. The Adamant Quarry Company, of East Montpelier, is no longer operating.

Definitions

On the earth's surface we recognize three principal classes of rocks: sedimentary rocks, which result from the consolidation of sediments eroded from other rocks; igneous rocks, which have come up from the depths of the earth in the form of molten magma and solidified on or in the crust; and metamorphic, or "made over", rocks, which have resulted from the action of the earth's heat, pressure, moisture and other chemical substances on the other two classes.

Molten igneous matter, and the gases and residual fluids associated with it, are called magma. If the magma reaches the surface and solidifies, it forms volcanic rocks, or lava, which are extrusive rocks. But if it solidifies and crystallizes slowly, within the crust, it forms intrusive rocks, whose nature depends upon the chemical composition of the magma, the effects of the volatile constituents, and the rate of cooling, factors which condition the crystallization of the resulting rock. The principal intrusive rocks are granite, syenite, diorite, gabbro, and peridotite.

Granite is an intrusive, igneous rock whose chief constituents are feldspar[1], quartz, and mica or hornblende. Many accessory minerals may occur, the most objectionable of which are pyrite (FeS_2) and pyrrhotite (Fe_7S_8). These are oxidized and produce unsightly stains of iron oxide which quarry men call "sap". The mineral constituents have crystallized out of the magma spontaneously and produced the interlocking grains which give the stone its characteristic appearance. For commercial purposes uniformity of grain size and even distribution of mineral constituents are demanded.

Granite occurs chiefly in the form of batholiths, which are intrusive bodies of great areal dimensions and of unknown depth; or as laccoliths, which are great mushroom-shaped masses, fed through the "root" of the mushroom. Both these types may tear off masses of the country rock through which they pass, which are known as **xenoliths**, or foreign rocks.

Physical Properties

The hardness of granite is of course controlled by this property of its chief constituent minerals: feldspar and hornblende, about No. 6; quartz, No. 7 in the Moh's scale of hardness, in which talc rates No. 1, and diamond No. 10. Granite is therefore a hard rock and cannot be scratched by steel.

The specific gravity of granite is also a function of the gravity of its constituent minerals: feldspar, 2.55 to 2.76; quartz about 2.65. Tests made years ago by Whitman Cross, U. S. Geological Survey, on Jones Brothers Barre Granite, showed for "dark Barre", 2.672; for "Medium Barre", 2.662. A cubic foot of granite weighs approximately 170 pounds. The Pittsburg Testing Laboratory, investigating the E. L. Smith Barre granite, found its crushing strength to be 22,750 pounds per square inch. For absorbtion, samples of the Smith granite were dried to constant weight, at 210 degrees Fahrenheit and then immersed in water, at room temperature of 72 degrees Fahrenheit. The percent absorbtion was, after 24 hours, 0.265; after 48 hours, 0.330. There was no increase after 72 and after 96 hours.

1 Feldspar is the name of a family of minerals. It includes the potash feldspars (orthoclase and microcline) and the lime-soda feldspars, or plagioclases, which consist of albite, oligoclase, andesine, labradorite, bytownite, and anorthite.

Chemical Analyses

As Bowles[1] points out, chemical analyses have but little economic significance since the same chemical element may occur in several minerals; for instance, Silica (SiO2) occurs as free quartz and in the feldspar; iron is a constituent of biotite mica and also of pyrite and pyrrhotite; lime (CaO) is found in the feldspars and also in calcite. Chemical analyses do, however, indicate the general composition; for instance, a high silica content indicates a high percentage of free quartz.

The following analyses, from the U. S. Geological Survey laboratories, are available:

	E. L. Smith Co. "light Barre"	J. K. Pirie Co. "dark Barre"
SiO_2,	69.56%	70.87%
Al_2O_3,	15.38	15.96
Fe_2O_3	2.65	2.63
MgO,	trace	1.13
CaO,	1.76	1.56
Na_2O,	5.38	5.78
K_2O,	4.31	
CO_2 & moisture,	1.02	1.08
	100.06	99.01

The proportions of the minerals present, calculated from the chemical analyses or obtained by direct grain count, are much more enlightening. Dale[2] showed that these proportions vary widely. The Hardwick granite consists of about 62 percent feldspar, 22 percent quartz, and 16 percent biotite; while the "dark Barre" stone contains about 65 percent feldspar, 27 percent quartz, and 8 percent biotite.

The color of granite depends upon the predominating shade of the feldspar, on the proportion of mica or hornblende present, and perhaps the color of the quartz. Feldspar varies in color from colorless to white, pink, red, and green. Muscovite mica is colorless to gray; biotite mica, black. Hornblende is black. Quartz is generally colorless but may have a bluish tinge. Red granite, whose color is due to red feldspar, is uncommon in Vermont. It has been reported in Newark. The Barre stone is a biotite-granite whose color is various shades of gray, and, in places, of a bluish tinge. It is classified as "light Barre", "medium Barre", and "dark Barre" and these

1 The Stone Industries; Bowles, McGraw-Hill Book Company. (1934).

2 The Granites of Vermont; T. Nelson Dale, 6th Rpt. Vt. State Geol. (1907-'08), and U. S. G. S. Bull. No. 404 (1909).

shades are generally attributed to the different amounts of biotite present. But biotite grain counts in the three varieties do not vary decisively, while the iron content of "light" and "dark" Barre is practically the same. Mr. Donald W. Smith, of E. L. Smith & Company, suggests that "the names, Dark Barre Granite and Light Barre Granite, are closely connected with the finish which is applied to rough granite. Granite which is acceptable to the trade for applying the polished finish is known as Dark Barre Granite. All other Barre granites are known as Light and, in the process of manufacturing, the axed, hammered, or steeled finish is used." Other quarrymen, and the writer, do not subscribe to this view but believe that the color of Dark Barre is due to the darker shades of the component minerals, quartz or feldspar, or both.

In 1909 Dale classified the granites of Vermont in three divisions: (1) Biotite granite, (2) quartz-monzonite, (3) hornblend-syenite granite. Of these, the first is characterized by its large content of black mica (biotite) which, with the light minerals, give the "pepper and salt" effect; the second by its lack of biotite and its considerable content of oligoclase feldspar, giving the light gray, clouded appearance; while the third is not really granite at all, but a dark green variety of syenite, called nordmarkite, which was sold under the tradename of "green granite." It is no longer quarried.

The principal granite-producing centers of the State, grouped under Dale's classification, are (or have been) as follows:

Biotite granite	Quartz-monzonite	Hornblend-syenite
Barre	Bethel	Mount Ascutney
Newark	Calais	(There are also large deposits of syenite at Cuttingsville and Mt. Monadnock, Vt.)
Ryegate	Derby	
Woodbury	Dummerston	
	Groton	
	Hardwick	
	Kirby	
	Randolph	
	Rochester	
	Ryegate	

Petrography

For Barre granite Dale showed that the mineral constituents, in descending order of abundance are: (1) Clear, colorless or bluish to translucent potash feldspar (microcline) with or without a little orthoclase, rarely minutely intergrown with a little soda-lime feldspar; (2) light smoky quartz, showing optical effects of strain, rarely with hair-like crystals of rutile, etc.; (3) bluish, translucent to milk-white soda-lime feldspar (albite to oligoclase-albite, in some sections with flexed twinning lamellae), considerably kaolinized and micacized, and with plates of calcite; (4) biotite, some of it chloritized and associated with a little muscovite; (5) accessory minerals: pyrite, magnetite, titanite, allanite, apatite, zircon, rutile; (6) secondary minerals: kaolin, a white mica, calcite, epidote, chlorite. Exceptionally there are minute veins of quartz, calcite and epidote.

Of the localities given below, granite is being quarried today only in the Barre district[1], in Woodbury, and in Ryegate.

"Bethel white" is classified as a quartz-monzonite, which contains quartz and about equal amounts of orthoclase and plagioclase. It is a beautiful, very light-colored stone, devoid of biotite, which should find extensive use in monumental and structural work. The Union Station at Washington, D. C. is built of this granite. The Bethel quarry is idle at present.

Pegmatite, of giant granite, occurs as dikes or off-shoots from a granite mass. It has the same essential mineral composition as granite but with a crystallization so coarse that large, irregular cystals of quartz, feldspar, and mica (predominantly muscovite), sometime several feet in diameter, result. The coarseness of the crystallization is due to the presence of volatile constituents, especially moisture, in the magma from which the rock crystallized. Other minerals, which depend for their formation on magmatic vapors, such as tourmaline, beryl, apatite, and others, often occur in pegmatite, which thus forms "happy hunting grounds" for mineral collectors. Pegmatite is the source of large sheets of muscovite (isinglass) and of feldspar which finds use in the ceramic industries.

No large pegmatite deposits have been found in Vermont.

Occurrence

MILLSTONE HILL

Millstone Hill is the center of the granite industry in Vermont while, according to Bowles[2], the Barre district is the most important monumental granite-producing area in the Union.

1 In order to stop pirating, the Federal Trade Commission has defined the "Barre District for the Quarrying of Granite" as beginning at the southerly part of the city of Barre, Washington County, State of Vermont, and extending westerly about two and one-half miles, then southerly about four miles to and including Williamstown, in Orange County. All granite quarried elsewhere may not legally be named and advertised as "Barre granite" hereafter. The location indicated comprises the whole of the eminence south of Barre City, locally known as Millstone Hill.

2 *Op. cit.*

Quarrying operations date back to about 1832, when blocks of granite were drawn by ox teams to Montpelier to furnish columns for the Capitol. Since then over fifty quarries have been opened on the hill and the adjacent areas and many firms have been in business. In recent years many consolidations have taken place so that now the granite industry is carried on by five companies, some of which are owned by the same interests. See Plate 2.

Millstone Hill received its name from the superior quality of millstones which were once made there and were used extensively in the mills of New England and Canada. Robert Parker and Thomas Courser are believed to have opened the first quarry. The Central Vermont Railroad extended its line from Montpelier to Barre in 1875, while the Barre Railroad, connecting this line with the quarries on Millstone Hill, was opened in 1888.

Millstone Hill lies about three miles southeast of Barre. It is really a double eminence. The northern member, on the slope of which lies the village of Websterville, rises 1700 feet above sea level; while the southern is a hundred feet lower, with Graniteville lying on its flank. The railroad and a highway pass between the two. Cobble Hill, on which granite was formerly quarried, lies two miles to the north, while still farther, in the same direction, lie the granite deposits of Adamant, Woodbury, and Hardwick.

Millstone Hill is rather a flat dome, about two and one-half by one and one-half miles in extent. Its shape is controlled by the surface of the granite of which it is chiefly composed. This granite forms an enormous batholith which, northward, crops out under Jail Branch and also makes up Cobble Hill. The area of this batholith is said to be about eight by four miles.

The rock of the region (the country rock) is a complex of metamorphic substances, prevailingly phyllite (which quarrymen call slate) but also quartzite, amphibolite, gneiss, and quartz-sericite-schist, probably of Ordovician age, some 440 million years old. The trend (or "strike") of this country rock varies in different parts of the area, from N. 20° to 50° East, and its slope (or "dip"), measured from the horizontal plane, is often as high as 80° easterly, but westerly dips also occur. The granite magma was forced up by pressure from below into the country rock, thrusting it aside but often enclosing large fragments called xenoliths or, by the quarrymen, horses. These xenoliths are to be seen on the borders as well as in the bottoms of some of the quarries. One of them measured 57 by 10, by 6 feet.[1]

Narrow "sills", or tongue-like masses of the granite extend into the country rock. One is to be seen on the road side, by the Post Office in Websterville, about three feet wide, tightly wedged within the foliations of the phylite. Another sill, four or five feet wide, occurs in the south wall of the Wells-Lamson quarry. A granite "dike", two feet wide, cuts across the foliations of the phyllite, in the border of the E. L. Smith quarry. A dike of rather fine-grained pegmatite is found in the south end of the Smith quarry.

The granitic magma solidified far below the old land surface where conditions of slow cooling were right for crystallization. Age-long erosion of the overlying country rock has revealed the granite, which is thought to have been intruded in Devonian time, some 330 million years ago.

Fractures in the Granite

In the quarries the granite is seen cut by major fractures, called joints, which traverse the rock in many directions (Plates 3 and 4). Those which are parallel to the surface are called beds or sheeting planes. They are thinnest near the surface and increase in thickness with depth. In some of the quarries they are about a foot thick at the top but increase to as many as fifty feet. Besides these, other irregular joints run through the granite in various directions. Of course these joints limit the size of the blocks that can be quarried. Here it may be noted that 75 or 80 percent of the quarried stone is waste, great grout piles of which are seen, which await the discovery of some useful purpose. The Georgia School of Technology is working on an electromagnetic process of removing, to a large extent, the biotite from this waste. Further separation of the quartz and feldspar, probably by flotation, will, it is hoped, recover the feldspar for use in the ceramic industries.

The origin of the fractures is not clearly known. The release of vertical pressure, due to the erosion of the overlying country rock, or the expansive effect of solar heat, or both, may account for the sheeting joints. The oblique joints may be due to tangential stresses, evidence of which are seen in the change of drill holes in shape, from round to oval, and in the observed fact that great monoliths of granite, after quarry-

1 The best article that has appeared on the granite of this region is entitled, A Contribution to the Structural Relations of the Granitic Intrusions of Bethel, Barre, and Woodbury; by Robert Malk, 15th. R'p't. Vt. State Geol. (1925-'26).

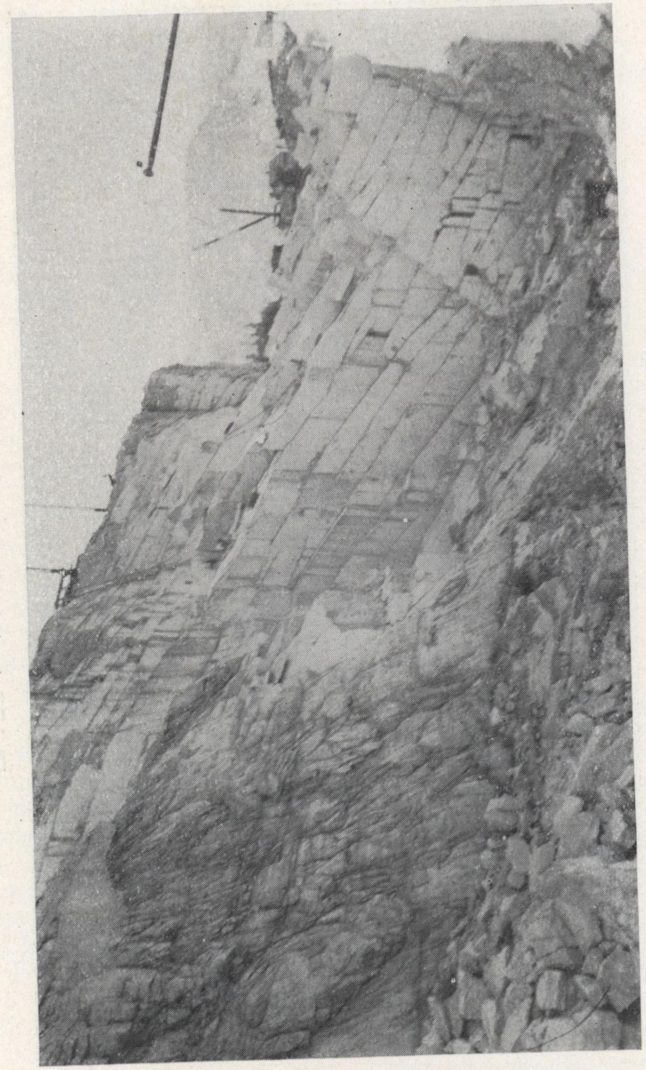


PLATE 3—A BARRE GRANITE QUARRY

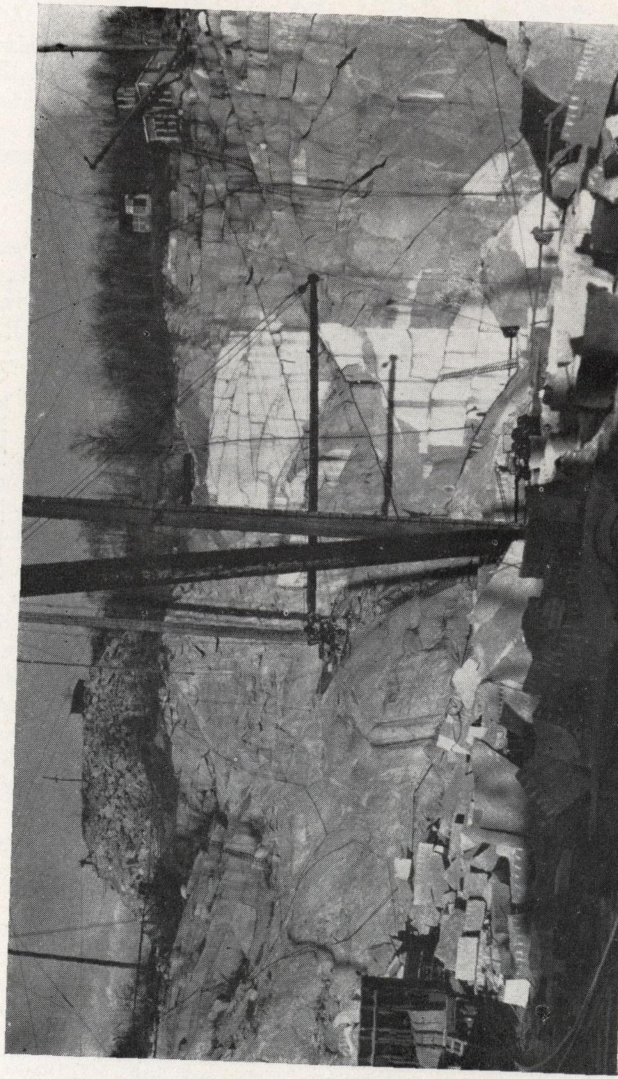


PLATE 4—A BARRE GRANITE QUARRY

ing, are too large for the holes from which they came. Furthermore, thin sections of the rock, studied with the microscope, show that granite existed under strain.

Sheeting quarries are those in which granite occurs in sheets or beds (Plates 3 and 4). Boulder quarries show no sheeting, although oblique joints are present. The Rock of Ages quarry shows sheeting downward for about thirty feet, below which it is a boulder quarry. The other four quarries are of the sheeting class.

In the quarries occur masses of mongrel granite (Plate 3) which are worthless. Such masses are called headers.

Rift, Grain, Hardway

Granite, in a way, resembles wood in that it can be split more easily in certain directions than in others. The quarryman looks at a block of the stone, passes his fingers over it, and announces: "This is the rift, that is the lift (grain or run), here is the hardway" (or head-grain), and chooses the directions of his splitting accordingly. These three directions are mutually at right angles to one another, as shown by the faces of a cube. The rift is the direction of easiest splitting and gives the smoothest surface. The hardway is the direction in which the granite will not split smoothly and is roughest to the fingers. The lift is intermediate between the others. The hardway takes the best polish.

Curiously enough frozen granite (it will be remembered that any rock contains a certain amount of moisture; Smith granite has 0.265 percent) refuses to abide by the rules.

The cause of rift, lift, and hardway is obscure.

Now rocks are studied microscopically by grinding small pieces to the thinness of tissue paper (about 0.03 millimeter), mounting them between polished glass and thin cover glass, by means of Canada balsam, and examining them with a microscope equipped with polarized light apparatus, which causes the light rays to vibrate in one direction instead of in all directions, as in ordinary light. With this aid the component minerals of the rock are recognized, the shapes of the individual grains are shown, optical and cleavage directions are noted, and the chemical changes which the minerals have undergone are made clear. This study is called petrography. Photomicrographs record what is seen.

In granite sections the feldspars tend to be oblong in shape, biotite is seen in thin prisms and shreds, and quartz, which is the last mineral to crystallize, is irregular in shape and fills in the interstices.

As regards rift, lift, and hardway, some observers have attributed them to the orientation of the feldspars; that is, their arrangement in lines of planes. Others think they are caused by fluidal cavities in parallel lines, or incipient joints, caused by strain[1]. But studies by the writer on thin sections of Barre granite do not bear out these theories. There seems to be no visible orientation of any of the constituent minerals. But there are certain optical directions in the feldspars, parallel to the rift, which are roughly parallel to one another. These may be parallel to cleavage directions. The problem needs further study.

Quarries in the "Barre District"

Plate 2 shows the location of the quarries, which are on the south and east flanks of Millstone Hill. Jones Brothers quarry is idle at present. The Pirie quarry is in Williamstown.

The quarries appear to be located on one great batholith, since the rift and hardway in them have the same general compass course. The rift, like the strike of the country rock, varies from N 30° to 60° E. The lift is generally horizontal, while the hardway is at right angles to the other two.

The Wetmore and Morse and E. L. Smith quarries are opened on the rift; that is, their long axes are parallel to this direction. The Wells-Lamson, Rock of Ages, and Pirie quarries are opened on the hardway.

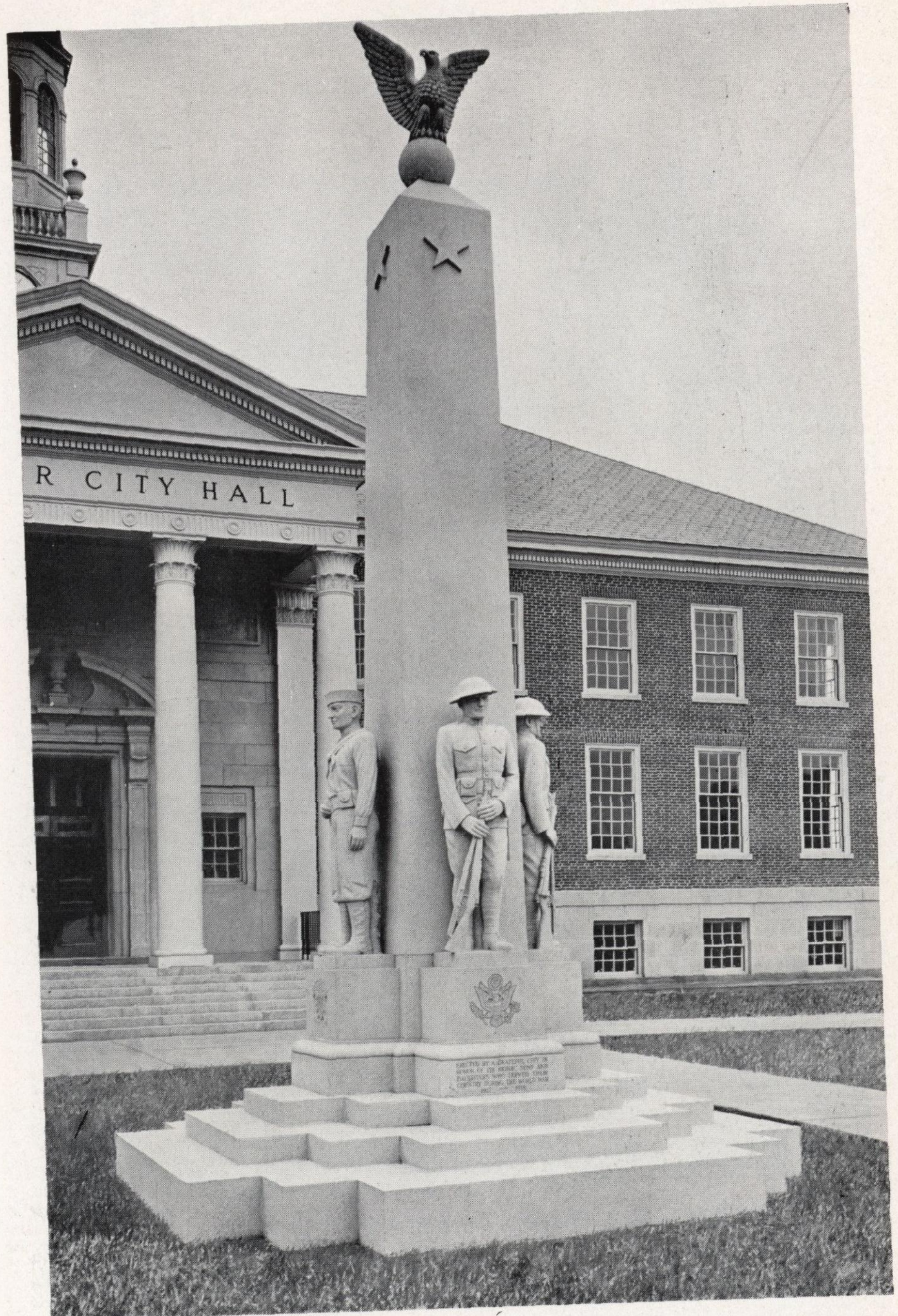
The minimum elevations of the quarry rims are: Wells-Lamson, about 1300 feet above sea-level; Rock of Ages, 1369; E. L. Smith, 1400; Wetmore and Morse, 1590; Pirie about 1350.

The great derrick masts are made of Oregon fir and are capable of lifting blocks weighing 50 to 60 tons.

At present there are five active granite companies in operation in the "Barre District". The Wells-Lamson Company ships its granite to Jones Brothers (both companies are owned by the same interests) manufacturing plant in Barre City and also supplies other manufacturing plants with rough stock. The Rock of Ages Company sells granite in the rough and also has manufacturing plants in several Vermont towns. E. L. Smith, Wetmore and Morse, and Pirie Estate do not operate manufacturing plants but ship their entire product to fabricating firms throughout the United States and in Canada.

Practically all the Barre District granite is used for monumental purposes.

1 Bowles, *Op. cit.*



MONUMENT OF BARRE GRANITE

MONUMENT OF BARRE GRANITE

Production

According to the Minerals Yearbook for 1939, the latest available, the total value of granite produced in the United States, for all purposes (building, monumental, paving blocks, curbing, and rubble) was, in 1938, $9,778,032.

Vermont stood first in dollar value, with $1,909,895, of which $1,849,890 was for monumental stone; Massachusetts stood second, with $1,575,832, mostly used for building and curbing; Georgia, third, $1,021,939, the majority for monumental purposes; Maine, fourth, with $931,464, used for building, paving blocks and curbing; Minnesota, fifth, $712,903, largely for monumental purposes; Wisconsin, sixth, $688,641, largely for monuments. Twenty other states produced smaller values. Vermont produced, in dollar value, 18.9 percent of the whole.

Vermont Production

The total Vermont production of granite and value, as reported to the writer, was as follows:

1937	1938	1939
792,410 cu. ft.	603,151 cu. ft.	652,577 cu. ft.
Dollar values:		
$7,932,644	$6,891,302	$7,304,356

The great discrepancies between these figures and those of the Minerals Yearbook will be noted. Vermont figures are for total valuation of the finished granite. The basis for the Yearbook data is not given.

The following table, kindly provided by the Barre Granite Association, gives interesting details of the industry.

ESTIMATED OUTPUT OF MONUMENTAL GRANITE IN BARRE DISTRICT

	1937	1938	1939
Total Quarry Output rough stock (cu. ft.)	765,390	589,440	614,256
Shipped out of Barre District in rough (cu. ft.)	153,078	117,888	122,851.2
Manufactured in Barre District (cu. ft.)	612,312	471,552	491,404.8
Light Stock Consumpeion in District (cu. ft.)	478,369	294,720	307,128
Dark Stock Consumption in District (cu. ft.)	287,021	176,832	184,276.8
Number of Cutters in District	1,550	1,550	1,550
Average Daily Wage	$8.00	$8.00	$8.50
Average Number of Days Worked	230	220	220

	1937	1938	1939
Total Pay for Year	$2,852,000	$2,813,250	$2,898.500
Estimated Overhead	1,426,000	1,406,625	1,449,250
Estimated Light Stock Valuation	1,544,699	1,176,987.50	1,247,714
Estimated Dark Stock Valuation	1,234,191	934,347	990,492.10
Estimated Polishing Cost	484,263	372,938.70	388,639.80
Output from Saws	161,421	124,312.90	129,546.60
Total Valuation of Finished Granite	$7,702,574	$6,828,461.10	$7,104,142.50

MEMBERS OF THE BARRE GRANITE ASSOCIATION, INC.
JULY 15, 1940

BARRE
Acme Granite Co.
Adams Granite Co.
American Granite Co.
Anderson-Friberg Co.
Anderson & Johnson
Barre Blue Granite Co.
Barre Hickey Mill
Batchelder Co., E. J.
Beck & Beck
Bilodeau & Co., J. O.
Burke Brothers
Buttura & Sons
Caccavo Granite Co.
Celente & Bianchi
Cerasoli & Cerasoli
Chioldi Granite Co.
Comolli & Co.
Cook, Watkins & Patch
Dessureau & Co.
Giudici Brothers & Co.
Granite Memorial Shop
Grearson & Lane
Green Valley Granite Co.
Hebert & Ladrie
Hinman Co., H. P.
Hoyt & Milne, Inc.
Initial Granite Co.
Johnson & Gustafson
Jones Brothers Co.
Jones Brothers Dark Quarry
Lawson Granite Co.
Letter Granite Co.
Marr & Gordon, Inc.
Mascitti, Paul
McDonnell & Sons
Milne Granite Co., Alex.
Modern Granite Co.
Morlote Granite Co., S.
Nativi Granite Co.
North Barre Granite Co.
Novelli & Calcagni

BARRE
Olliver & Co.
Peerless Granite Co.
Pirie Estate, J. K.
Revilla Granite Co., J.
Robins Brothers
Rock of Ages Corporation
Roux Granite Co.
Saporiti & Co., William
Shield Co., Waldron
Sierra Granite Co.
Smith & Co., E. L.
South Barre Granite Co.
South End Polishing Co.
Steele Granite Co.
Thurber Granite Co.
Union Granite Co.
Usle & Perojo Granite Co.
Valz Granite Co.
Veino Granite Co.
Wells Lamson Quarry Co.
Wetmore & Morse Granite Co.
White Granite Co.
Zampieri & Buttura

MONTPELIER
Bonazzi & Bonazzi
Capitol Granite Co.
Desilets Granite Co.
Everlasting Memorial Works
Excelsior Granite Co.
Jurras Granite Co.
Montpelier Granite Works
Riley Brothers
Sheridan & Poole
United Granite Co.

NORTHFIELD
Cross Brothers Co., Inc.
Duprey Granite Co.

WATERBURY
O'Clair Granite Works, C. L.

From the data it is calculated that, in 1939, 94 percent of the total Vermont granite quarry output, in cubic feet, was produced in the Barre district.

Following the general business trend in the United States, the high point in granite production, after the business slump in October, 1929, was reached in 1937. 1929 was an all-time high year in the Barre district, with a total granite output of $12,152,174. (See the Report of the State Geologist for 1935-'36, p. 5)

Employment

In 1939 about 1650 men were employed in the granite industry. They received in aggregate $3,007,000.

Active Granite Quarrying Companies in the Barre District

JONES BROTHERS COMPANY, INCORPORATED

Main office, 10 High Street, Boston, Massachusetts.

Branch office, 700 Main Street, Barre, Vermont.

Officers: President, M. Walker Jones; vice-president, Marshall J. England; treasurer, Seward W. Jones.

Quarry at Graniteville; not active, at present.

Fabricating plant, 700 Main Street, Barre.

Products: Monuments and mausoleums, granite machinery, rolls for paper companies and chocolate grinding, ornamental sundials, garden seats, etc.

J. K. PIRIE ESTATE

Main office, Barre.

Trustees and managers, James G. and Fred F. Pirie.

Quarries in Williamstown.

Cutting plant, none. This company simply quarries granite.

Products: Mostly dark Barre granite; some light Barre.

ROCK OF AGES CORPORATION

NOTE: This corporation is the consolidation of the following old companies: Boutwell, Milne and Varnum, which operated quarries in the Town of Barre, and the following manufacturing plants: Barclay Brothers, Canton Brothers, E. A. Chase Granite Company, Eureka Granite Company, Grearson and Lane, Lawrence Granite Company, William Milne Granite Co., Perry Granite Corporation, Phillips & Slack, and George Stratton Granite Co. The consolidation was effected in 1930.

Main office, 206 Bank St., Burlington, Vt.

Officers: President, Roy L. Patrick; executive vice-president, Joseph T. Smith; vice-president and general manager, Alex. D. Straiton; treasurer, Athol R. Bell; clerk, Warren R. Austin.

Quarries at Graniteville.

Fabricating plants at Barre, Montpelier, Northfield, Waterbury.

Products: Mostly Dark Barre Granite; some Light Barre.

E. L. SMITH COMPANY

Main office, Barre.

Officers: President, Donald W. Smith; vice-president, J. Wendell Smith; Treasurer, Maurice W. Dewey; ass't.-treasurer, Bernard V. Funk.

Quarries at Graniteville and Websterville.

Fabricating plant, none. The company simply quarries granite.

Products: Light and Dark Barre Granite.

WELLS-LAMSON QUARRY COMPANY

Main office, Barre.

Officers: President, Marshall J. England; treasurer, H. Brandon Jones.

Quarries at Websterville.

Fabricating plant, none. The company simply quarries granite.

Product: Light Barre Granite.

WETMORE AND MORSE GRANITE COMPANY

Main office, Barre.

Officers: President, Fred A. Howland; vice-president, Maurice W. Dewey; sec'y-treasurer, Herbert R. Pierce; ass't. sec'y-treasurer, William H. Duthie; general manager, John P. Davis.

Quarries at Websterville.

Fabricating plant, none; the company simply quarries granite.

Product: Light and medium Barre granite.

Active Granite Companies outside the Barre District

GRANITE, INCORPORATED

Office and manufacturing plant at Hardwick; quarry in Woodbury.

General manager, John B. Hall.

Products: Structural and monumental granite.

This company succeeded John B. Hall and Associates. It has recently completed delivery of a $75,000 contract for the Naval Academy, at Annapolis, and is furnishing granite for the Waterman Memorial at the University of Vermont.

THE WINCHESTER-GIBSON GRANITE COMPANY

Office and quarry at South Ryegate.

Partners: H. E. Winchester and C. E. Gibson.

Products: Structural and monumental granite.

Limestone and Dolomite

The essential mineral of limestone is calcite ($CaCO_3$). This may be replaced by varying amounts of magnesian carbonate ($MgCO_3$), giving magnesium limestone or, when the percent of magnesia (MgO) reaches about 20, the mineral, dolomite, results. Limestone and magnesian limestone are sedimentary rocks, consolidated from sediments of diverse origin, largely from organic remains but to some extent from chemical precipitation.

Limestones are seldom pure but contain more or less silica, magnesium, aluminum silicates, iron compounds and carbon, giving silicious limestones, magnesian limestones, ferruginous limestones, or carbonaceous limestones.

The colors vary widely: white, buff, yellow, reddish, blue, or black. The hardness is about No. 3, in Moh's scale, hence the rocks are soft and easily scratched with steel.

Limestones vary in texture from very fine-grained and compact to more or less porous. A cubic foot weighs from 110 pounds, in the porous varieties, to 170 pounds in the compact forms.

Pure limestone will effervesce in cold, dilute hydrochloric acid (one part of acid, by volume, to 25 parts of water) while dolomite requires strong acid to produce effervescence.

Limestone heated in kilns (lime burning) is reduced to lime (CaO). Burned marble of course produces the same result.

If this lime is hydrated, calcium hydroxide, or hydrated lime results. $CaO + 2H_2O = Ca(OH)_2$. Burned marble of course produces the same result.

Travertine

Travertine is a variety of limestone which is usually regarded as a product of chemical precipitation from hot springs. It is characterized by its porous nature, the pores varying in size from minute openings to voids an inch or more in diameter. It is extensively used for interior paneling, and flooring. No travertine occurs in Vermont.

Marl

Marl is a calcareous clay deposit, found in ponds. It is often overlain by peat. It is white or gray in color and has been formed by the accumulation of minute shells. It contains much water and, dehydrated, is used in soil sweetening.

Uses of Limestone

Many uses are found for limestone, magnesian limestone and its products: dimension stone for building and interior decoration, in large masses for riprap, railroad ballast, bridge, dam, and other structures; in the crushed condition for fluxing in blast furnaces and open hearth furnaces, concrete aggregates, in glass factories, paper mills, alkali works, in calcium carbide manufacture, carbonic acid production, mineral wool, poultry grit, Portland cement, lime, pharmaceutical preparations, for correcting land acidity (agricultural limestone), and others.

For agricultural limestone, specifications call for 100 percent to pass a 20-mesh sieve, and 75 percent to be finer than 100 mesh. Much of this material is magnesian limestone, containing from a trace to over 16 percent MgO. Such material is found to be preferable to pure limestone for soil sweetening since the magnesia is found not only to neutralize the organic acids in the soil but also to correct the acidity of the fertilizers.

Hydrated lime is used in the chemical industries, in building, for tree spraying, and other purposes.

Occurrence

The chief source of commercial limestone in Vermont is in the Champlain Lowland: at Highgate Springs, Swanton, Fonda Junction, Winooski, New Haven Junction, and Leicester Junction. Here occur belts of generally dove-colored, Ordovician and Cambrian limestones which have been quarried for many years, the quarries dating back at least to 1846. The rock may contain varying amounts of magnesia (MgO), from a trace to 12 percent. It is generally of high grade, carrying from 85 to 99 percent of total carbonates[1].

Besides this western belt of limestone Dale[2] examined some thirty-five localities of calcite or dolomite marble, of which thirty lie within the metamorphic rocks of the Green Mountains. He found these marble masses infolded with the metamorphic schists and gneisses, of inconsiderable thickness and sporadic distribution. Small lime kilns, or their remains, are found in many places in Franklin, Lamoille, Washington, Windsor, and Windham counties. At present, as far as the

1 Vermont Agricultural Experiment Station analyses.
2 *Op. cit.*

writer is informed, the rock is being quarried within the metamorphics, at Amsden, in Windsor County; Plymouth Union, Windsor County; Williamstown, Orange County; and Brandon, Rutland County.

Production

According to the Minerals Yearbook for 1939, the total amount of lime produced in the United States, in 1938, was 3,346,954 short tons, valued at $24,137,638.

The great lime-producing States are, in order of production: Ohio, 836,589 tons, valued at $6,658,853; Minnesota, 289,151 tons, $1,724,140; Tennessee, 162,661 tons, $901,460; Alabama, 151,937 tons, $911,033; Illinois, 135,256 tons, $965,835; and Indiana, 102,054 tons, $581,922. Thirty-five other States produced less than 100,000 tons each and, of these, Vermont furnished 58,149 tons, valued at $415,846.

Vermont Production

Vermont lime production in 1939, as reported to the writer, was 67,370 short tons, valued at $463,451. These figures are somewhat too low, since several small producers of agricultural lime failed to furnish data.

It is estimated that about 150 men are employed in the lime industry of the State.

Lime-Producing Companies

THE VERMONT ASSOCIATED LIME INDUSTRIES, INC.

Office, Leicester Junction, Vt.

Officers: President, H. B. Huntley; vice-president, O. C. Huntley; secretary, Nina S. Huntley.

Quarry and kilns at Leicester Junction.

Products: Agricultural, fluxing, crushed and pulverized limestone.

CHAMPLAIN VALLEY LIME COMPANY

Main office, Worcester, Mass. (Brewer & Company, Inc.)

Branch office, Winooski.

Officers: President, H. D. Brewer; secretary, Edwin A. Brewer; manager, E. H. Beaumont, Burlington.

Quarry and kilns, Winooski, Vt.

Products: See Green Mountain Lime Corporation.

THE GREEN MOUNTAIN LIME CORPORATION

Main office, Worcester, Mass. (Brewer & Company, Inc.)

Branch office, Winooski.

Officers: President, H. D. Brewer; secretary, Madeline C. Wood; manager, E. H. Beaumont.

Quarry and kilns at New Haven Junction.

Products of both companies: Building, chemical, spraying, agricultural limes, etc.

Among the hydrated lime brands are "Chemical Hydrate", "Mason's Hydrate", "Snow Fluff Spraying Hydrate", "Agricultural Hydrate", and "Sure Crop".

FONDA LIME KILNS

Office, St. Albans, Vt.

Manager, L. F. Willson.

Quarry and kilns at Fonda Junction.

Products: Lime for chemical purposes, wire-drawing mills, tanneries, etc.

SWANTON LIME WORKS

Office, Swanton, Vt.

Proprietor, Davis Rich.

Products: Lime and limestone products, rock ballast, etc.

Among the products are "Swansdown" and "Soilsweet".

THE VERMARCO LIME COMPANY

This is a subsidiary of the Vermont Marble Company. It produces hydrated lime for building, chemical, and agricultural purposes.

The following companies and persons produce ground limestone for soil-sweetening: The Amsden Lime Company; the Brandon Rock Products Company; L. A. Garrow, East Charlotte; Paul Robinson, Pawlet; Shelburne Lime Company, and Farrell and Webster, Shelburne; and Edward Vivie, Plymouth-Union.

Marl is produced by Will Businо and J. A. Jamieson, of Williamstown; Frank Lathrop and Percy Lathrop, Arlington; and E. A. Lawson, Lyndonville.

Marble

For many years Vermont stood first in marble production. In 1939 she yielded priority to Tennessee on account of the latter's large contracts of exterior marble for the National Gallery of Art, at Washington, D. C. In 1939 sales of Vermont marble increased about 2 percent in "footage" and about 16 percent in dollar value over 1938, but the industry is still in a depressed condition, owing no doubt to lack of real prosperity in the country. The Vermont Marble Company's contract for some 500 carloads of Imperial Danby for the Jefferson Memorial at Washington, and contracts of verde antique for the National Gallery of Art are the present outstanding features of the industry.

Definitions

The word, marble, is a rather loosely-used trade term which includes, besides crystallized calcite marble, some limestones and dolomites, whether crystallized or not, verde antique, which is commonly called green marble, and even a rather massive chrome-mica fuchsite which was for a time quarried on the north side of Round Hill, three and three-quarter miles southeast of Rutland, and was also called green marble.

Marbles may therefore be classified as calcite marble, onyx marbles (travertine is closely allied to this), dolomite marbles, and verde antique.

Calcite Marble

This stone was produced by the metamorphism of limestone. The crystallization produced by metamorphic action has resulted in brilliant, minute interlocking crystals of varying size.

If the limestone were pure, the beautiful Carrara, the Rutland Statuary, the Imperial Danby, and other varieties resulted. If various impurities, such as graphite, hematite, limonite, etc., were uniformly distributed, many varieties were formed, such as the Belgian and Isle la Motte Black, the blue marble of West Rutland and Florence, Vt., the Verona and Numidian Red, the Yellow Sienna, the Pink Kasota, and others. If the impurities in the limestone occurred in layers, banded marbles resulted, such as the West Rutland Brocadillo; while, if the rock were fractured into irregular fragments and re-cemented in the ground, brecciated marbles were produced.

The Vermont Marble Company has a very beautiful and instructive display of domestic marbles at Proctor which is visited by over 30,000 people annually. In the exhibit there are 55 varieties of marble, each arranged in the shape of three-sided booths which vary from eight to sixteen feet in length, and are uniformly six feet, seven inches in height. The colors of the marbles run from pure white, Secondary Statuary, through the Westland Dark Cream, Northern Pearl, Neshobe Gray, Pink Lapanto, Variegated Champlain, Royal Red, Verde antique, Champlain Black, and many other varieties. Besides the panels, there are displays of gifts in marble: carved fire-places, garden seats, baptismal fonts, bird baths, flower pots, etc., while the masterpiece is, undoubtedly, a carving, in white, statuary marble, of Leonardo da Vinci's "Last Supper".

There is also a display of a new product of the Company, Lumar Marble, which is a scientifically-developed luminous stone, possessing remarkable properties of light transmission and diffusion. Varieties of this marble are known as Lumar Yule, Lumar Antique, Lumar Green Vein, Lumar Pavonazzo, and Lumar Brocadillo.

A small chapel in the exhibit has panels of Lumar Yule on either side of the altar, which produce a very beautiful effect.

The company has also developed an artificially-colored black marble, Jetmar, made by a secret process by which the impregnation of the stone has been so thorough that the color extends throughout the mass.

More recent developments are Markwa, a marble tile; and marble bricks. The former consists of marble cut thin and to uniform size, which offers a decorative treatment not found in the field of vitreous wall tile. Marble bricks are cut to standard size and either sawed or sheared. They are used for building and garden walls. The Berry residence at Bald Mountain, Brunswick, N. Y., is built of sawed bricks of West Rutland Marble.

The latest Vermont Marble Company products will be found on page 66, under New Products.

Occurrence

According to Dale[1]: "The longest (calcite) marble belt lies partly in the Vermont Valley, between the Green Mountain

1 The Commercial Marbles of Western Vermont; T. Nelson Dale, Bull. 521 U. S. Geological Survey (1913); reproduced in Ninth R'p't. Vt. Geol. Survey (1913-'14), 223 pp. This the most complete article on the subject that has appeared.

and Taconic ranges, and partly between the Taconic Ranges and an intermediate range from Pine Hill to Danby Hill. It also extends north of the Taconic Range, ending between Middlebury and Bristol, and its length from north to south is about 80 miles***". "Within the Taconic Range iself, and west of Rutland, is still another marble belt, six miles long and half a mile wide, occupying a minor longitudinal valley, through which the Castleton River flows in the north-south part of its course. This is the West Rutland belt of marble. At several points within the Taconic Range, north and south of this minor belt, there are small marble areas."

In his extensive studies of this belt, Dale found that the geological succession (stratigraphic succession) was as follows:

	Geologic Age	Thickness
Berkshire schist, interbedded with quartzite and conglomerate.	Ordovician (probably Upper and Middle Trenton).	2000-2500 ft.
Marble: beds of calcite marble, alternating with beds of dolomite and schist.	Ordovician (Trenton, Chazy, and Beekmantown).	500-900 ft.
Dolomite, thin-bedded and fine-grained.	Ordovician and Lower Cambrian.	500-800 ft.
Quartzite, with some beds of conglomerate and schist.	Lower Cambrian.	1600 ft.
Green Mountain gneiss.	Pre-Cambrian.	Unknown.

Chemical Analysis

Calcite marble is essentially calcium carbonate ($CaCO_3$). It is never quite pure but contains varying amounts of such impurities as dolomite ($Ca(Mg)CO_3$), iron and aluminum oxides, and Silica (SiO_2).

An analysis of Italian Carrara, probably the most famous of marbles, gave:

Calcium carbonate,	99.77%
Magnesium carbonate,	0.90
Silica,	0.16
Aluminum and iron oxides,	0.08
	100.91

U. S. Bureau of Standards analyses of Vermont marbles showed:

	Rutland Italian	Imperial Granby
Calcium carbonate,	99.67%	98.68%
Magnesium carbonate,	0.71	0.86
Silica,	....	....
Fe_2O_3,	0.02	0.03
Al_2O_3,	0.06	0.10
	100.46	99.67

A comparison of these analyses shows the high quality of Vermont marble.

Physical Properties

Hardness: In Moh's scale (see under Granite) calcite stands No. 3 and so is a comparatively soft rock, easily scratched with steel. It is somewhat harder than most limestones.

Specific Gravity: The specific gravity of marble is about 2.7 and a cubic foot weighs from 165 to 180 pounds, varying with the impurities and amount of pore space.

Solubility: Marbles are slightly soluble in water containing carbon dioxide, the rate depending on the chemical composition, texture, and porosity. Calcite marbles are more soluble than dolomites.

Color: The color of marble is mainly due to the foreign substances contained in it and these, as already noted, may be uniformly distributed or in bands. Black and gray marbles are due to carbonaceous material; red and pink are due to hematite and manganese; yellow and cream marbles owe their color to limonite; greenish, banded marbles contain chlorite.

Texture: The texture of marbles has reference to the size and arrangement of the crystals. Dale graded Vermont marbles into six classes, based on the average crystal diameters, as follows:

Extra fine, 0.06 millimeters; very fine, 0.10 mm.; fine, 0.12 mm.; medium, 0.15 mm.; coarse, 0.24 mm.; extra coarse, 0.50 mm.

Historical

Marble has been quarried in the calcite-marble belt for probably 180 years. The industry seems to have begun in Tinmouth. The first large enterprise was the Rutland Marble Company which, in 1860, was operating twelve cutting mach-

ines (gangs) and producing 150,000 cubic feet of marble annually. In 1870 Redfield Proctor organized the Sutherland Falls Marble Company which, by 1880, was operating sixty-four gangs and was the dominant factor in the marble industry of the State. Later, the consolidation of many smaller companies resulted in the Vermont Marble Company which is normally the largest producer of marble in the United States.

Over forty quarries have been operated on the marble belt: at West Rutland, Proctor, Pittsford, Florence, Brandon, Sudbury, Middlebury, Clarendon, Danby, Dorset, and Manchester. At present the active quarries are at Danby, West Rutland, Florence, St. Albans, and Isle la Motte.

Marble Buildings and Interiors

Some of the well known public edifices built of Vermont marble are the Supreme Court, Arlington amphitheater, and Red Cross buildings in Washington; the Federal Reserve Bank of Philadelphia; the New York City Public Library; and the Dental Infirmary at Boston.

Vermont marble has been used very largely on the interiors of the Federal Reserve Bank in Philadelphia; the New England Mutual Insurance Compay in Boston; the R. C. A. Building in New York; and the Social Security Building in Washington.

The Vermont Marble Company is at present furnishing over 150,000 cubic feet of its Imperial Danby for the Thomas Jefferson Memorial in Washington and also marble for the Waterman Memorial Building at the University of Vermont.

Isle la Motte Marble

The gray and black, fossiliferous calcite marble of Isle la Motte was quarried for lime-burning as early as 1664, while stone for building purposes was produced in 1778. Most of the sidewalk curbing in Burlington also came from here.

The marble is Ordovician in age and, in places, is highly fossiliferous. Beautiful slabs showing cross-sections of cephalopods are to be seen in the Fleming Museum of the University and in the State Cabinet at Montpelier. The Vermont Marble Company is at present working one of the quarries. It is interesting to note that the world's oldest coral reef[1] was discovered on this island.

1 The Oldest Coral Reef; P. E. Raymond, 14th. R'p't. Vt. State Geol. (1923-'24), p. 72.

Onyx Marble

Onyx marble is a banded, unmetamorphosed calcite, generally regarded as a deposit from cold water solutions, commonly in limestone caves. Mexican onyx is probably the most beautiful. No onyx occurs in Vermont.

Travertine

Travertine, according to Bowles[1], is the product of precipitation from hot springs. It is also an unmetamorphosed calcite, is very porous, containing voids of various sizes, and, unlike onyx, does not take a polish. It is used largely for interior paneling, floor tile, and stairs. The best travertine comes from Italy; none is known in this State.

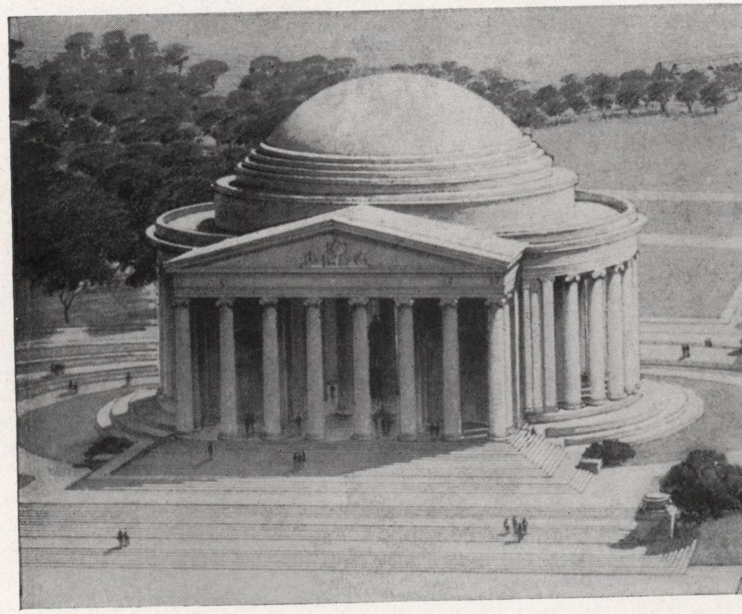
Dolomite Marble

Magnesium is found replacing the calcite in limestone in varying amounts, forming magnesium limestone. If the magnesium content rises to about 20 percent of magnesium oxide (MgO) it is classed as dolomite. Dolomites which contain various amounts of impurities, such as quartz, carbonates and oxides of iron, kaolin, scales of mica, etc., and which will take a polish are classed as dolomite marbles.

In Vermont some phases of the formation which in the past has been called Winooski dolomite, or Winooski marble, but which recent investigations have been shown to be a separate formation, have long been quarried under the name of the Champlain marbles. The formation extends from Snake Mountain, in Weybridge, Addison County, northward along the Champlain thrust fault and into Canada. These marbles vary widely in color: gray, pink, red, mottled, etc. In texture they are from massive to brecciated. They are somewhat heavier and harder than calcite marbles and are therefore more difficult and more expensive to work.

In the past the Champlain marbles were extensively quarried in Winooski, Burlington, Malletts Bay (by the Wakefield Marble Company), and at Swanton (by the Barney Marble Company). They found extensive use in the days of black walnut furniture, as table and dresser tops and like purposes. Today the Vermont Marble Company is working a quarry near St. Albans Bay.

[1] *Op. cit.*



THOMAS JEFFERSON MEMORIAL
WASHINGTON, D. C.

Verde Antique Marble

Verde antique is of igneous origin. In Vermont alterations of igneous intrusions of peridotite produced serpentine, a hydrous silicate of magnesium ($H_4Mg_3Si_2O_9$), of which two broken chains extend, within the ranges of the Green Mountains, pretty much throughout the length of Vermont. Derivatives of the serpentine are talc and chrysotile asbestos. Serpentine, as such, has but little commercial value.

If serpentine, irregularly cracked and sheared by earth forces, has these cracks "healed" by infiltering carbonate solutions, there results verde antique, sometimes called ophicalcite, or ophi-dolomite, depending upon the nature of the solutions. Vermont verdes are ophi-dolomites. The expression comes from the Greek word for serpent, used on account of the sinuous courses of the carbonate through the serpentine.

Verde antique is one of the oldest ornamental stones, dating back to Egyptian and Greek times. The term is from the old Italian, "verde antico", or ancient green. In the United States the stone is, or has been, quarried in Vermont, Massachusetts, New Jersey, Maryland, Georgia, and Michigan. The fine grain, deep, rich green color, white veining, and susceptibility to polish make verde antique one of the most attractive ornamental stones.

In Vermont verde antique was quarried at Roxbury as early as 1858 and Roxbury quarries are still operating. The Barney Marble Company, of Swanton, worked the oldest quarry for many years but has been succeeded by the Vermont Marble Company. This company has also quarried verde in Rochester, Moretown, and in Windham County. At Proctorsville the Proctorsville Marble Company is quarrying this stone.

Verde antique is used chiefly for interior and exterior paneling, as in the Marine Hospital, at Brighton, Mass.; the Home-owners Loan Corporation and the Railroad Retirement Board buildings at Washington, D. C.; and in a host of other places. The flooring for the National Museum of Art, in Washington, is being quarried by the Proctorsville Marble Company, and cut by the Vermont Marble Company.

Production

The Minerals Yearbook, for 1939, states that the sale of marble in the United States, in 1938, decreased seven percent in quantity and three percent in value below the figures for the preceding year. Data for 1939 are not yet available.

Tennessee stood first, on account of marble furnished for the National Gallery of Art, with 342,610 cubic feet, mostly for structural purposes, valued at $1,779,961; Vermont, second in quantity, with 212,080 cubic feet, structural and monumental, valued at $1,003,381; Georgia, third, 195,580 cubic feet, mostly monumental, valued at $1,031,121; Missouri, fourth, 140,230 cubic feet, mostly structural, valued at $375,-116; Alabama, fifth, 65,230 cubic feet, somewhat more for monumental than for building purposes, valued at $367,762. Arkansas, Maryland, and Massachusetts produced much smaller amounts. The total production in the United States was 1,045,680 cubic feet, valued at $4,973,065.

Vermont Production

The following figures, compiled from data reported to the writer, differ somewhat from those given above.

The total cubic feet of all classes of marble produced in the State were 223,574, valued at $1,324,677, in 1938; and 269,752 cubic feet, valued at $1,533,824 in 1939.

The increase in cubic feet, over 1938, was 20.6 percent. Vermont furnished 21.3 percent of the total United States production in marble.

The Vermont marble industry employs about 1300 men.

Marble Companies

THE VERMONT MARBLE COMPANY

Main office: Proctor.

Branch offices in the larger cities of the United States.

Officers: Chairman of the Board, F. C. Partridge; president, Redfield Proctor; vice-presidents, Benjamin Williams, Mortimer R. Proctor, D. H. Bixler; treasurer, H. V. Smith; secretary, Benjamin Williams; assistant-secretary, H. L. Smith.

Quarries at (Brandon)[1], Danby, (Dorset), Florence, Isle la Motte, (Proctor), (Rochester), West Rutland, (Roxbury), St. Albans, (Swanton); also in (Alaska), Colorado, and (Montana).

Fabricating plants at Florence, Proctor, Center Rutland, West Rutland.

Products: Memorials, mausoleums, exterior building stone, interior finish, Lumar, Jetmar, garden furniture, gifts in marble, scale tops, imposing stones, electric switch boards, and others.

By-products: Fluxing material, road metal, whiting substitutes, "Vermarco" products (see under Limestone).

Research Department: For the past eighteen years the Vermont Marble Company has maintained a Research Department, studying the technical and scientific aspects of the marble business. This study has

1 Quarries in parentheses are not active at present.

covered a wide range of subjects, such as: Cement for use with marble, physical and chemical tests of marble, use of bronze and other metals in conjunction with marble, care and cleaning of marble, development of stain removers, the dyeing of marble, weatherprofing methods for stone, new uses of marble and marble waste.

THE GREEN MOUNTAIN MARBLE CORPORATION

Office at West Rutland.

President, P. F. McCormack.

Quarries at West Rutland.

Products: Exterior, interior, and monumental marble.

PROCTORSVILLE MARBLE COMPANY

Office at Proctorsville.

Partners, P. F. McCormack, A. F. Moriglioni.

Product, verde antique marble.

This company is furnishing verde antique marble for the flooring of the National Art Gallery, at Washington. This material was specified to match the columns of the rotunda, which are made of Italian verde.

Mica

Mica is a group, or family, of complex hydrous silicate minerals whose commonly-occurring members are as folows: Biotite, or black "iron mica", which occurs disseminated in many Vermont granites. It has no commercial value. Muscovite, or white "potash mica", also occurs in granite but is found in largest development in pegmatite dikes. It is sometimes called giant granite because of the large sized development of the quartz, feldspar, and muscovite. This as already stated, is due to the presence of "mineralizers"; that is, various gases and water vapor in the magma from which the pegmatite has crystallized. Certain minerals which require these mineralizers for their formation, such as tourmaline, beryl, topaz, cassiterite, and others, are found in pegmatite dikes. Pegmatites yield large sheets of muscovite, which are used in stove doors, lamp chimneys, insulation, and for other purposes[1]. The feldspar is used for glazing pottery, while its decomposition product, kaolin, is the basis of clays.

Unfortunately, no considerable deposits of pegmatite have as yet been discovered in the State, but very large ones are being worked in New Hampshire.

Phlogopite, of "bronze mica" can be used in place of muscovite. A considerable deposit of phlogopite has been discovered in Mt. Holly township, near the Weston line. It has not yet been investigated by the writer. The phlogopite is being studied by the U. S. Bureau of Mines and is found to contain, besides potash and soda, small percentages of the rare elements, rubidium and caesium.

Besides occurring in igneous rocks, such as granite, syenite, etc., muscovite is found in metamorphic rocks, such as schists and gneisses. Furthermore, a secondary, metamorphic mica, called sericite is also found in these rocks.

In several places in the State, notably at Gassetts, in Morrisville, north of Elmore Mountain, and in Windham County, schists occur rich enough in muscovite to be used commercially.

1 Mica finds many scientific uses and is now considered a strategic mineral. It is used in radio tubes, condenser sheets, airplane spark-plugs, magneto condenser films, and for other purposes. See Minerals Yearbook, U. S. Bureau of Mines, for 1940.

At present the schists are being worked for mica and garnet by—

THE GREEN MOUNTAIN MICA CORPORATION

Office and quarry at Gassetts.

President, Francis A. McGreavy.

Products: ground mica and garnet.

The ground mica is finding use in the roofing trade, while the garnet is being shipped to the Vermont Marble Company for use as an abrasive in sawing verde antique.

In 1939 some 550 tons of mica and about 900 tons of garnet were produced. About a dozen men are employed.

Vermiculite

Vermiculite is an alteration product of biotite. On ignition it loses a part of its water and assumes long, worm-like threads (Latin, vermiculari, to breed worms).

It is used in some plasters, in conjunction with fire-clay and bentonite for refractories, and for house insulation in place of mineral wool.

It occurs in Montana, California, and Wyoming. Some of our micas may contain it. The test of heating them intensely would reveal its presence.

Slate

Although Vermont stands second in the production of slate and, together with the adjacent New York slate district, showed an increase of 26 percent in quantity and 29 percent in value, over 1938, the slate industry is in a most deplorable condition. For, whereas other industries thrive by united efforts, such as advertising associations, Vermont and New York slate men suffer, as one of them expressed it, "from too much rugged individualism and cut-throat competition" which have resulted in lost markets, financial distress among the quarry men, and the increase in slate substitutes. This condition is more regrettable because the slate of the district is probably the best in the country.

The Vermont slate industry is now operating at about 40 percent normal. It is to be hoped that the quarry men will soon organize, advertise their wares, and put the industry where it rightfully belongs.

Definition

Slate is a dense, fine-gained, homogeneous rock, the mineral grains of which are too fine to be distinguishable to the naked eye. It is characterized by its superior quality of cleavage which enables it to be split into smooth sheets and slabs of various thicknesses. Geologically, it is a metamorphic rock; that is, one (in this case, shale) which has been altered in its physical properties by the action of natural agents: heat, pressure, and chemical action. True slates are found in regions of rock folding and, often, rock thrusting.

There are several slate belts in Vermont but only in the southwestern one is high-grade slate to be found.

Properties

The specific gravity of slate is about 2.75, so that a cubic foot weights about 172 pounds, though impurities may cause considerable variation.

The color of slate varies widely: black, red, green, purple, mottled, variegated, etc. These various colors are due to the presence of graphite, hematite, chlorite, or admixtures of these minerals, or their decomposition products.

Occurrence

The principal slate belt lies along the border of southwestern Vermont and eastern New York. In Vermont the belt extends from about Sudbury to Rupert, with quarries at Castleton, Hydeville, Fair Haven, Poultney, Wells, and Pawlet. The varieties are sea-green, unfading-green, fading-green, purple, and mottled or variegated. In New York the slate industry centers around Granville, where principally red slates occur.

Geologically the slate has been derived from ancient sedimentary rocks of Lower Cambrian and Ordovician ages. Many years ago the late Dr. T. Nelson Dale[1] studied the geology of the region; while more recently, David M. Larrabee[2], geologist for the Staso Company, has studied a section across the slate belt in Vermont and New York, including Poultney, Vermont, and Hampton, N. Y., and covering an area of some 65 square miles. The article will be of much interest to slate quarriers and others interested in the subject.

Uses[3]

Theere are many uses for slate, the chief of which is for roofing. For this purpose the slate is cut into rectangular pieces, ranging from 6 by 10, to 4 by 24 inches, and from three-sixteenths to one-fourth inch thick, sold in "squares", which cover 100 square feet of roof surface exposed three inches to the weather. Shingles made of slate granules, set in an asphalt base, are also sold as "squares".

Mill stock includes slate of greater thickness, used for electrical switchboards, structural purposes, lavatories, floor tile, grave vaults, billiard table tops, blackboards, school slates and pencils, ornamental flagging, for which the multi-colored Vermont slates are especially adapted, and for other purposes.

Ground slate is used for surfacing tennis courts and play grounds, while slate flour finds use as a filler for paints, road asphalt mixtures, and the like.

1 Geology of the Slate Belt in Eastern New York and Western Vermont; T. N. Dale, 19th. Annual Report, U. S. G. S., part 3.

2 The Colored Slates of Vermont and New York; D. M. Larrabee, Engineering and Mining Journal for December, 1939; and January, 1940.

3 The Stone Industries; Bowles, McGraw-Hill Book Co., New York City (1934).

Production

The Minerals Yearbook, for 1940, will give the following data, for 1939:

	ROOFING		MILL STOCK		OTHER USES(1)	TOTAL
	Squares	Value	Sq. feet	Value	Value	
Pennsylvania	267,710	$1,607,929	3,648,690	$ 888,571	$ 560,353	$3,056,853
Vermont	106,500	763,846	162,470	96,506	1,087,963	1,948,315
New York	2,220	15,740	(2)	(2)	450,007	465,837
Maine	3,840	32,768	(3)	(3)	(2)	215,951
Other States(4)	19,050	448,678	233,370	183,594	546,169	995,258
TOTALS	399,320	$2,868,961	4,044,530	$1,168,671	$2,644,582	$6,682,214

(1) Flagging, granules, flour.
(2) Included under "other States".
(3) Included under "other uses".
(4) Arkansas, California, Georgia, Maryland, Tennessee, Virginia.

Vermont Slate Companies

Since the last report several companies have ceased to operate. Those still active follow.

Castleton

The large quarries and mill of the Staso Milling Company are located in Castleton, just south of the village. Headquarters are at Poultney.

Hydeville

THE HINCHEY CONSOLIDATED SLATE COMPANY

This company is a consolidation of the P. F. Hinchey Slate Company, the G. R. and J. F. Hinchey Slate Company, and the General Slate Company.

Main office at Hydeville.

Officers: President, James Hinchey; treasurer, M. H. Fain.

Quarries at North Poultney and Fair Haven.

Fabricating plants at Hydeville, North Poultney and Fair Haven.

Products: Unfading-green, unfading-mottled-purple, and green slate, sold as roofing slate and mill stock (electrical panels, billiard slabs, flooring, flagging, etc.).

THE HYDEVILLE SLATE WORKS

This partnership has succeeded the old McDougal and O'Day Company.

Partners: J. O'Day and F. D. O'Day.

Quarry at Castleton (north of the village).

Products: Panels for switchboards, flagging, etc.

Fair Haven

HARVEY BUSH SLATE COMPANY

Office at Fair Haven.

Partners: Joel Griffith, Mrs. Joel Griffith, John R. Griffith.

Quarries at Scotch Hill, Fair Haven.

Products: Unfading-green, mottled, purple, and gray, sold as roofing slate.

THE FAIR HAVEN MARBLEIZED SLATE AND VERMONT STRUCTURAL SLATE COMPANY

Office at Fair Haven.

Officers: President, Frances Wheeler; treasurer, M. A. Owens; manager, A. L. Carpenter.

Quarries at Castleton, Fair Haven, and Poultney.

Products: All unfading colors, except red, made into roofing and structural slate (flooring, electrical slate, etc.); also marbleized slate.

This company recently celebrated its eightieth birthday and is the oldest slate company in Vermont.

MAHAR BROTHERS SLATE COMPANY, INCORPORATED

Office at Fair Haven.

Officers: President, George M. Mahar; vice-president and general manager, Thomas Mahar; secretary-treasurer, Edward F. Mahar.

Quarries at Poultney and Castleton.

Fabricating plants: Roofing slate mill at Poultney; electrical and structural slate mill at Hydeville.

Products: Unfading-purple, unfading-mottled-green, and purple-slate, sold mostly as roofing slate, but also for electrical and structural purposes.

This company also leases the Minogue Brothers and Quinn mill at Hydeville.

PEDRO BROTHERS PARTNERSHIP

Office at Fair Haven.

Partners: Joseph Pedro, Rivese Pedro, Tony Pedro, John Foote, Dominic Sbardella.

Quarry at Scotch Hill.

Products: Unfading-green, mottled-green, purple, and gray slate, sold for roofing slate and flagging.

W. H. PELKEY, INCORPORATED

Product: Roofing slate.

Poultney

THE CAMBRIAN SLATE COMPANY

Office at Granville, N. Y.

Officers: President, David O. Roberts; secretary-treasurer, Iola San.

Quarry at Poultney.

Products: Sea-green and variegated roofing slate.

FRED GRAVES

Product: Roofing slate.

LANDSCAPE SLATE AND ROOFING COMPANY

Office at Poultney.

Officers: President, D. O'Brien; vice-president, W. H. Williams; treasurer, R. I. Williams; sales manager, G. W. Sutter.

Quarries at Poultney.

Products: Roofing and flagging.

H. A. MATOT

Product: Roofing slate.

MONTVERT SLATE COMPANY, INCORPORATED

Office at Poultney.

Officers: President, George Ebel; vice-president, W. H. Williams; treasurer, R. I. Williams.

Quarries at Poultney and in New York.

Products: Roofing and flagging.

THE McCARTY SLATE COMPANY

Office at Poultney.

Officers: President, Michael McCarty; manager, H. D. McCarty.

Products: Unfading-green and gray roofing slate.

THE STASO MILLING COMPANY

Office at Poultney.

Officers: President, John W. Powers; secretary-treasurer, W. F. Krohn; general manager, Charles T. Kett.

Quarries at Castleton and Poultney.

Processing plants at Castleton and Poultney.

Products: Slate granules (green, red, and other artificial colors).

The company also has quarries and mills in Maryland, Georgia, Missouri, and Michigan.

THE UNITED SLATE COMPANY

Product: Roofing Slate.

THE VERMONT SLATE FLOORING CORPORATION

Pawlet

OWEN W. OWENS SONS, INCORPORATED

Office at Granville, N. Y.

Officers: President, D. O. Owens; vice-president, W. R. Owens; secretary, D. O. Owens Jr.

Quarries and mill at Pawlet.

Product: Roofing slates.

Note—The Progressive Slate Company, of Granville, has been merged with this corporation.

THE O'BRIEN SLATE COMPANY, INCORPORATED

Office at Granville, N. Y.

Officers: President and secretary-treasurer, James O'Brien.

Quarries at Pawlet.

Product: Roofing slate.

West Pawlet

RISING AND NELSON SLATE COMPANY

Office at West Pawlet.

Partners: S. M. Rising, T. S. Nelson, A. H. Morrill.

Quarries and mills at West Pawlet. Poultney, Fair Haven, and in Maine.

Products: Roofing, flagging, flooring, etc.

Wells

NORTON BROTHERS

Office at Granville, N. Y.

Proprietor, E. R. Norton.

Quarries at Wells and Pawlet.

Products: Roofing slate and flagging.

OWEN L. WILLIAMS AND SON

Post Office address, Granville, N. Y.

Office and quarry at Wells, Vermont.

Products: Roofing slate and flagging.

Dealers in all slate products.

About 600 men are employed in the slate industry.

Talc

According to the Minerals Yearbook the production of talc, ground soapstone, and pyrophyllite, which were lumped together, declined some 17,000 tons from the all-time high of 1937.

In 1917 and 1918 Vermont stood first in talc production, in the United States, with 93,960 tons and 90,537 tons, respectively. This was because, during the Great War when the importation of English clay was much reduced, talc found an increased use as a paper filler. It may well happen again during the present world crisis.

At present Vermont talc production is estimated at from 60 to 75 percent of normal.

Talc is a hyderous silicate of magnesium, having the chemical formula, $H_2Mg_3(SiO_3)_4$. When pure it contains 31.7 percent magnesia (MgO), 63.5 percent silica (SiO_2), and 4.8 percent water (H_2O). It is characterized by its softness, standing No. 1 in Moh's scale, and its greasy feel. The specific gravity is 2.7 to 2.8. Talc is highly heat-resistant, yielding up its water completely only at high temperatures. The color varies from pure white, green, through various shades of gray, sometimes to yellow and red. For commercial purposes the pure white mineral is most desired, and hence the presence of metallic sulphides, as pyrite and pyrrhotite, are objectionable. These sulphides are the worst impurities with which the talc miller has to contend. Such sharp, splintery minerals as actinolite and tremolite, which are more or less associated with talc, militate against its use for cosmetics.

Talc occurs in two chief varieties: the beautiful sea-green, foliated form, which is rather rare; and the massive material which is the talc of commerce. Milling processes for talc production aim at an exceedingly fine powder, down to 4.45 microns[1] in size—so fine that 99.99 percent will pass a 325-mesh screen—and the elimination, as far as possible, of the objectionable minerals noted above.

Talc is a metamorphic mineral, produced in nature by the action of hot solutions on such ultra-basic, intrusive rocks as peridotite, dunite, and others. In the alteration of these ultra-basics Hess[2] recognizes "two distinct and unrelated types. The first is serpentinization (serpentine is another hydrous-silicate, with the formula, ($H_4Mg_3Si_2O_9$) and the second, the talc-soapstone type of alteration, which will be called steatitization". He finds that the alteration may produce both of these types together, or either one alone. When they occur together, serpentine is always the older product. "Serpentine occurs during the last stages of the same cycle of igneous activity as the intrusion of the ultra-basic" which, as Benson describes it, "stews in its own juice". "Steatitization occurs at a later time as the result of dilute hot, aqueous solutions from below".

1 A micron is one-millionth of a meter; a meter is 39.37 inches.

2 The Problem of Serpentinization and the Origin of Certain Chrysotile-Asbestos, Talc, and Soapstone Deposits; H. H. Hess, Economic Geology, vol. 28, pp. 634-657 (1933).

To quote Hess further: "The mineral succession series, hornblende, actinolite, chlorite, talc, and carbonate, is characteristic of steatitization. Hornblende is the high-temperature, end member of the series and talc and carbonate the low- temperature, end members. If the temperature is sufficiently high at the start of the alteration, hornblende will be the first mineral to form; otherwise any lower-temperature mineral may be the first to form. Similarly, the alteration may stop with any member of the series, provided that the solutions are removed from contact with the ultra-basic before the temperature has fallen sufficiently low for talc and carbonate to form." The passages quoted will explain briefly the association of actinolite, chlorite, talc, and carbonate in our Vermont deposits, but a study of the whole article is recommended. The "carbonate" in most of our Vermont deposits is dolomite but at Johnson it is the breunerite ($MgFeCO_3$) variety of magnesite.

Talc is also formed by the alteration of pyroxenes and amphiboles, as at Gouveneur, N. Y., where the fibrous variety, agalite, occurs.

Occurrence

In Vermont the talc occurs in a broken chain of lenses, or pods, running throughout the length of the State, between the second and third ranges of the Green Mountains[1]. The lenses are very irregular in shape and often lie "en echelon" to one another. One of the largest, at North Johnson, is some 360 feet long by 90 feet wide. The talc generally lies along the borders of the lenses, surrounded by so-called "black wall", which is a chloritic schist (see "mineral succession", above) containing from 22 to 24.5 percent MgO. The central part of the lenses is largely composed of carbonate, often penetrated

1 The Talc and Verde Antique Deposits of Vermont; E. C. Jacobs, Tenth R'p't. Vt. State Geol., pp. 232-292. (1915-'16).

by stringers of the black wall material. The lenses lie concordantly within the foliations of the country rock, which is schist or gneiss. The country rock strikes somewhat east of north and dips at high angles to the east.

Today talc is being mined in North Johnson and at Moretown by the Eastern-Magnesia Talc Company; in the northeast corner of Fayston, by the Mad River Talc Corporation; in Chester, by the Vermont Mineral Products Company; and in Windham, by the Vermont Talc Company. Talc mills are located at Johnson, Moretown, Fayston, and Chester Depot.

The best imported talc comes from France, Italy, and Japan. In this country the best material is obtained in California.

Uses

There are many uses for talc: paint, ceramics, roofing material, rubber, cosmetics, foundry facings, wall tile, textiles, soap, wire insulation, lubricants, wall plaster, insulating material, crayons for marking castings, paper filling, and other.

About 92 percent of the talc sold in this country is ground. It is generally sold on the basis of grain size and color; the preferred shade is white.

There is a growing use of talc for wall tile and other ceramics. A lime-free talc is also needed for electric-heater plates. For porcelain insulators, talc containing a definite content of lime is desired. A froth-flotation product is considered best.

Soapstone

Soapstone is an impure talc. It is associatied with amphibole, chlorite, carbonates, and pyrrhotite. It has about the same physical properties as talc but is more compact, tougher, and more heat-resistant, so that it is better adapted to the manufacture of foot-warmers, griddles, laundry tubs, chemical laboratory fittings, etc.

In Vermont soapstone occurs at the old Holden quarry, southeast of Chester; in Athens, Perkinsville, and probably in other localities. The deposits have been worked for many years and not much good stone remains, though some is still being obtained from the Holden quarry.

Pyrophyllite

This mineral is a hydrous silicate of aluminum ($H_4Al_2Si_4O_{12}$). It has about the same properties as talc and is used for much the same purposes. The commercial deposits occur in North Carolina; none is known in Vermont.

Production

According to the Minerals Yearbook, so often quoted in these pages, for 1939, the United States is by far the greatest producer of talc and soapstone, furnishing 196,124 metric tons[1], in 1936; 208,650 in 1937; 193,025 in 1938. Figures for 1939 are not yet available. France ranked second, in 1938, with 56,300 metric tons; Italy, third, with 45,714; Norway, fourth, with 24,701. Germany (including Austria and Bavaria), fifth, with 23,517; India sixth, with 13,249; while other countries produced lesser amounts.

For the United States production of talc and soapstone the following figures are also taken from the Minerals Yearbook.

	1937		1938	
	Short Tons	Value	Short Tons	Value
New York,	96,140	$1,215,834	86,423	$1,110,024
California	32,495	427,031	30,053	391,456
Vermont	41,118	384,474	35,126	329,084
North Carolina	28,250	271,013	27,460	241,337
Georgia	11,984	148,177	15,117	130,595
Washington	406	6,754	174	894
Maryland, Pennsylvania, Virginia	19,606	108,470	18,416	99,170
TOTALS	229,999	$2,561,753	212,775	$2,302,560

It may be noted that Vermont stands second in tonnage production but that the value per ton ($9.30) is considerably below that of California ($13.00) and that of New York ($12.80).

In 1938 the United States imported, chiefly from Italy, Canada, France, and Japan, 22,127 short tons of talc and soapstone, valued at $391,198.

Vermont Production

The total Vermont production of talc, reported to the writer, was, in 1938, 29,964 short tons, valued at $284,853; in 1939, 38,344 short tons, valued at $230,137. The Mad River Talc Corporation is not yet in production.

1 A metric ton weighs 2205 pounds.

The Eastern-Magnesia Talc Company also produced, in 1939, 405 tons of magnesite and about 20 tons of nickel concentrates.. These amounts will be largely increased when the new concentrating plant is fully developed.

About 130 men are employed in the talc industry of the State.

The Talc-Producing Companies

THE EASTERN-MAGNESIA TALC COMPANY, INCORPORATED

This corporation is a consolidation of the former American Mineral Company of Johnson, Eastern Talc Company of Rochester, and Magnesia Talc Company of Moretown. Consolidation was effected January 1, 1924.

Main office, Burlington.

Officers: President, John S. Patrick; vice-presidents, Joseph T. Smith, E. W. Magnus; treasurer, Roy L. Patrick.

Mines at Johnson and Moretown.

Grinding plants at Johnson and Moretown.

This is the largest and best-equipped talc company in the State—as regards equipment, probably the best in the country. Its mineral reserves are enormous and its plant at Johnson, recently equipped with froth-flotation apparatus, represents the most up-to-date practice in talc milling. The company operates two deposits:

Moretown

The talc body here lies on the lower slopes of the Green Mountains, about a mile and one-half from Waterbury. It was acquired by the Magnesia Talc Company in 1912.

The deposit here is extremely large and consists of several great lenses, lying concordantly with the country rock, which is Green Mountain gneiss of Pre-Cambrian age. The mineral is very compact, gray talc derived from serpentine, large relicts of which occur in the lenses. The "grit", or carbonate core, which is so characteristic of other Vermont deposits, is here found only in small amounts.

The deposit was opened by an adit, running along the west wall into the mountain slope and has now attained the length of almost a mile, while overhead stoping has reached the surface, some 600 feet above the end of the workings. The mill is located at the mouth of the adit and talc cars run to it by gravity, while empty cars are returned to the headings by an electric locomotive.

The mill is equipped with the usual talc-grinding machinery: jaw and rotary crushers for coarse grinding; a Raymond mill and its accessories for fine grinding.

Products

The dense, compact nature of much of the mineral enables the company to produce talc crayons in large quantity for use in iron foundaries and steel mills. The best grades of ground talc (0.2% on 200 mesh 99.3% through 325 mesh; average size of particles, 9.95 to 11.04 microns) are sold for use in lacquers and in paper filling, while the poorer grades are used for insecticides, and other purposes.

Chemical Analysis

The best grade of talc (No.21) shows the following analysis:

SiO_2	56.33%
Al_2O_3	3.19
FeO	5.39
MnO	0.11
CaO	0.41
MgO	27.89
Na_2O	0.76
K_2O	0.11
CO_2	0.36
Combined water	5.68
	100.23

Johnson

In North Johnson the Eastern-Magnesia Talc Company owns some 375 acres of mineral land. The talc occurs in irregular lenses, lying more or less "en echelon", concordantly with the gneissic country rock which strikes about N. 30° E. and dips at a high angle to the east. The lenses vary much in size, the largest one being worked is about 350 feet long and varies from nothing to 90 feet wide. This deposit is apparently unique, in Vermont at least, in that the talc is associated with the breunerite variety of magnesite. This fact gives the company an additional valuable product. Nickel and cobalt, in the form of gersdorffite ($NiAsS$) and possibly smaltite ($CoAs_2$) are sparingly disseminated through the talc body and are also being recovered.

The old shaft, which was sunk in the talc body, collapsed in 1938 and has been replaced by a new one, driven in the country rock. It is about 200 feet long on the incline and 148 feet in virtical depth. The 200-foot level is being worked at present and the mineral is being mined by overhead stoping.

One-ton mine cars, hauled by an electric locomotive, bring the mineral to the foot of the shaft, up which it is hoisted to the surface. Motor trucks haul the mineral to the mill which is located in Johnson, near the St. J. & L. C. R. R. The flow sheet is shown on Plate 5.

Flotation

Flotation is a process of mineral separation in which the finely-ground mixed minerals are agitated with a small amount of certain chemical solutions in flotation cells. It is a very widely-used process, adapted to the separation of many classes of minerals. In talc milling the talc particles float to the surface and are skimmed off in the froth, while magnesite, unaffected by the solution, sinks to the bottom of the cell and is drawn off.

By this separation an exceedingly pure talc is obtained, which compares favorably with the best California product. The magnesite tailings will find a market for refractory brick and for other purposes. The nickel and cobalt minerals are recovered on Wilfley tables and will find use in the preparation of salts of nickel and cobalt.

Mill Products

(For numbers in left column, see Plate 5)

Talc Grade No.	Percent thro' 200	Percent thro' 325	Average particle size (microns)	Commercial Uses
549	100	99.99	5.0	Cosmetics, varnish, lacquers.
M-500	99.95	99.52	6.5	Cosmetics, paper, textiles.
R-500	99.94	99.48	12.19	Cosmetics, paper, textiles.
49	100.0	99.98	4.45	Varnish, lacquer, insecticides.
490	100.0	99.99	4.65	Insecticides.
40	99.92	99.36	10.28	Textiles, high-grade rubber.
41	99.93	99.42	9.75	Rubber, textiles, paper.
42	99.96	99.55	15.26	Rubber, saggers, paint, etc.
45	88.2	63.2	....	Roofing, filler, etc.
47	19.5	9.91	....	Roofing, rubber gloves.
42	99.99	99.85	11.57	Insecticides.
Magnesite	80.0	....	....	Refractories.
Nickel-cobalt concentrates				Metal salts.

Chemical Analyses

	Grade No. 41	Grade No. R-500
SiO_2	42.73%	60.15%
Al_2O_3	1.17	0.26
FeO	4.93	1.36
MnO	0.08	0.03
CaO	0.10	0.15
MgO	33.16	32.34
Na_2O	0.35	....
K_2O	0.15	....
CO_2	4.74	1.76
Combined water	12.95	4.30
	100.36	100.35

THE MAD RIVER TALC CORPORATION

Post Office adress, Moretown.

Main office, 122 E. 42d St., New York City.

Officers: President, Horace Parker, New York City; treasurer, Hudson Miller, New York City; general manager, L. M. Hayes, at the mine.

Mine and mill at Fayston.

This corporation has taken over the mine and mill of the old International Mining Company, which was mining and milling talc about 1905, and is rehabilitating them. It is expected that production will start this fall. The products will be ground talc and crayons. The shipping point will be Middlesex.

THE VERMONT MINERAL PRODUCTS COMPANY

Main office, Chester.

Officers: President, Harry F. Douglas; secretary, Walter H. Austin; treasurer-manager, Urban F. Durand.

The company obtains its material from the Carleton quarry, in west Chester, from which it is hauled to the mill at Chester Depot. The talc is an impure mineral, associated with chlorite, tourmaline, pyrite, magnetite, actinolite, etc. The milled products are used in the manufacture of asphalt roofing, for agricultural, and other purposes.

THE VERMONT TALC COMPANY

Main office, Chester Depot.

Officers: President, Nathan P. Avery, Holyoke, Mass.; secretary, Giles Blague, Springfield, Mass.; treasurer and manager, John B. Aikman, Chester.

The company mines its talc by the open-pit method, in Windham, some twelve miles south of Chester, from where the mineral is trucked to the mill at Chester Depot. The product is finely-ground talc which finds uses in wire insulation, rubber manufacture, textiles, foundry work, etc.

Chemical Analysis

SiO_2	34.96%
Fe_2O_3	6.83
Al_2O_3	0.68
CO	0.40
MgO	33.51
CO_2	18.18
Combined water	5.10
	99.66

Soapstone

THE VERMONT SOAPSTONE COMPANY

Office and mill at Perkinsville.

Proprietor, John H. Hicks.

Products: soapstone sinks, wash tubs, griddles, laboratory fittings, etc.

The company obtains its soapstone from the Holden quarry, near Chester, and from Virginia.

Jasper

Jasper is an opaque variety of impure (ferruginous) quartz, of various colors: red, brown, gray, green, or black.

There is a small deposit of red jasper on the Parrot farm, in Colchester, just north of Malletts Bay. It has been quarried to some extent for use in artificial stone.

Sand, Gravel and Crushed Stone

Vermont Dealers in Sand and Gravel

H. G. Calkins,	Lyndonville
R. J. Cone,	Woodford
Daily Crusher	Shaftsbury
R. W. Overocker	Burlington
Rutland Sand & Gravel Co.	Rutland
Vermont Stone Products Co.	Burlington & Morrisville

Dealers in Crushed Stone

Barton Construction Co.	Barton
Alfred Berotta, red quartzite	Burlington
Fonda Junction Lime Company, limestone	Fonda Junction
H. B. Huntley, limestone	Leicester Junction
Rutland City Quarry	Rutland
St. Albans City Quarry	St. Albans
Swanton Lime Works, limestone	Swanton
Vergennes City Quarry, dolomite	Vergennes
Vermont Stone Products Co.	Burlington & Morrisville
Wells-Lamson Granite Co., granite	Barre

Summary

Total Value of Mineral Products and Number of Men Employed in Them, in 1939

		Number of Men, Approximately
Asbestos	Data Confidential	160
Clay products	$ 791.032	60
Granite	7,304,356	1650
Limestone and Dolomite	463,451	150
Marble	1,533,824	1300
Mica and Garnet	12,771	12
Slate	1,948,315	600
Talc	230,137	130
Soapstone, Jasper, Sand, Gravel Crushed Stone	No Data Received	
TOTAL	$12,283,886	4062

Exports

VERMONT EXPORTS ASBESTOS, GRANITE, AND MARBLE

The Vermont Marble Company ships some of its products to New Zealand, British West Indies, New Foundland, the Eastern Provinces of Canada, Ontario, Quebec, Alberta, and British Columbia. The granite companies ship some of their products to Canada. Asbestos is also exported in small amounts.

In 1936 the total value of these exports was $81,964; in 1937, $84,540; in 1938, $81,226. No figures for 1939 are at hand.

Status of Topographical Mapping in Vermont

Topographical surveying and mapping were begun by the U. S. Geological Survey in 1914, under a cooperative agreement by which the Federal Government and the State of Vermont each paid half the expense. This agreement has been in force ever since, except in 1917 when the Legislature failed to make an appropriation for the work. The amounts of Federal and State appropriations have varied considerably but of late years each has contributed $2000 per annum.

For topographical mapping the State is laid out into quadrangles, each 15 minutes of latitude by 15 minutes of longitude, in area; or roughly 15.5 by 10.5 miles. The linear scale is: one inch equals 62,500 inches, or 0.986 mile.

The average cost of mapping a quadrangle, in Vermont, is about $11,000, so that progress has been slow, though it has been considerably expedited by special allocations by the War Department for work on some of the international boundary quadrangles, for strategic reasons.

The State appears, either wholly or in part, on 60 quadrangles, of which 36 are practically wholly in Vermont while, of the remainder, Vermont includes varying proportions.

The plan of the quadrangles follows. Quadrangles without footnote designations are complete. They may be obtained from the U. S. Geological Survey, at Washington, at 10 cents each (7 cents each for 100 or more) or, generally, from book stores in the larger cities and towns. A key sheet, showing the localities covered by each quadrangle may be obtained, gratis, from Washington.

	1.	2.	3.	4.	5.	6.	7.	8.
1.	Rouses Point N. Y.	St. Albans	Enosburg Falls	Jay Peak	Irasburg	Memphremagog	Island Pond	Averill
2.	Plattsburg N. Y.	Milton	Mt. Mansfield	Hyde Park	Hardwick	Lyndonville	Burke 1	Guildhall
3.	Willsboro N. Y.	Burlington	Camels Hump	Montpelier	Plainfield 2	St. Johnsbury	Littleton N. H.	Whitefield N. H.
4.	Port Henry N. Y.	Middlebury	Lincoln Mt.	Barre	Corinth 1	Woodsville 3 N. H.		
5.	Ticonderoga N. Y.	Brandon	Rochester	Randolph	Strafford	Mt. Cube N. H.		
6.	Whitehall N. Y.	Castleton	Rutland	Woodstock	Hanover N. H.			
7.	Fort Ann N. Y.	Pawlet	Wallingford	Ludlow	Claremont N. H.			
8.	Cambridge N. Y.	Equinox	Londonderry	Saxtons River	Bellows Falls			
9.	Hoosick N. Y.	Bennington	Wilmington	Brattleboro	Keene N. H.			
10.		Greylock Mass.	Hawley Mass.	Greenfield Mass.	Warwick Mass.			

1. Name tentative; field work not begun.
2. Map is being drafted.
3. Map will soon be ready for distribution.

The No. 1 vertical tier is very largely in New York; the No. 10 horizontal row is nearly wholly in Massachusetts.

The topographical survey of the State is about 94 percent completed; five or six years, at the present rate of progress, should see the end of this very important work. Then, some of the oldest quadrangles should be resurveyed since, with the old methods used, many inaccuracies occur.

New Products

Recently the Thompson-Weinman Company and the Vermont Marble Company formed a new cooperating company to be known as the White Pigment Corporation. This new development will extend the market for the present pulverized marble products, and finer sizes will be made to fill many new applications.

The present plant at Florence, Vermont, is being extended and, within a few months, will be producing a large tonnage of six different calcium carbonate fillers that have already demonstrated their superior qualities. These products are:

Atomite, which grades 85 percent finer than two microns and is finding general acceptance as a substitute for English china clay, for coating glazed papers.

Snowflake, averaging about ten microns, and Keystone, about fifteen microns, are in demand for paint, putty, linoleum, rubber, and a wide range of filler and pigment applications. These new, finer products are also going into rubber heels, wire insulation, and a recently-patented process for R. C. A. and Decca records.

Three other dry-ground fillers, averaging finer than 99.5 percent through 300 to 325 mesh, are known as Verlac, Veroc, and Drikal. These will find appropriate uses.

It is expected that this rapidly-growing branch of the marble business will absorb labor that would be otherwise laid off because of the temporary slack business in the building and memorial field.

The Mineral Resources Committee and its Aims

In January, 1940, the New England Council, which has been in existence since 1925, organized a New Products Committee for the purpose of discovering new economic minerals, new localities for those already known, and new uses for mineral substances in general. The Mineral Resources Committee, a sub-body, of which Mr. Harold Ladd Smith, of the Vermont Marble Company, is chairman, is made up of the State Geologists of those New England states which have such officers, and of other geologists and laymen interested in the subject.

In order to further this important movement the Vermont State Geologist has, by letters published in the leading newspapers of Vermont and by a radio address which will be repeated from time to time, asked the people of the State to look about for considerable masses (not isolated fragments) of, to them, unknown mineral substances and to send him specimens for examination. He particularly asked them not to send fragments or crystals of the hard, brass-colored pyrite, or yellow mica, in the hope that they were gold—he receives far too much of such things already. (Gold is soft and malleable).

The response has been encouraging and a number of promising minerals have come to light and are being investigated.

There are without doubt other mineral substances to be discovered and it is hoped that the people of Vermont, or elsewhere, will aid in finding them. Ordinary blue clay may be suitable for stone ware. Pure, white clay and pure white sand are needed in the industries. Such minerals as kyanite, vesuvianite, sillimanite, barite (kyanite has been reported in Irasburg) are in demand. Large pegmatite dikes, so far undiscovered in Vermont, are of value for their mica, feldspar, and quartz content. The search for gold has so far not proved economically successful but commercial quantities may exist.

Therefore, in your leisure time, look about and see if you cannot aid the cause of "more mineral wealth for Vermont".

FLOWSHEET–EASTERN MAGNESIA TALC MILL

Plate 5