Protypus senectus Billings. 10 Ann. R. U. S. G. S., p. 575.
Ptychoparia adamsi Billings. 10 Ann. R. U. S. G. S., p. 575. R. V. S. G., VI, p. 215.
Ptychoparia teucer Billings. R. V. S. G., V, p. 119.
Rustella edsoni Walcott. R. V. S. G., VI, p. 216.
Salterella pulchella Billings. R. V. S. G., VI, p. 226.

SWANTON, S. of village.
Chazy.
Girvanella ocellata (Seely). R. V. S. G., XIII, p. 194.
Maclurites magnus (Lesueur). R. V. S. G., XIII, p. 194.

SWANTON, bed of river.
Trenton.
Diplograptus foliaceous (Murchison). R. V. S. G., V, p. 212.

SWANTON FALLS.
Trenton, Canajoharie.
Glossograptus quadrimucronatus (Hall). R. V. S. G., XIII, p. 191.

VERGENNES, W. of playgrounds, Industrial School.
Chazy B.
Girvanella ocellata (Seely). R. V. S. G., XIII, p. 236.

VERGENNES, 3½ mi. S. of.
Chazy B.
Maclurites magnus (Lesueur). R. V. S. G., X, p. 242. R. V. S. G., XIII, p. 236.

VERGENNES, 2 mi. NE.
Trenton.
Calymene senaria Conrad. R. V. S. G., XIII, p. 236.
Cryptolithus tessellatus Green. R. V. S. G., XIII, p. 236.
Diplograptus amplexicaulis Hall. A. M. N. H., Cat. No. $\frac{1040}{8}$.

VERGENNES, Industrial School grounds near boat landing.
Trenton, Canajoharie.
Glossograptus quadrimucronatus (Hall). R. V. S. G., XIII, p. 236.

WALTHAM, 1½ mi. S. of Vergennes.
Chazy.
Girvanella ocellata (Seely). R. V. S. G., XIII, p. 244.
Maclurites magnus (Lesueur). R. V. S. G., XIII, pp. 244, 245.

WILLISTON.
Chazy.
Stromatopora. A. J. S. (3), VI, p. 276, 1873.

THE CLAY DEPOSITS AND CLAY INDUSTRIES OF VERMONT

ELBRIDGE CHURCHILL JACOBS.

CONTENTS.

INTRODUCTION.

At the request of the State Geologist the writer has made a survey of the clay resources and clay industries of the State. He has found that the deposits of Quaternary (glacial) clays are enormous and that the resources of the State in china clay are much greater than is generally supposed. At the present time Vermont has only a small clay industry, but there are good reasons for believing that in the near future this will be greatly enlarged by the development of her china clay deposits.

In a region of many streams and glacial lakes and in one everywhere covered with glacial drift, Quaternary clay deposits naturally occur in many places, and numbers of old brick houses in many parts of the State testify to their abundance and former extensive use.

It has been one object of the present investigation to locate and to describe those considerable deposits of clay which are not being worked but are available and commercially accessible for the various purposes to which they are suited.

Since the report is written chiefly for the general reader it is presented in perhaps greater detail than would be the case if it were intended wholly for the technical student.

Professor Ries,[1] who is the authority on the subject, defines clay as "the term applied to those earthy materials, occurring in nature, whose most prominent property is that of plasticity when wet." "On this account," he continues, "they can be moulded

[1] Clays, Occurrence, Properties, and Uses, Heinrich Ries.

into almost any desired shape, which is retained when dry. Furthermore, if heated to redness or higher, the material becomes hard and rock-like."

Merrill[1] points out that "clays although alike in their general physical and even ultimate nature, have widely diverse origins, being indefinite admixtures of more or less hydrated aluminum silicates, free silica, iron oxides, carbonate of lime, and various silicate minerals which, in more or less decomposed and fragmental condition, have survived the destructive agencies to which they have been subjected." In other words, clay is composed of certain residual products of rock disintegration.

Lindgren[2] notes that sedimentary clay is a rock rather than a mineral and, this being so, that kaolin or china clay is to be distinguished from kaolinite, which is a mineral having a definite chemical composition with the formula, $H_4Al_2Si_2O_9$, calling for 46.5 percent SiO_2, 39.5 percent Al_2O_3, and 14 percent water.

Of late years much attention has been paid to so-called colloids and to the colloidal state of matter. Popular definitions are difficult to give, but it may be stated that the colloidal state results generally from an exceedingly fine subdivision of many different substances. Opposed to the colloidal state is the crystalline condition, in which the mineral molecules are organized, forming planes and faces often definitely related to one another. Egg albumen, glue, jellies, etc., are well-known examples of substances in the colloidal state, while Bancroft[3] points out that so many substances in our every day experiences—cement, bricks, pottery, porcelain, glass, rubber, soaps, etc.—exist in this state, that "colloid chemistry is the chemistry of every day life"; that it is a common and not an unusual condition of matter.

Ashley[4] has studied the colloidal state as it exists in clay and, defining clays as mixtures of various silicate minerals, among which kaolinite is the most characteristic, he points out that these mineral grains which exhibit both crystal faces and irregular shapes, are enveloped by colloidal coatings. These coatings are chiefly of silicate constitution, but also consist of organic colloids, iron, manganese and aluminum hydroxides, and of hydrated silicic acid.

In clays the proportion of crystalline and colloidal matter is such that, when moistened, plasticity results. If the colloidal matter is in excess the clay is considered very plastic, "fat," or sticky; while if the crystalline material is in excess, the clay is sandy, weak, or non-plastic.

[1] Rocks, Rock-weathering and Soils, G. P. Merrill.
[2] Mineral Deposits, Waldemar Lindgren.
[3] Applied Colloidal Chemistry, W. D. Bancroft.
[4] The Colloid Matter of Clay, and its Measurement, H. E. Ashley, Bull. U. S. G. S., No. 388.

USES OF CLAYS.

The uses of clay are many and varied. The following partial list, taken from Ries,[1] will give some of the more common, local ones:

Domestic.—Porcelain, stoneware, yellow ware, Rockingham ware for table service and cooking. Fire-kindlers.

Structural.—Brick, 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.—Food adulterants, paint fillers, paper fillers, electric insulators, scouring-soap, chemical apparatus, smoking-pipes, filter-tubes, plaster, alum, etc.

Vermont clays have been used in the past, are being used at present, or will probably be used in the future for making porcelain, white ware, stoneware, yellow ware, Rockingham ware, Parian ware, bricks (common and faced), drain-tile, saggers, stove- and furnace-lining, ornamental pottery, paints, fillers, paper-filling, electrical insulators, etc. It is, furthermore, proposed to use some of the best grades as a basis for the production of alums.

CLASSIFICATION OF VERMONT CLAYS.

The origin of clays is so varied and their properties and uses are so diverse that their classification is a matter of considerable difficulty.

As regards origin, Vermont clays may be listed as follows:

RESIDUAL CLAYS.

Under this heading are included those clays which are found in contact with the rock from which they were derived by the process called kaolinization. This parent rock may contain feldspar (a family of anhydrous silicates of aluminum, potassium, sodium, calcium, or isomorphous mixtures of these) or any other mineral which, on weathering, produces more or less of the mineral kaolinite, together with other aluminum silicates. Common parent rocks are pegmatite, granite, feldspathic quartzite, etc.

The clays derived from these residual deposits give us the kaolins, which Ries defines as "White-burning clays of residual character, which are composed mostly of silica, alumina, and

[1] *Loc. cit.*

chemically-combined water, and have very low percentages of fluxing impurities, especially iron."

This class of clays occurs in Vermont along the western border of the Green Mountains.

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 may include white-burning, plastic clays, derived from residual deposits, or colored clays, having oftentimes remote and complex origins. Transported clays include:

ESTUARINE CLAYS.

These, as Ries states, "Represent bodies of clays laid down in shallow arms of the sea." The Champlain Clays belong to this class of deposits, since Lake Champlain at the close of the Glacial Epoch formed a part of the ~~Hudson~~-Champlain-St. Lawrence arm of the Atlantic Ocean which separated New England and south-eastern Canada from the rest of the continent.

LAKE AND POND CLAYS.

Vermont is a region of many lakes and ponds, probably all of which are of glacial origin. These formed settling basins into which the clay and other material, brought down by streams from the melting ice on the retreat of the ice-cap, were deposited and settled out, more or less interstratified with other rock débris, especially sand.

FLOOD-PLAIN AND TERRACE CLAYS.

Ries[1] states that: "Many rivers, especially in broad valleys, are bordered by a terrace or plain, there being sometimes two or more, extending like a series of shelves or steps up the valley sides. The lowest of these is often covered by the river during periods of high water, and is consequently termed a flood-plain. In such times much clayey sediment is added to the surface of this flood-terrace, and thus a flood-plain clay deposit may be built up."

In Vermont the Missisquoi, Lamoille, Winooski, and Otter Rivers, as well as the Connecticut, are bordered by flights of terraces, which represent old flood-plains through which the rivers have cut their courses, owing to the rise of the land. On these terraces are found deposits of sedimentary clays, some of which have been used for brick-making, while many more would afford material for this or other clay industries for many years to come.

[1] *Loc. cit.*

DRIFT OR BOWLDER CLAY.

During the last glacial epoch, the so-called Pleistocene, the ice-sheet which came down from the North, burying a large part of the continent to a depth of thousands of feet, brought with it an enormous amount of bowlders, rock-débris, sand, clay, etc. This material is called "till" or "glacial drift" and it is found everywhere in Vermont, filling old depressions and leaving transported bowlders or "erratics" in the fields and even on the mountain tops. The clay and associated rock waste, formed by the grinding action of the englaciated material, is known as "bowlder-clay" or "hardpan." Splendid examples of hardpan may be seen at Clarendon Springs and elsewhere in the State. Clays derived from this class of deposits are generally too impure for commercial use.

SEASONAL OR VARVE CLAYS.

As the Great Ice Age came to a close and the ice-cap retreated northward, owing to the coming of a more moderate climate, many temporary streams were formed in and on the borders of the ice. These streams, working over the englaciated rock marial, sorted it according to its size and specific gravity and formed it into eskers and outwash-plains. When the glacial streams discharged into standing water, the coarser, heavier sand was deposited near shore, while the lighter, clay material was carried farther out, gradually to sink in the still water. Even here there was a sorting action going on, owing to the extremely fine, colloidal state of division of which clay particles are susceptible. In the warmer seasons, with their vigorous stream-flow, coarser clay particles and correspondingly finer particles of sand, having the same "settling power," to use a term employed in ore-dressing, settled together; while in the colder parts of the year, when streams no longer issued from the ice and standing bodies of water were frozen over, the finer clay particles, and associated with them, fine shreds of organic matter, gradually sank to the bottom and formed a stratum quite distinct from the sand-clay layer. Evidently these two strata were the result of one season's deposition, and the number of pairs of strata found in a given clay deposit is a measure of the number of years needed for its formation. Such deposits are called "seasonal clays" and the annual layers are called "varves."

In Europe De Geer, and in this country Ernst Antevs, have made use of such varve clays to establish a glacial chronology. It will be seen that many Vermont clays belong to this class of deposits.

Plate XXI, printed by permission of the Harvard Museum of Comparative Zoology, shows a large deposit of varve clay, on the Vermont side of the Connecticut River, near Hanover, N. H.

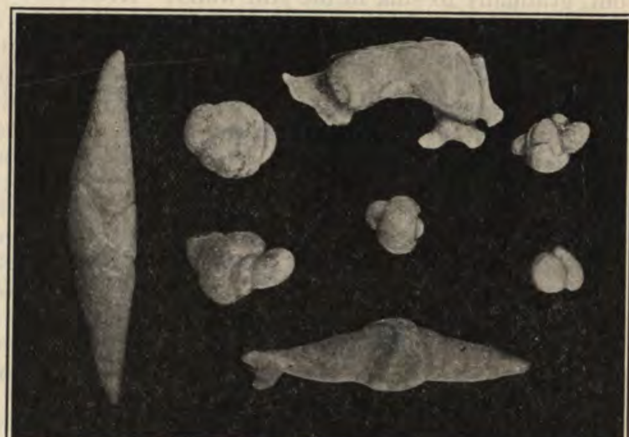
CLAY CONCRETIONS.

Besides the stones and bowlders which are associated with glacial clay banks, there are found deep within the clay itself (derived from it, in distinction from the stones and bowlders)

PLATE XX.

A varve-clay deposit.

PLATE XXI.



Clay concretions.

various mineral substances, such as limonite, siderits, pyrite, and carbonate of calcium. The calcium carbonate manifests itself in curious shapes and forms, as shown in Plate XXII. These do not appear to have formed around nuclei—or if they have,

the nuclei are too microscopic to be discovered in the broken concretions. The concretions are found only in clays which have a considerable lime content and appear to have been formed by a gathering together of the lime carbonate molecules. In this respect they resemble the crystallized pyrite which one finds in the chlorite schist around Chester. By the brick-maker they are called "clay-dogs."

PROPERTIES OF CLAYS.

The commercial value of a clay will depend upon its chemical and mineral composition and upon such physical properties as its color, plasticity, shrinkage, porosity, fusibility, absorbtion, etc. Clays are therefore tested chemically, microscopically, and physically and on the following pages the results of such tests, made on various clay deposits, are tabulated. It will, therefore, be illuminating to consider these properties and tests in some detail.

CHEMICAL ANALYSIS.

The chemical analysis shows the ultimate composition of the material. For convenience the elements present are expressed as oxides and acid-radicals and these should (but never do) aggregate exactly 100 percent. The analysis will reveal the identity and amount of both desirable and undesirable ingredients in the sample. If we may take kaolinite as the essential clay substance, we may regard it as having the formula: Al_2O_3, 2 SiO_2, 2 H_2O, which corresponds to the composition: SiO_2, 46.50 percent; Al_2O_3, 39.57 percent; water (H_2O), 13.93 percent. Other constituents of a clay, such as oxides of iron, the alkalies and alkaline earths, etc., will have their effect on its color, fusibility, etc.

The chemical analysis may be "recast" to show the percentages of *mineral* constituents present, as kaolinite, feldspar, free quartz (sand), etc. This gives the "rational analysis." Or a special chemical procedure may be carried on, which will serve to give the same thing. (See the analyses of Bennington clays, p. 206).

PLASTICITY.

Ries defines plasticity as "The property which many bodies possess of changing form under pressure, without rupturing, which form they retain when the pressure ceases." He states that plasticity is not restricted to clays, but is more highly developed in them than in some other substances.

For the purpose of obtaining reliable results from physical tests made upon clays, The American Ceramic Society has adopted standard procedures and standard sizes for the test pieces used. These test pieces are made from the clay under examination and are approximately 1⅛ x 1⅛ x 1⅞ inches. With such pieces the following tests are made:

WATER OF PLASTICITY.

This shows the percent of water present in the sample of plastic clay in question. It is based on the weight of the dry clay test-piece and is calculated from the equation:

$$T = \frac{W_p - W_d}{W_d} \times 100$$

in which T is the percentage water of plasticity,
W_p is the weight of the plastic test-piece,
W_d is the weight of the dry test-piece.

LINEAR DRYING SHRINKAGE.

This test shows the extent to which a clay will contract in linear dimension on drying under uniform conditions. It will depend on the fatness of the clay and on the fineness of its grain. It is based on a test piece of plastic clay of definite length and is expressed in percent as above.

SOFTENING POINT.

The softening points of clays are determined by forming them into small cones or pyramids of standard dimensions, properly dried, and comparing their behaviors with those of standard cones (Seger or Orton) or pyramids of known softening points, when exposed to the same temperatures, under standard conditions.

The standard cones are made of various refractory materials, or of mixtures of these materials. These standard cones have softening points of pretty definite temperatures, varying with their composition. Thermo-electric pyrometers, set into the furnace, serve to relate the softening points of the cones to the Centigrade scale. The standard cones are distinguished by numbers: 1, 2, 4, 7, 10, 13, etc.

PERCENT BURNED SHRINKAGE.

This is the percent diminuation in length of a dry test-piece, when exposed to a definite temperature, under standard conditions. It shows the clay manufacturer to what extent his clay will shrink under the conditions of firing which are required for the ware he is making. From this he will judge how to modify his clay mixture to obtain the desired results.

PERCENT ABSORBTION.

This is obtained by allowing test-pieces, exposed to different temperatures, to absorb their maximum amount of water, and then determining the amount of the water absorbed, by drying the pieces under standard conditions.

Various other tests can of course be made, but the above are the ones used by various testing laboratories. Tests on clays are made by the Bureau of Standards, Washington, D. C.; the Mellon Institute, of Pittsburg, Pa.; Ellis Lovejoy, of Columbus, Ohio, etc.

THE PRESENT CLAY INDUSTRIES IN VERMONT.

Today there are being worked in the State:

1. Quarternary or Glacial Clays, for the manufacture of bricks.
2. Kaolin Deposits, for paper-filling, electrical-porcelain manufacture, stove and furnace linings, and other purposes.

BRICK MANUFACTURE.

The producers of bricks are:

The Drury Brick and Tile Company.

The Bennington Brick Company, now owned by the Green Mountain Kaolin Corporation.

The Wells River Brickyard.

THE DRURY BRICK AND TILE COMPANY.

This company was incorporated in 1897, but dates back to 1867, when it was known as J. K. Drury and Son.

The plant and clay deposits are situated in Essex Junction, near the highway leading to Jericho and Cambridge. A spur-track connects the works with the Central Vermont Railroad.

The corporation has for many years worked the clay on a tract of land some twenty-eight acres in extent. Recently it has purchased the adjoining Place farm of one hundred acres and it is now estimated that the supply of clay is sufficient to last for at least fifty years. The clay lies near the foot-hills of the Green Mountains, whose outcrops of sericite schist appear a few hundred yards to the north.

The clay was probably deposited in an old glacial pond. It is underlain by glacial till and contains considerable quantities of transported glacial débris: Black Isle La Motte limestone, Champlain "marbles," as well as clay concretions, or "clay dogs." The maximum thickness exposed is about thirty feet and it is covered with a sandy loam.

The material is a varve or seasonal clay, varying in color from blue to red.

An analysis of the blue clay, made in the laboratories of the University, shows:

	Percent
SiO_2	53.69
Al_2O_3	21.24
Fe_2O_3	8.65
$TioO_2$	.41
MnO	.02
CaO	2.84
MgO	1.03
Na_2O	1.78
K_2O	3.94
H_2O	5.36
Moisture	.79
	99.75

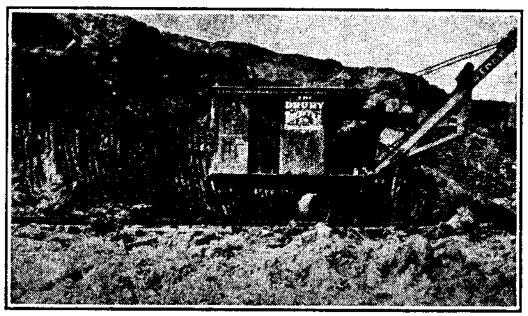
CO_2 and SO_2 present, but not determined.

Unfortunately, fusibility tests have not been made.

METHOD OF WORKING AND MANUFACTURE OF BRICK.

The clay is dug with a Thew Automatic Electric Shovel and a Schofield & Burkett Excavator, which deliver the material to cars. These are hauled by a gasoline locomotive over narrow-

PLATE XXII.



Thew automatic electric shovel.

gauge tracks to the moulding department. Here the clay is mixed with the proper amount of sand, slack coal and hydrated lime, the amounts depending upon the character of the clay and its water content. This mixture passes through a disintegrator and then, by means of a belt conveyor, is delivered to the pug-mill, the knives of which, set into a horizontal, revolving shaft, cut up the lumps and thoroughly mix the mass. This then passes to a Martin Automatic Brick Machine, which forms the bricks, sands them, and delivers them to pallets, which are carried by cable conveyors either to open-air drying sheds or to steam dryers. The bricks remain in the open-air dryers generally ten days; in the steam dryers, over night—in either case till they are sufficiently strong to be built into kilns. The burning takes place in scove-

type, up-draught kilns, fired with oil during the greater part of the time, but finished with wood-firing, in order to give the desired color. About 680,000 bricks are burned at a time. The building of the kiln requires three weeks, the firing four or five days, and the cooling about five days more.

The standard brick is 2¼ by 3¾ by 8 inches. It weighs approximately four pounds.

The Drury Company shipped 6,076,074 bricks in 1925. The base price is $18 a thousand. The bricks are sold in Vermont, New Hampshire, and eastern New York. The new Ira Allen Chapel, being built for the University of Vermont, and the new Burlington City Hall are being constructed of Drury bricks.

BENNINGTON.

In 1924 the Bennington Brick Company was formed for the purpose of working a deposit of clay on the Fred Foster farm, in the southeastern part of the village. Bricks had been made from this clay over a period of at least seventy years, and used locally with good results.

The deposit is a blue varve-clay and is remarkably free from inclusions and concretions of foreign material. The face exposed to date is about eleven feet in depth and the clay is overlain by three or four feet of glacial débris.

The material is a blue, coarse-grained, fairly homogeneous clay, having a softening-point of about 1,190 degrees Centigrade and a linear drying shrinkage equal to 7.6 percent of the plastic length. Other tests made on the clay showed the following results:

Cone	Percent burned shrinkage	Percent absorbtion	Color
08	10.6	18.7	buff
06	12.6	7.8	salmon
04	16.8	3.6	lt. red
02	18.2	.6	red
1	8.0 (overfired)	1.7	chocolate

The bricks produced are colonial red in color. Several local structures, built of them, have developed no excresences whatever.

The company made about half a million bricks in 1925, while up to September 1, 1926, it had burned about a million more.

In 1925 the Green Mountain Kaolin Corporation was formed (see under Kaolin), and took over the Bennington Brick Co.

THE WELLS RIVER BRICKYARD.

This yard is located in the northeast part of the town of Newbury, on the Wells River, about two miles from its confluence with the Connecticut. The industry was established seven years ago by D. S. Stone. Two years ago, when the writer visited the

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Thew automatic electric shovel.

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THE WELLS RIVER BRICKYARD.

This yard is located in the northeast part of the town of Newbury, on the Wells River, about two miles from its confluence with the Connecticut. The industry was established seven years ago by D. S. Stone. Two years ago, when the writer visited the plant, it was making about 360,000 bricks a year. The selling price varied from $15 to $20 a thousand.

The deposit from which the bricks are made consists of a slate-colored, fat, varve-clay, some twenty feet in visible thickness, overlain by fifteen or twenty feet of fine sand.

KAOLIN DEPOSITS.

Along the western side of the State there is a broken chain of kaolin deposits, extending from Monkton to Pownal and including outcrops at Monkton, Brandon (Forestdale), Rutland, South Wallingford, Tinmouth, North Dorset, Shaftsbury, and Bennington. It is quite possible that future discoveries will fill in some of the breaks in this chain.

These deposits are more or less associated with iron ore and manganese minerals. Some of them were worked, years ago, for iron and manganese. It is probably safe to say that kaolin has been mined to some extent for over a century. In the last few years there has been increased activity in kaolin mining and at the present time the prospects are extremely good for the establishment of an important kaolin industry in the State.

PRESENT STATUS OF THE INDUSTRY.

At the present time kaolin is being produced, or will probably soon be produced, by the folllowing organizations:

The Vermont Kaolin Corporation, at East Bennington.

Frank E. Bushy and Sons, at East Monkton.

The Green Mountain Kaolin Corporation, at Bennington.

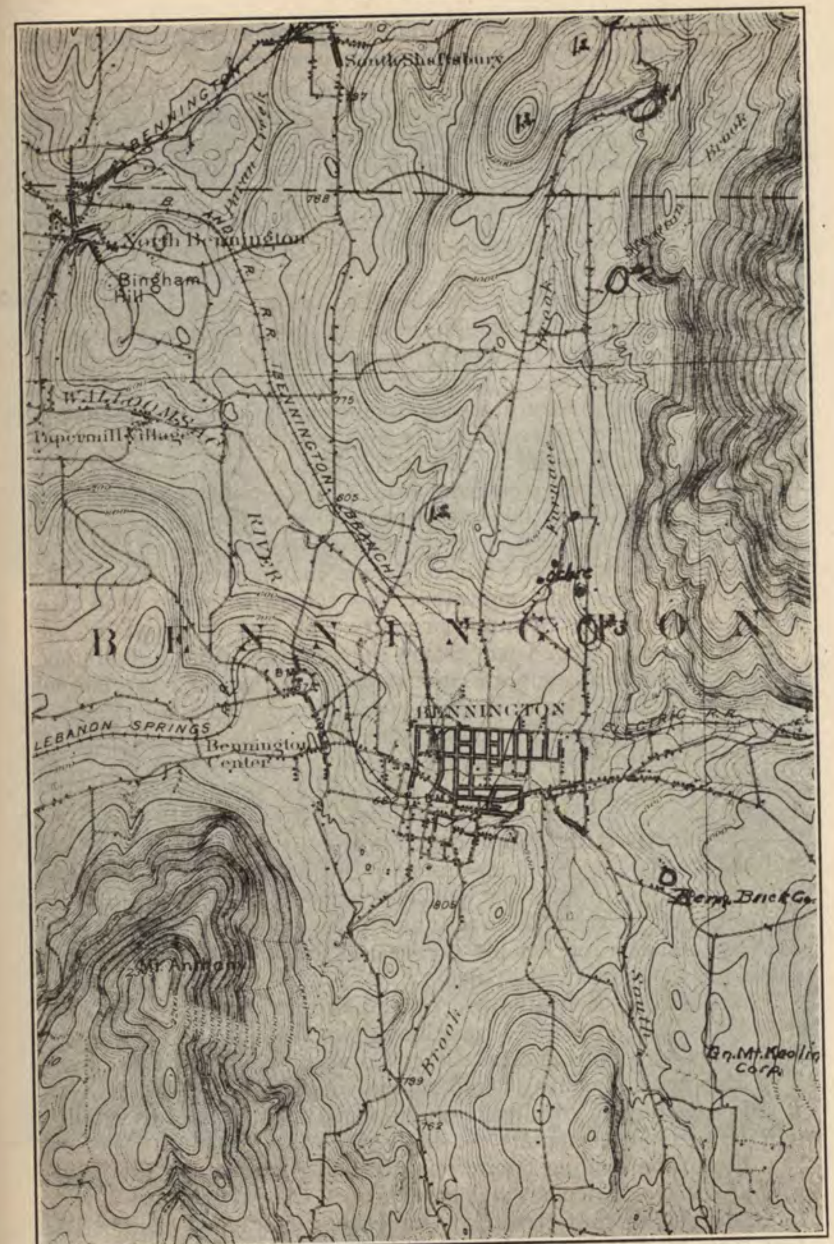
In addition, the Rutland Fire Clay Company is producing a series of fire-resisting substances, which depend more or less on kaolin for their manufacture.

THE VERMONT KAOLIN CORPORATION.

Shaftsbury and Bennington.

In the southeastern part of Shaftsbury and the northeastern part of Bennington, lying somewhat east of Furnace Brook (Plate XXIV), 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.

In East Shaftsbury (location No. 1 on the map) 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. In that year the property passed into the hands of S. C. Lyons and Brothers, who mined the clay till 1915, after which time operations were suspended for several years.



Map of Bennington area.

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 (location No. 2, on the map), on which clay was mined by Homer Lyons in the eighteen-seventies. Two or three thousand tons were removed and hauled to Furnace Brook, one mile west, where the clay was washed. During 1917 Messrs. Horn and Crockett prospected the deposit, drilling five holes to depths of 105 feet. In 1926 the mineral rights were sold to the Vermont Kaolin Corporation.

Recent 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 about fifty to more than 150 feet. The overburden of glacial material averages perhaps twenty feet. The clay does not appear to differ markedly from that in the No. 3 location (see map), being prevailingly of white, blue, or buff color. It seems to carry a relatively low percentage of grit and is unusually free from iron. It is possible that this clay may serve as a material for the manufacture of aluminum sulphate.

The third location (No. 3 on the map), which has so far proved to be the most important, lies somewhat more than two miles south of the Stratton property. It was operated by the United States Pottery Company in the eighteen-fifties and sixties. In the seventies and eighties the deposit was worked by Samuel Keyes, who sold the clay for paper-filling. Later the Stevens and Thompson Paper Company, of Hoosic, N. Y., mined the clay for the same purpose for about a year. The property was sold to S. C. Lyons and Brothers in the eighties, and passed into the possession of the Vermont Kaolin Corporation in 1923.

This corporation went energetically to work, reopened the old shaft, sunk by S. C. Lyons and Brothers, erected a modern clay-washing plant, near the workings and sold the washed product for paper-clay, enameled ware, and other purposes. The crude material found a market for sagger and fire-clay. Unfortunately the plant was destroyed by fire.

Negotiations with the Merrimac Chemical Company, of Boston, Mass., are now under way, looking to the lease of the properties owned or controlled by the corporation for a term of years. The Merrimac Chemical Company has in view the use of this clay for the production of aluminum sulphate, as well as for supplying the ordinary demands for high-grade clay.

Extensive drilling operations are being carried on this summer at the No. 3 deposit and have proved the existence of a very large deposit of first-class clay, underlying a tract of land, 1,100 feet long, by 600 feet wide. Drill-holes have reached a depth of 130 feet and are still bottomed in white clay. It is estimated that

PLATE XXIV.

Clay deposits A and B.

at least one and one-half million tons of clay are now "in sight." The overburden of glacial drift varies from one foot to fifty feet, but probably averages thirty feet. It is proposed to strip off this overburden and mine the clay with steam, or other mechanical shovels.

TESTS ON THE CLAY.

Analysis of the clay shows:

	Percent.
Free moisture	.19
Combined moisture	8.31
SiO_2	52.65
Fe_2O_3	.57
Al_2O_3	32.80
CaO	0.00
MgO	.45
K_2O	3.66
	98.63

Na_2O and TiO_2 were not determined, though probably present.

Practically all of the clay is of comparatively low grit content, much lower than the English residual clays or those of the South. By far the greater part of the material at Bennington contains less than 40 percent of sand, while practically all the white clay carries less than 20 percent. It is estimated that, for the whole deposit, the material other than clay will average around 30 percent.

Fusibility tests on several samples gave the following results:

Sample No. 1, a fine, white, homogeneous clay.

Water of plasticity, based on net weight, 20.5 percent.

Linear drying-shrinkage, 4 percent of the plastic length.

Softening-point, equivalent to Orton pyrometric cone No. 26, approximately 1,595 degrees C.

Results of a draw-trial burn:

Cone	Percent burned shrinkage	Percent absorbtion	Color
01	7.2	17.7	white
3	7.6	16.4	white
6	10.1	13.3	white
9	14.4	6.7	

The relatively low refractoriness of this sample was attributed, by the experimenter, to an admixture of fluxing impurities, probably soda, potash, lime, or magnesia—or to all of them.

Sample No. 2, a fine-grained, homogeneous, plastic clay.

Water of plasticity, based on net weight, 27.5 percent.

Linear drying-shrinkage, 7.6 percent of the plastic length.

Softening-point, equivalent to Orton pyrometric cone No. 32, approximately 1,700 degrees C.

Results of a draw-trial burn:

Cone	Percent burned shrinkage	Percent absorbtion	Color
1	12	11	white
4	15.1	6.8	buff
7	17.2	5.4	buff[1]
10	19.4	3.2	yellow
13	20	1.8	yellow

Sample No. 3, best white kaolin.

Water of plasticity, based on net weight, 27.2 percent.

Linear drying-shrinkage, 6.2 percent of the plastic length.

Softening-point, equivalent to Orton pyrometric cone No. 33, approximately 1,720 degrees C.

Results of a draw-trial burn:

Cone	Percent burned shrinkage	Percent absorbtion	Color
1	7.8	31.2	clean white
4	11.4	24.4	clean white
7	15.4	16.5	clean white
10	15.6	14.6	clean white
13	16.8	10.7	very light cream

GEOLOGY OF THE DEPOSIT.

This is undoubtedly a residual deposit of kaolin, derived from feldspathic rocks lying below it.

The Green Mountains, in this part of the State, are made up prevailingly of Cambrian quartzite. Bald Mountain, at the foot of which (see the map, Plate XXIV) the deposit lies, shows on the accessible outcrops no rock from which the kaolin could have been derived. To the west of the valley the ridges show outcrops of shaly limestone (l. s. on the map). On the other hand, feldspar fragments, much kaolinized, and quartz, are associated with the clay—are mined with it and make up the tailings from the washing. One must conclude, therefore, that the feldspathic rocks, whose alteration has resulted in the formation of the kaolin, lie below the clay deposit.

It is noteworthy that, west of the deposit, there exist some beds of limonite (these were worked for iron in the past), associated with more or less manganese. This of course suggests the former presence of ferro-magnesian minerals, associated with the feldspar, and also argues that the clay was formed "in situ."

SUMMARY.

We have here the largest deposit of kaolin thus far discovered in the State. The clay is of high grade, easily mined, adapted to a variety of purposes, and advantageously located with respect to transportation.

[1] Iron-stained.

THE GREEN MOUNTAIN KAOLIN CORPORATION.
Bennington.

This organization was formed in 1925 and, as already noted, has taken over the business of the Bennington Brick Company.

The corporation also has purchased a tract of land, some 150 acres in extent and underlain by kaolin, lying east of Bennington, at the foot of the Green Mountains.

This property has been examined by Prof. W. F. Jones, whose report to the corporation is in part as follows:

"The deposits of kaolin lie about a mile and a half east of Bennington at the base of a high north-south ridge which bounds the valley on the east. The deposit is about a mile and a half long and of variable width, but averages 100 yards. A number of bore holes put down into the clay showed that the material extends from about one foot beneath the surface to a depth of from six to twenty feet, averaging about twelve feet.

"The clay contains a few scattered bowlders, but no gravel. Here and there in the clay are lenticular layers of sand, the result of freshets during the period of deposition.

"The clay contains a surprisingly small amount of grit, or sand, and is exceedingly finely comminuted. All of it, when wet, has a distinctly 'greasy' smooth texture.

"The deposit may be divided into two parts. The northern two-thirds is kaolin of light buff or cream color, which dries in the sun to an almost pure white. The southern third is a light grayish blue and dries to a pure chalk white. This difference in color is dependent on the percentage of iron present (see the analyses).

"All the clay bakes a pure white and all of it may be said to be a fire clay, in that the material fuses at quite a high temperature.

"The entire deposit contains at least a million tons of clay, of which 250,000 tons are of the grayish blue color."

ANALYSES OF THE KAOLIN.

	North End	Middle	South End
	Percent	Percent	Percent
Loss on ignition	8.30	6.08	6.98
SiO_2	60.14	65.59	65.34
Al_2O_3	28.48	24.39	24.59
Fe_2O_3	1.51	.66	.78
CaO	trace	trace	trace
MgO	trace	trace	trace
Alkalies	not determined		

RATIONAL ANALYSIS.

	Percent
Clay substance (kaolin)	88
Silica sand	7
Zircon, tourmaline, garnet	3½
Feldspar	1½
	100

This analysis shows a very large percentage of clay substance and a very small percentage of sand and feldspar.

ORIGIN.

Professor Jones believes that the kaolin is "the result of disintegration by normal processes of rock decay of the granite rocks of which the high ridge above the clay deposits is largely composed." "These products of disintegration consist of silica sand, soluble potash, and clay. The sand and clay are left as residium, the potash being removed in solution. The residium either accumulated *in situ,* or was washed down by surface waters and carried to favorable points of deposition. In the case of this deposit there has been some transportation, not enough to allow the admixture of impurities to any extent with the clay, but sufficient to separate almost entirely the clay and sand, each being deposited in different places."

If this theory of origin is correct, this deposit differs markedly from the other kaolin beds already described. In these the parent rock was shown to be below the clay, at or near the contact of the Cambrian quartzites and limestones forming the country rock of the region. The writer has not been able to find any feldspathic facies in the quartzite which makes up the mountains to the east of the kaolin deposits. He suggests that the clay deposit under discussion is a transported one, whose origin was to the north, perhaps in the deposits of the Vermont Kaolin Corporation.

The Green Mountain Kaolin Corporation is investigating the adaptability of their clay to paper-making and the ceramic arts. Furthermore, experimental face-bricks are being made from varying mixtures of clays with encouraging results. No light colored face-bricks are being manufactured in New England, the sources of this product being Pennsylvania and Ohio. There seems to be reason to expect that in the future the production of face-brick may take its place as an important Vermont industry.

FRANK E. BUSHY AND SON.
Monkton.

On the Middlebury Quadrangle of the United States Geological Survey, in East Monkton, there is shown the location of an ore-bed lying on the west side of a valley in the western ranges of the Green Mountains.

Here iron ore, called hematite but more probably limonite, was mined many years ago by the Boston Iron Company. Some of the ore was sent to the smelter at Port Henry, across the lake.

North of the ore-pit kaolin is found, extending for at least a mile. This clay has been prospected and worked, on and off, for many years. Early in this century, according to the Report of the Vermont State Geologist for 1905-06, six bore-holes were sunk, varying in depth from 41 to 174 feet, revealing kaolin in all of them to the greatest depth reached.

On the south end of the deposit Samuel Goss quarried clay at one time. O. N. Williams formed the American Paper Clay Company and was working the north end when the 1921-22 Report was written. Later the mill burned down. This property is now owned by the Continental Clay Company, which is controlled by the R. T. Vanderbilt Company of New York City. It is not being operated at present.

Immediately south of the Continental Clay Company's holdings, Frank E. Bushy and Son have been working a clay-pit for the past three years, producing about a thousand tons annually. The material mined is a white kaolin of good quality. It is being air-dried and shipped to the Rutland Fire Clay Company for use in its products.

The clay of the Monkton district lies under a quartzite capping, contains fragments of feldspar, and is probably residual.

THE RUTLAND FIRE CLAY COMPANY.

This company does a large business in the manufacture and sale of certain specialties, which includes: plastic stove lining, boiler-covering cement, patching plaster, furnace cement, waterproof cement, etc.

The output in 1923 reached $700,000 and was sold widely over the country as far west as Kansas and Nebraska.

The works are located on Curtis Avenue, South Rutland, while the pits are in South Rutland and Mendon.

The material mined by the company at present is a fine-grained, mica schist. The company buys kaolin of F. E. Bushy and Son, at East Monkton, and of the Vermont Kaolin Corporation, at Bennington; and also asbestos, for use in the manufacture of its products.

Evidently the material is not, properly speaking, a fire clay, but it fulfills some of the requirements of such a clay, while its usefulness is attested by the large business done, easily the largest of its kind in the State.

OTHER KAOLIN DEPOSITS.

RUTLAND.

In the southern part of Rutland township, in the hills on the west side of the Otter Creek valley, there is a considerable deposit of kaolin on the farm of D. W. Cutting. The deposit has not been opened up to any considerable extent, but surface outcrops of red and brown clay, which soon merge into white kaolin, as is shown in a small test pit three feet deep, seem to indicate a considerable deposit of china clay. Feldspar outcroppings nearby suggest the residual nature of the deposit.

This prospect is worthy of the attention of those interested in clays.

NORTH CLARENDON.

There is said to be a deposit of white kaolin in this place, near Cold River, a tributary of the Otter. The writer was informed that a shaft had been sunk to a depth of about eighty feet and that mining operations extended over a period of two years. Nothing could be found out about the present status of this enterprise.

SOUTH WALLINGFORD.

In South Wallingford, about a mile from the railroad station, there is a large deposit of clay, manganese ore, and limonite which has been worked for its manganese content, but not, as far the writer has been able to learn, for its kaolin.

To quote from E. C. Harder[1]: "The ores are found in a clay layer at the contact of the Cambrian quartzite and limestone. This layer has a general north-south direction and a nearly vertical dip. The deposit consists of associated iron and manganese ores, occurring in pockets and nests, in yellow, red, gray, or white clay. The ores of iron and manganese may be in separate pockets or may occur together in the same pocket, mixed in all proportions. The clay bed has a probable average thickness of several hundred feet, and ore is scattered through this at intervals. The deposit is overlain by ten to sixty feet of glacial drift. The iron ore is limonite; the manganese ore consists of massive psilomelane, crystalline pyrolusite, and probably some manganite."

The writer was informed that manganese was first discovered here over a century ago. The deposit was worked for this metal by Carnegie interests from 1888 to 1890 and it is said that more than 20,000 tons of ore were shipped.

The present owners are Dr. William Bull and Miss Vera Griffith. Their holdings comprise some 155 acres.

The outcrop of the deposit is over 1,000 feet, while its maximum width is about 200 feet. In several adits driven into the

[1] Bull. U. S. G. S., No. 427; 1910.

hill in recent years, kaolin and feldspar have been encountered. The so-called Curtis adit, after being driven through some sixty feet of glacial material, penetrated over 100 feet of kaolin and feldspar, showing the residual nature of the deposit. The kaolin was white and apparently of good quality.

Outcrops of kaolin are reported on farms lying north of this property and owned by Edward Foreman, J. O'Dare, and J. Fish.

All of these deposits should be investigated by those interested in kaolin.

A deposit containing more or less kaolin is also reported from the Gilmore farm, in Tinmouth.

NORTH DORSET.

The Vermont Lime Products Company owns a deposit of clay, situated on the Dacey farm about one mile from the railroad. The material underlies an area 200 by 100 feet and is called a fire clay, but whether or not this is its true nature would have to be determined by analyses and fusibility tests.

BRANDON.

Although the kaolin mine here has been practically worked out, the writer has thought best to describe it on account of the information it adds to our knowledge of the nature of Vermont clay deposits.

The deposit is located in the village of Forestdale, in a small tributary valley of the Otter Creek, and was opened up by the Horn, Crockett Company in 1902. This company operated the mine for twenty years, producing in this time some 80,000 tons of kaolin, which found a market as a paper filler. By April, 1922, the mine had reached a depth of 230 feet, along a strike of 200 feet and a width of 150 feet. The areal extent of the deposit had been accurately demarked by diamond drilling. Unfortunately the mine caved in at this time and was abandoned.

According to Harder's[1] description, the deposit here much resembles that at South Wallingford. Harder says: "The deposit consists of iron ore containing manganese ore in subordinate quantities. The ores occur in a brown and white clay that occupies the bottom of the tributary valley. To the east are ridges of quartzite; to the west, a white, dolomitic limestone. The clay bed overlies their contact, and is in turn overlain by glacial deposits. Fossil plants and fruits of Tertiary (probably Miocene) age have been discovered in lignite in a similar clay bed in the same locality. This makes it probable that the iron and manganese-bearing clay is a Tertiary deposit derived from an underlying clay, similar in position to that containing the South Wallingford ores."

[1] *Ibid.*

According to Messrs. Horn and Crockett the clay deposit never came nearer than fifty feet to the surface and, therefore, its geology is much concealed. The late Prof. J. B. Woodworth,[1] of Harvard University, examined the clay deposit and its associated lignites and came to the conclusion that the kaolin resulted from the decomposition of the underlying bed rock, hence was residual in origin.

Mr. T. Nelson Dale,[2] of the United States Geological Survey, has also made an examination of the Brandon deposit and also agrees that the "kaolin must be regarded as the product of the weathering of feldspathic rocks such as the gneisses and quartzites of the Green Mountain range."

As at Wallingford the fact that the kaolin is associated with iron and manganese minerals would argue its residual nature.

In regard to the lignite and its fossil fruits, the reader is referred to several articles in the Report of the Vermont State Geologist for 1903-04.

It may be noted that the deposit was originally worked for its iron content, the limonite being used in paint manufacture. It is also of much interest to read[3] that the famous English geologist, the late Sir Charles Lyell, examined the deposit and gave it as his opinion that "the clay alone would be found eventually to possess a value exceeding that of the iron," a prediction that was amply fulfilled.

CONSIDERABLE QUATERNARY CLAY DEPOSITS.

Under this heading the writer has located and more or less fully described such deposits of glacial clay as would, by reason of their quality, quantity, and accessibility, probably be suitable for brick-making or other purposes. Undoubtedly many deposits have been overlooked, since funds available for the survey have been limited, but a sufficient number has been tabulated to remove any anxiety concerning a dearth of this material in Vermont.

GRAND ISLE COUNTY.

In his Geology of Grand Isle County,[4] Professor Perkins states that "the greater proportion of South Hero is covered with glacial material, including deposits of clay, which in part are Quaternary and in part have been derived from the decomposition of the underlying Utica shale, of Ordovician age." Professor

[1] Report of the Vermont State Geologist, 1903-04, p. 166.
[2] *Ibid.*
[3] The Geology of Vermont, 1861, Vol. 2, p. 803.
[4] Report of the State Geologist, 1903-04.

Perkins notes a bank of glacial clay, some twenty feet in thickness, around Balls Bay. Presumably other deposits of considerable thickness occur. It is also very probable that some of the shale would make excellent material for the manufacture of drain-pipe, tile, and other lines, calling for a stiffer substance than glacial clay.

FRANKLIN COUNTY.

On the road leading from St. Albans to St. Albans Bay there is an excellent deposit of blue clay, on the farm of M. D. Jarvis. This has been used to some extent by the Foundry Manufacturing Company, of St. Albans, for moulding purposes.

In Fairfield there was formerly a small brick industry, based on a deposit of glacial clay of no present commercial importance. Also at Highgate Falls brick-making from the Missisquoi River clays was once carried on.. But there is probably no commercially important clay deposit in the county.

LAMOILLE COUNTY.

Lamoille River clays have been used for brick-making in the past, as shown by the number of brick structures in Cambridge, Johnson, Hyde Park, Morrisville, etc., and there are probably considerable deposits still available.

WASHINGTON COUNTY.

There is a good deal of river-clay along the course of the Winooski, in this county, and some of the deposits have been worked in the past.

In Middlesex there are clay-banks apparently of good quality.

In and around Montpelier there are very large deposits of blue river-clay. One is on Seminary Hill, where the clay is fifty feet thick.

On the road from Montpelier to East Montpelier, at Stevens Turn, there is a bank of fat, blue clay, forty to fifty feet high; while a quarter of a mile nearer Montpelier there are several great ridges of equally promising material.

Nearer the railroad bridge, not far from the above localities, there is a huge bank of fat, blue clay, thirty to thirty-five feet high.

Between Barre and East Barre, along a tributary of the Winooski, there are enormous sandy clay-banks, but they are probably too poor in quality and too inaccessible to be commercial possibilities.

On the high road from Barre to East Montpelier and Hardwick, small banks of clay appear.

At Waterbury the river clays were formerly used for brick-making by the Demerritt Company. The bricks used in the construction of the buildings of the Waterbury Insane Asylum were made at this yard.

CHITTENDEN COUNTY.

In Jericho, on the lands of A. A. Wizzle and Albert Byington, which border the Lee River, there is a bank, fifty feet high, of dark blue varve clay, which extends along the stream for perhaps half a mile. This deposit is enormous and, if the quality of the material proved suitable, would support a clay industry for many years.

Essex Junction. See the Drury Brick & Tile Co. (p. 200).

LOWER WINOOSKI RIVER CLAYS.

Along the lower course of the Winooski River there is a series of estuarine clay deposits, found in the river terraces for which this stream is remarkable.

In the terrace on which the Lower Road from Burlington to Winooski is built, a river-clay deposit was worked for brick-making purposes not many years ago.

In Richmond township, on the terrace back of C. S. Perkins' house, there is a large deposit of solid blue clay, which extends eastward to H. Stockwell's farm. The clay is twenty to twenty-five feet thick and is overlain by sand.

In the brook, just north of Stockwell's, there is a deposit of varve clay, which was quarried for paint-clay some fifteen years ago. The brook has probably cut down through an old glacial pond, in which the varves were laid down.

ADDISON COUNTY.

As already noted, the western tier of townships in Addison County (as well as those in Chittenden and Franklin) are built on old lake-bottoms, and there is much lacustrine clay. However, no sizable deposits were found.

RUTLAND COUNTY.

In North Poultney, on the property of the New York Consolidated Slate Company, two and one-half miles north of Poultney village, there is a great deposit of seasonal clay, with varves an inch wide, which accumulated in an old glacial basin. The slate quarry adjoins this deposit. A slip, some years ago, carried some thirty thousand yards of clay into the workings, entailing much expense for its removal. The clay is dark brown in color and may be of value in the industries.

There is also a clay deposit, associated with the slate at Pawlet, but this the writer has not visited.

BENNINGTON COUNTY.

Brick clay of good quality occurs near the road from South Shaftsbury to North Bennington, and also on A. G. Dewey's land, west of Bennington.

The clay deposit in the southeastern part of Bennington village, on which is located the Bennington Brick Company's plant, has already been described.

A search across the State, from Bennington to Brattleboro, failed to locate any considerable clay deposits.

ORLEANS COUNTY.

Around Lake Memphremagog there are naturally deposits of lacustrine clay. At Newport Center, along the road from the city farm to the lake, a great deal of plastic brown clay was seen. This might prove to be fit for brick-making or other purpose.

In Craftsbury, on the Young farm, there is brick-clay of good quality. Bricks were made here thirty years ago. In the same town, near the Albany line, there are considerable deposits of good blue clay. These are along the course of the Black River.

CALEDONIA COUNTY.

The History of St. Johnsbury recounts that Asa Lee established the first brickyard in that town in 1791. It continued in operation for many years, for in 1891 it furnished bricks for the new chimney of the Fairbanks Scale Works.

The Bagley Brick Works was founded by a Mr. Bagley, who came from Weare, N. H. The business was continued by his son throughout his lifetime. Many public buildings, including the Court House, Union School and the Athenaeum testify to the importance of the industry. The clay deposits worked were above Paddock village.

The brickyards of Sanford and Lewis Thayer, on the Danville Road, did a brisk business in the thirties.

At the present time there is no brick or other clay industry in this region. Building bricks are obtained chiefly from the New Hampshire yards.

THE CONNECTICUT RIVER CLAY DEPOSITS.

Along the course of the Connecticut River there occur by far the largest deposits of Quaternary clay in the State.

Ernst Antevs[1] has shown that with the retreat of the ice-sheet in New England, at the close of the so-called "Great Ice Age," chains of long, narrow lakes were formed along what is now the Connecticut River. This ponding of the ice water was made possible by the gradual up-tilting of the land towards the north. During the warmer parts of the year glacial rivers deposited in these lakes their mixed sediments of sand and clay; while in the colder months, the streams ceasing to flow, only the fine colloidal suspensions of clay, mixed with vegetable shreds settled out. Thus were formed the varves or seasonal clay deposits, which became exposed to view with the rising of the region and the cutting away of the barriers between the lakes by the rejuvenated Connecticut River. (Plate XX.)

[1] The Recession of the Last Ice Sheet in New England, Am. Geographic Society, Research Series, No. 11.

Antevs has examined the varve clays along the Connecticut as far south as Hartford. The writer, for the purpose at hand, has noted and briefly described those deposits along the Vermont side of the river which, by reason of their quality, quantity, and accessibility, promise best for commercial enterprises.

Going south from St. Johnsbury, one finds by the railroad bridge north of Passumpsic Station a large bank of excellent varve clay. It contains many concretions, but has evidently been found fit for brickmaking and has been worked a good deal. A great deal of clay still remains.

At Inwood (Antev's location No. 88), on the farm of G. A. Richardson, there is a great mass of clay which forms the east bank of Passumpsic River. The material is a very fat, lead-colored varve clay, surmounted by some twenty-five feet of sand. A tremendous tonnage of material, probably suitable for brick-making or kindred purpose awaits development. The river flat offers an excellent site for a brickyard and its proximity to the railroad would be of great advantage. New Jersey interests have tried, without success, to acquire this property for industrial purposes.

At East Ryegate, M. H. Gibson conducted a brickyard for some twenty years, but discontinued it in 1910, on account of the high freight rates. There is still much good brick clay in this vicinity.

It may be noted that the brickyard operated for many years at Woodsville, just across the Connecticut from Wells River, was closed in 1922.

The Wells River Brickyard has already been discussed.

In Newbury, seven miles south of Wells River and one mile north of Conicut Station, there is a clay deposit on the land of A. D. Downing (Antev's location No. 73). In the ravine of a brook good fat clay, not less than twenty feet in thickness appears, overlain by fifteen feet of sand. This is an excellent prospect.

Three-quarters of a mile north of White River Junction, in a ravine just west of the railroad, Antevs located a seasonal clay deposit more than thirty feet thick, covered by four feet of sand (his location No. 66). The writer did not visit this deposit.

In Ascutneyville, south of Windsor, there is a large deposit of apparently good brick-clay. There has been some agitation for the building of a brickyard here, but, as far as the writer could learn, nothing tangible has been done.

In Westminster, about a mile north of the railroad station (Antev's location No. 36), there is a deposit of blue clay in the walls of a ravine. This may have commercial possibilities.

In the same township, about a mile southwest of Grout Station (Antev's location No. 35) there is a bluff of blue varve clay, overlain by sand and gravel. There seems to be a great quantity of clay here.

Three miles south of the above deposit, a brook has cut a great ravine to the southwest of the road. Here is found not less than thirty feet of varve clay, overlain as usual by sand and gravel. Bricks were made here some thirty years ago. The property is owned by G. C. Woodburn.

Near Putney Station the Vermont Brick Company manufactured bricks from about 1900 to 1921, when the industry was given up. The deposit is a silty varve clay (Antev's location No. 31) of which much remains. It is said that this deposit produced excellent building bricks, which sold as far south as Boston. Prices during the war ranged from $30 to $35 per thousand.

At Guilford, on the land of George Houghton, there is a clay bank, northeast of his house, with about twenty feet of clay exposed. Bricks were made here twenty-five years ago and sold in Brattleboro. This neighborhood probably contains a great deal of glacial clay.

SUMMARY.

It is seen from this survey that the most important Quaternary or Glacial clays of the State are found along the rivers, and of these that the deposits along the course of the Connecticut offer probably the best opportunity for industrial enterprises.

PETROGRAPHY OF THE QUATERNARY CLAYS.

The microscopic examination of clay is attended with considerable difficulty, owing to the weathered condition of the component minerals, which show few crystal faces and lack some of the distinguishing characteristics of fresh material. The clays were sifted through a one hundred mesh sieve, immersed in a liquid of known refractive index and then studied with the polarizing microscope. The material was found to be made up predominatingly of flocculent kaolinite, or other hydrous silicate, with lesser amounts of quartz and occasional fragments of orthoclase, plagioclase, tourmaline, rutile, apatite, nephelite, grossularite, and talc. Considerable amounts of iron oxide were present, staining the clay mass. The clays along the Connecticut showed a greater variety of minerals than the Drury deposit and suggested

that Canadian talc and Mount Ascutney syenites, as well as the granites along the Connecticut River, had all made contributions to the deposits.

POTTERY.

Although the manufacture of pottery and porcelain in Vermont is now a thing of the past, a report on the clay industries of the State would be incomplete without a brief mention of this fascinating phase of the subject.

INDIAN POTTERY.

The first potters in what is now the State of Vermont were the Algonkian Indians, who were in possession of the region at the coming of the white man. In the old burial mounds, discovered many years ago near East Swanton and along the Missisquoi River, many objects of aboriginal craftsmanship were found and many of these are now to be seen in the various museums of the State and elsewhere.

In the Seventh Report of the Vermont State Geologist, 1909-10, Professor Perkins has an article on Indian Relics in the State Cabinet, illustrated by many cuts. Among these relics he mentions and gives illustrations of three earthenware jars, nearly intact, which are preserved in the University collections; as well as many fragments of pottery and several earthernware pipes. The pottery is for the most part of a reddish-brown color, but also includes drab and black specimens. The illustrations show that the ware was richly ornamented.

BENNINGTON POTTERY.

But it was in Bennington that Vermont pottery achieved its highest expression and fame. In his chapter 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 earthernware kiln and, in 1800, added the manufacture of stoneware." They also made bricks. Mr. John Spargo, in his recent 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.

The variety of the Norton wares is shown by an advertisement, appearing in the *State Banner* of Bennington, on February 27, 1841. This reads as follows:

[1] Walter A. Dyer, Early American Craftsmen.
[2] The Potters and Potteries of Bennington.

BENNINGTON

STONEWARE FACTORY

JULIUS NORTON

Manufactures and keeps constantly for sale at his factory in Bennington, East Village, Vt., a large assortment of

STONEWARE

Consisting of—

BUTTER, CAKE, PICKLE, PRESERVE, & OYSTER POTS,
JUGS, CHURNS, BEER & BLACKING BOTTLES,
JARS, PLAIN AND FANCY PITCHERS,
INKSTANDS, EARTHEN MILKPANS,
STOVE TUBES, KEGS, MUGS,
FLOWER POTS, &c., &c.

Also PATENT FIRE BRICK,
(the best in the world) at $50 per thousand.

Orders from Merchants faithfully executed, and ware forwarded on the shortest notice.

Bennington E. Village, Feb. 27, 1841.

The United States Pottery Company, founded by Christopher Webber Fenton, perhaps the most famous of the Bennington potters, was incorporated in 1853 and, according to Dyer, began the production of fine ornamental wares: Rockingham, Parian, white granite, etc. The local source of the china clay used by the corporation was the No. 3 deposit of the present Vermont Kaolin Corporation, but the company also used materials from New Jersey and imported clays from England. Tableware, toilet sets, elaborate ornaments, toys, plain crockery, door plates, foot warmers, door knobs and many other articles were made. The corporation was very prosperous in the middle fifties, but after that its fortunes waned and it became insolvent in 1858.

ST. JOHNSBURY.

In the History of the Town of St. Johnsbury, we read the following: "Pottery. An old-time land mark with low red buildings west of the river half a mile south of the Center Village, was the Pottery established in 1808 by Gen. R. W. Fenton, somewhile known as the St. Johnsbury Stone Ware Pottery. Its products were in constant demand until the introduction of tinware. The business was successfully carried on by Gen. Fenton and by his son Leander until the entire establishment went down

in flames in 1859. All sorts of domestic ware were turned out on those potters' wheels, from jugs, jars, bowls, bottles, and milk pans, at a dollar a dozen, to fancy flower pots at sixty cents each, and St. Johnsbury pottery gained high repute; occasionally surviving specimens of it may still be seen. The power was supplied by a merry little brook that came tumbling down the hillside."

It is said that this pottery was unsigned, hence little is known of its present whereabouts. The Fairbanks Museum, in St. Johnsbury has possessed for some years two pots of grayish-brown mottled ware, while during the past winter it came into ownership of a marked Fenton and Hancock pottery churn, made at a later date than the unmarked ware. The writer has been unable to learn whether or not Gen. R. W. Fenton was related to Christopher Webber Fenton.

BURLINGTON.

According to Spargo, Capt. John Norton's business passed into the hands of his son, Luman Norton, in 1828. His nephew, Norman L. Judd, worked in the Norton pottery from 1796 to 1806 and then came to Burlington and established a pottery, one of the first if not the first in that town. Its location is quaintly, if indefinitely, described as follows: "On the left as we go down to the wharf, stands a brick building, in the under part of which Mr. Norman Judd of Bennington once carried on a pottery." Whether this described the old red brick building on Pearl Street, just west of Church Street, where E. L. Farrar conducted a pottery from 1830 to 1892 the writer has been unable to learn.

OTHER OLD POTTERIES.

Richard L. Fenton, a brother of Christopher Webber Fenton and once employed in the Norton works, conducted a pottery in Dorset for some years.

Middlebury also had a small pottery at one time in her history.