MICHIGAN'S CLAY DEPOSITS AND INDUSTRY

by

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Abstract

This paper is a review of the clay and shale resources of Michigan including past, present, and potential utilization and outcrop localities. Clay and shale suitable for the production of clay products and cement are found in much of the State.

Glacial clays are used in the manufacture of brick, tile, cement, pottery, and lightweight aggregate while undeveloped deposits could be used for pottery purposes such as flower pots, earthenware, and glazed tile. Some may be suitable for special purposes such as slip clay and Fuller's Earth. It is possible that other special uses may be found as the clays are more carefully tested.

Shales of the Traverse Group and the Antrim and Ellsworth formations, all Devonian in age, are used in the manufacture of Portland cement; and shale of the Saginaw Formation of Pennsylvanian Age is used in the manufacture of tile. Other potential shale beds occur in formations of the Ordovician, Silurian, Devonian, and Mississippian periods. There is additional potential in the utilization of these shales in the manufacture of brick, cement, and lightweight aggregate,

INTRODUCTION

In addition to a general review of the clay and shale resources of Michigan, an appendix is included (Tables 3 and 4) showing percent of total alkali (Na_2O+K_2O) and the silica-alumina ratio (SiO_2 / Al_2O_3) for 17 shale and 25 glacial clay deposits. These data should be of value in determining the suitability of the material for use in the manufacture of Portland cement.

History

The manufacture of clay products is one of Michigan's oldest mineral industries. The first plant is believed to have been the Daniel's Brick Company in Detroit, which is reported to have begun production in 1864.

After that date, many brick and tile plants, as well as some pottery plants, were established in and near Detroit and elsewhere in the state where suitable deposits and a market existed. By 1911, as many as 138 plants were operating, but many were closed from 1911 to 1913. In 1926, only 42 plants remained and by the end of World War II the number had decreased to 12. The building boom following the war led to an increase of three brick plants in the period 1945-49, but then the decline resumed. The only new operations in recent years have been two lightweight aggregate plants.

The general distribution of former brick and tile plants in Michigan is shown in Figure 1. Most of the operations were very small and many operated seasonally or only long enough each year to meet demands of the local market.

Developments

Today, clay products are produced on a rather modest scale from clay and shale deposits in Michigan. Present operations include a brick plant in Detroit; tile plants at Tecumseh, Corunna, and Grand Ledge; a pottery plant at Rockwood; and lightweight aggregate plants at Livonia and Grand Haven.

In addition, Michigan clay and shale resources are also used by seven cement companies operating nine Portland cement plants. In the manufacture of cement, shale, if readily available and of suitable quality, is preferred to glacial clay. Shale quarries are located: 1 mile south of Ellsworth (for cement plant at Charlevoix); 5 miles west of Petoskey (for plant there); and 10 miles west of Alpena (for plant in Alpena).

Figure 1. Map showing location of some 133 birch and tile plants formerly in operation in Michigan.

All cement plants in the southern part of the state use glacial clay from local or nearby surface deposits. Pits are located at Saginaw {plant at Essexville); 10 miles west and south of Port Huron (plant in Port Huron); Ford Motor Company land in Detroit (2 plants in Detroit); overburden stripped from sandstone quarry at Rockwood; and overburden stripped from limestone quarry at cement plant 2 miles north of Dundee.

Excluding overburden stripping, 5 shale quarries and 7 glacial clay pits are being worked. (See Figure 2.)

Production

Most of the clay and shale produced in Michigan is used in the manufacture of Portland cement. In 1968, 2,394,569 tons of clay and shale were used with 7,844,384 tons of limestone and 258,780 tons of gypsum in the production of 32,368,574 barrels of Portland cement. Clay and shale produced and used in the manufacture of clay products totaled 329,990 tons, or about one-seventh of that amount used for cement.

The 1968 total clay and shale production for the state was 2,724,559 tons valued at $3,038,572. Figure 3 shows clay and shale production and clay products and Portland cement industires developments during the period 1951-1959.

SHALE RESOURCES

Shale from the Traverse Group, Antrim Shale, Ellsworth Shale, and Saginaw Formation accounted for about half of the Michigan's 1969 clay and shale production. Shale also occurs in other Paleozoic formations (See Table 1).

The oldest shales having economic potential outcrop in the Northern Peninsula. These are the Bill's Creek Shale of the Richmond Group and the Point aux Chenes Shale of the Salina Group. The shale beds of most economic value, however, are those of Devonian, Missis-ssippian and Pennsylvanian ages in the Southern Peninsula. These are the Bell Shale and the "upper blue shale" of the Gravel Point Formation of the Traverse Group; Antrim Shale; Ellsworth Shale, Coldwater Shale; and shale of the Saginaw Formation ("coal measures" of Michigan).

Shale beds, some of appreciable thickness, are common in a number of the predoninantly limestone formations of the Traverse Group. In the Michigan Formation shale is interbedded with gypsum. These shales, however, are restricted in occurrence under relatively thick rock overburden, or too calcareous to be of any present importance. Neither these nor the Bedford or Sunbury shales which do not outcrop in the state will be discussed here because of time limitation. The aerial extent and outcrop areas of shale strata in Michigan are shown in figure 4.

Ordovician

Rocks of the Ordovician Period are predominantly limestones and dolomites. Twelve feet of shale of this formation is exposed for about one mile along the east shore of Little Bay de Noc on the Stonington Peninsula, Delta County (section 14 and 23, T39N, R22W). It consists of thinly-bedded, light gray to dark brown, soft to hard shale. Other exposures are found to the north along Bill's Creek in section 12, T42N, R21W, and along Haymeadow Creek in section 19, T42N, R20W. Total thickness for the Bill's Creek is estimated to be about 70 feet.

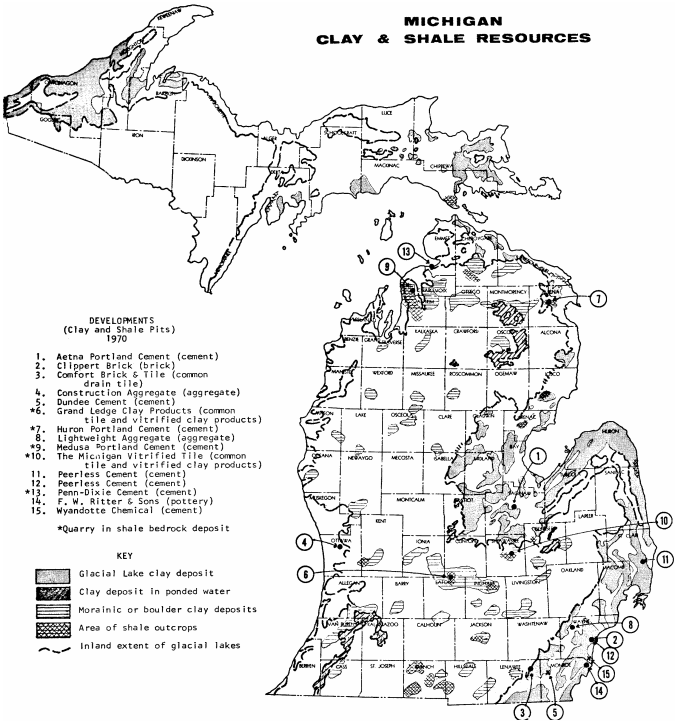


Figure 2. Map showing area of clay and shale deposits and location of clay products and Portland cement clay and shale pit and quarry operations.

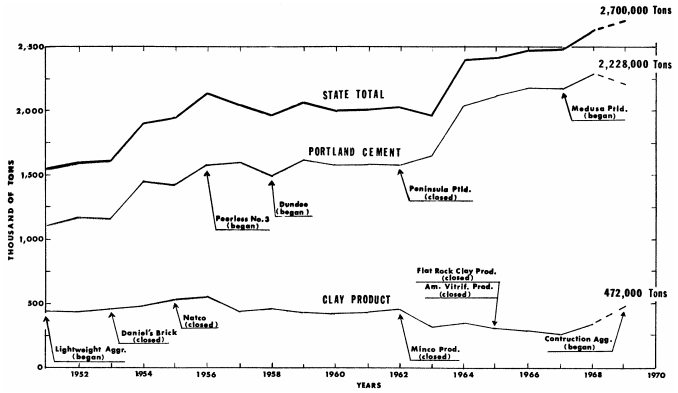


Figure 3. Clay and shale production and development, 1951-1969

Many years ago, the Bill's Creek Shale was dug from the Stonington Peninsula and skidded across the ice to Escanaba for making bricks. However, the shale is very calcareous and it is doubtful that it has any present value for that purpose, but it could possibly be used in the manufacture of cement.

Silurian

The Silurian rocks are almost entirely dolomites and limestone. The exception is the Point aux Chenes Shale which is exposed at a few places on and along the shore of the St. Ignace Peninsula. The formation in outcrop is a gray-green to red shale with some very thin layers of dolomite. Thickness of the formation is 500 to 600 feet,

and individual shale beds may be 20 to 45 feet thick. The Point aux Chenes Shale has not been investigated for its suitability in the manufacture of ceramic products.

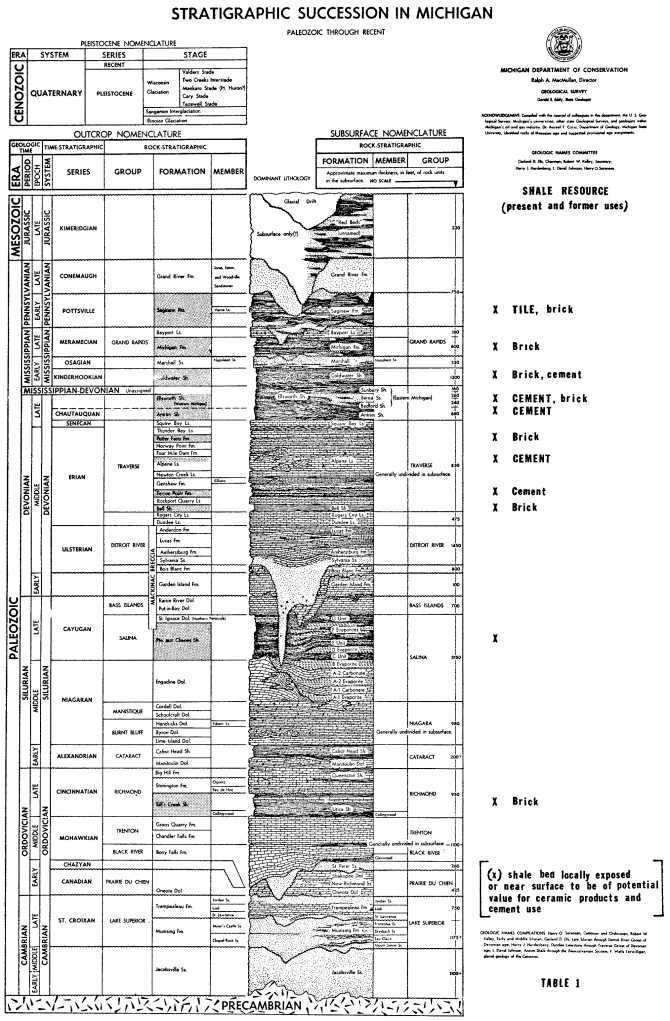


TABLE 1

Devonian

The Bell Shale, generally 60 to 80 feet thick, is the basal formation of the Traverse Group. It subcrops in a narrow belt extending from the old Rockport Quarry on Lake Huron in the northeast corner of Alpena County (section 6, T32N, R9E), northwestward to Rogers City, then westward into the vicinity of Black Lake in Cheboygan County where it becomes covered by thick glacial drift. Best exposures are in the drainage ditch of the old abandoned Rockport Quarry, a pit on the south edge of Presque Isle Corporation Limestone Quarry near Presque Isle, Presque Isle County (NW corner 11, T33N, R8E); in the overburden stripping of U.S. Steel Corporation Limestone Quarry at Rogers City; and in a small roadside gulley about 2.5 miles southwest of Rogers City (NW¼ Section 29, T25N, R5E). The Bell Shale is a bluish-gray soft shale, generally limey and fossiliferous. It weathers rapidly to a blue plastic clay.

The Bell Shale was formerly dug on a small scale near Presque Isle (SW¼ Section 11, T33N, R8E) for the manufacture of a soft mud brick. It has been found satisfactory in the manufacture of Portland cement, and burning tests indicate it to be of good material for common brick, tile, and some pottery.

In western Michigan, the “upper blue shale” of the Gravel Point Formation contains an 8 to 20 foot bed or bluish-gray, calcareous shale with pyrite crystals and nodules. This shale is best exposed west of Petoskey in the shale pit of Penn-Dixie Cement Company where 20 feet of the rock is quarried (NE¼ section 8, T34N, R6W) and west of Charlevoix on Medusa Portland Cement Company property where some 5 to 10 feet is exposed in a shale pit.

Directly overlying the Traverse Group is the Antrim Shale, a brownish black to black hard fissile bituminous shale about 350 feet thick. In certain zones, numerous anthraconite concretions occur ranging in size up to three or more feet in diameter. Smaller marcasite concretions from the size of walnuts to a foot across are also present but in less abundance.

The best exposure of the Antrim Shale is in the quarry of Huron Portland Cement Company 10 miles west of Alpena where 20 feet is quarried. Other exposures are: three miles south of Afton (NW¼ SE¼ Section 14, T34N, R2W); on the north side of Walloon Lake (Section 36, T34N, R6W); on the north and south sides of Lake Charlevoix; and on the shore of Lake Michigan in a bluff just north and south of Norwood.

In addition to the present utilization in the manufacture of Portland cement, the Antrim Shale was formerly used at a Charlevoix brick plant.

Exposures of the Ellsworth Shale are located in Antrim and Charlevoix counties. The Formation, some 450 feet thick, consists of hard to soft, blue gray to greenish banded shale, contains some calcareous and arenaceous zones, and weathers easily to a gray clay. It is quarried about one mile southeast of Ellsworth (SW¼ Section 24, T32N, R8W) for cement use by Medusa Portland Cement Company in Charlevoix, and was formerly quarried one and a half miles south of Ellsworth (NE¼ Section 26, T32N, R8W) for the plant at Petoskey. About 50 feet of the shale is exposed in the two quarries. At East Jordan, Charlevoix County (NW¼ Section 24, T32N, R7W) the Ellsworth Shale was formerly used for the manufacture of bricks.

Mississippian

The Coldwater Shale, the lowest rock strata of the Mississippian Period, is predominantly a gray to greenish-blue shale. However, certain zones are calcareous or silicious and contain Kidney Ore. The Formation is from 500 to more than 1,000 feet thick. Over 50 feet are exposed in the Lake Huron shore bluff between Forestville and White Rock in Sanilac and Huron counties. Other exposures are in old abandoned quarries near Union City (NE¼ Section 16, T5S, R27W), Coldwater (NW¼ Section 32, T6S, R6W), south of

Quincy in the banks of Fisher Creek, and northwest of Reading where the shale is exposed in stream cuts. The shale was formerly quarried near Union City and Coldwater and mined near Bronson for the manufacture of cement and near Coldwater it was used for the manufacture of brick. Coldwater Shale has not been utilized for many years, but tests indicate it is excellent material for brick, tile, or almost any vitrified product as well as Portland cement. Large reserves are available in Branch and Hillsdale counties.

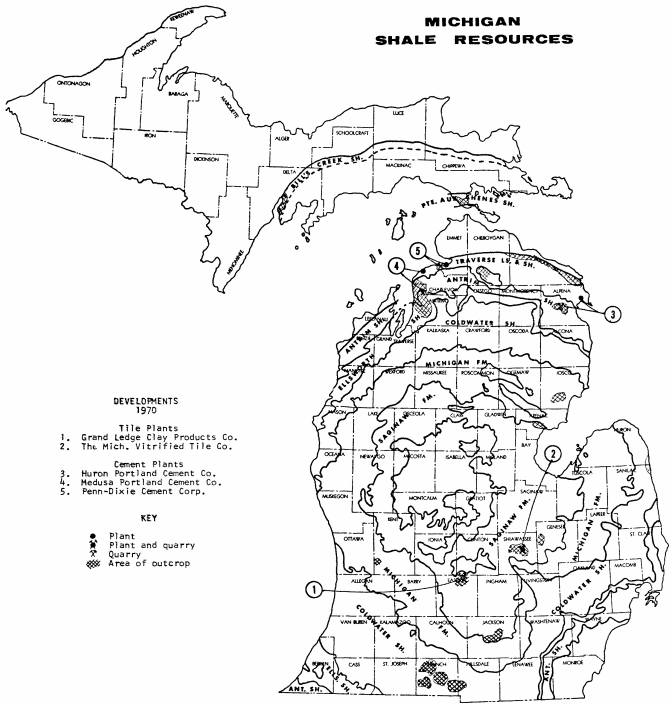


Figure 4. Map of shale bedrock and outcrop areas in Michigan with location of quarry developments.

Pennsylvanian

Shales of the Saginaw Formation are extensively worked at Grand Ledge in Clinton County for manufacture of drain tile, sewer pipe, septic tanks, flue liners, and other products, and at Corunna in Shiawassee County for drain tile and various fittings.

Deposits of Saginaw Formation shale were formerly used for the following: paving bricks near Flushing (SE¼ Section 22, T8N, R5E) and north of Omer (Section 5, T19N, R5E); face brick at Grand Ledge and Williamston, and sewer pipe at Jackson.

The shale of the Saginaw Formation ranges from light gray to black, is somewhat bituminous, and may contain calcareous and arenaceous zones. Iron carbonate concretions, pyrite, and thin coal beds are usually present.

CLAY RESOURCES

In general, the surface clays of Michigan can be divided into three classes: (1) morainic clays; (2) lake clays; and (3) residual clays. The first two are products of the Pleistocene Age whereas the third, residual clays, represents the weathered shale in areas of shale outcrops and thin glacial drift cover. (See figure 2.)

The morainic clays are confined to the morainic and till plain areas of the State, and therefore, are generally inland away from the present shores of the Great Lakes. These clays are often stoney and sandy and high in lime content.

The lake clays were deposited in water of former glacial lakes or in ponded water in the morainic areas. In the Southern Peninsula, these clays are almost entirely confined to a 40-mile strip running north from the Ohio State Line along the east side of Michigan to the “Thumb Area” around Saginaw Bay and into Alcona County. The glacial lakes were not as extensive on the west side of the State. Lake clays were deposited in narrow strips in a few indentations along the Lake Michigan shoreline, generally extending only one or two miles inland except from Holland northward across Ottawa and Muskegon counties where deposits are encountered 10 to 25 miles inland.

Lake clays cover much of the eastern part of the Northern Peninsula, particularly in Chippewa and Mackinac counties, where thicknesses of 300 to 400 feet have been encountered. Lake clay deposits in the western part are comparatively thin and are mainly confined to areas inland from Lake Superior in Gogebic, Ontonagon, Houghton, and Baraga counties.

Major ponded water clay deposits are in Genesee, Clinton-Gratiot, Oscoda-Montmorency counties and in a strip southwestward from Kalamazoo County through Van Buren and Cass counties. Undoubtedly many of the more plastic, smooth, and gritless clay deposits in the morainic areas of the state are clays of ponded water origin.

The composition of lake clays is similar to morainic clays, but they generally are free of glacial pebbles and boulders. Lake clay generally covers more extensive areas. Usually the upper 2 to 5 feet are weathered and low in lime, whereas the underlying blue clay may be loaded with lime pebbles. Most of the surface clays presently used by the clay product producers and cement companies in Southern Michigan are lake clays.

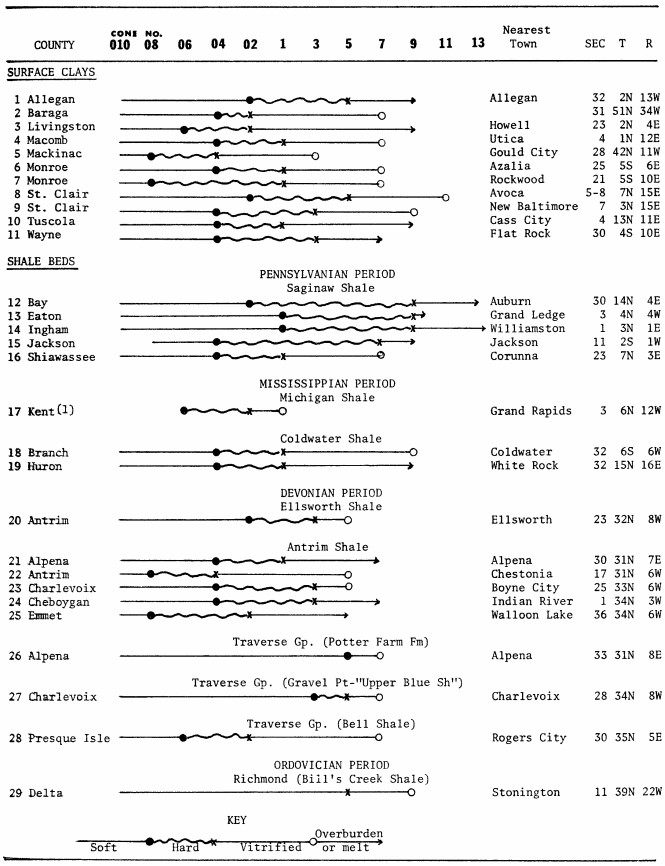
The third class, residual clays, is found where the shale bedrock is exposed or under very thin glacial drift cover. In these areas, the shale may be weathered to a depth of three or more feet. Much of the surface clay in Antrim, Charlevoix, and southern Emmet counties may be residual clay formed by weathering of the underlying Antrim and Ellsworth shales. Some of the clay in the Coldwater area of Branch County and St. Ignace, Mackinac County may also be residual of the underlying Coldwater and Point aux Chenes shales. Other areas of

residual clays may be present within the belts of shale outcrops.

White burning kaolin clays are not known in Michigan, however, some of the calcareous plastic clays in the State burn almost white, and therefore, might be adaptable for special uses. A blue, very plastic, gritless, calcareous clay deposit on the north limits of Lansing has been tested and burns almost white.

Other clay deposits which may be suitable for special uses have been reported. At Harrietta, Wexford County, an extremely-grit-less, fine-grained clay was tested for its Fuller's Earth properties some years ago and was reported to be effective in clarifying oil. A white or nearly white clay from Ontonagon County about 2 miles southwest of Rockland was formerly used for slip clay in Ohio. A deposit at Crosswell, Sanilac County, has a low melting point (glaze at about 1230° C) and may be suitable for slip clay use.

TABLE 2.--BURNING TEST RANGE OF CLAYS AND SHALES FROM SELECTED DEPOSITS IN MICHIGAN (*from Brown, 1926*)



Some surface clays have a tendency to swell upon burning and may be suitable for lightweight aggregate production. Such a clay exists near Marine City, St. Clair County, and near Farwell, Clare County. A clay from about 10 miles west of Baraga, Baraga County, indicated positive signs of swelling beyond the first stage of vitrification.

BURNING TESTS

The most practical test for determining the suitability of a clay for use as a ceramic product is the burning test. If the temperature from the time the clay becomes hard burned (incipient vitrification) to the point where it becomes viscous and melt exceeds 120° C (6 pyrometric cones), the clay is considered to have a good burning range and may possibly be adaptable for vitrified ware. If less than 6 cones, the clay would only be suitable, at best, for common brick or tile.

Because of the calcareous nature of Michigan surface clays, most have rather narrow burning ranges and will burn to an off-shade red, pink, or salmon color. However, those surface clays that have been subjected to weathering and leached of much of their lime content have better burning ranges, and in many cases, are quite suitable for ail kinds of brick and tile and sometimes vitrified products of various kinds.

Burning range spreads for samples from various shale deposits in Michigan and 11 surface clay deposits are presented in Table 2. The table shows that the Bill's Creek Shale (no. 29) in Delta County does not burn hard before vitrification takes place and melt occurs. With a burning range of less than 4 cones (80° C) the shale would not be suitable in the production of vitrified ware. Inability to bum hard suggests a high lime content. The "upper blue shale" (no. 27) of the Gravel Point and Potter Farm (no. 26) formations, Ellsworth Shale (no. 20) and the Michigan Formation shale (no. 17) also have a short burning range, and hence, may be considered almost worthless for production of clay products of any kind.

The Antrim (no. 21-25), Coldwater (no. 18 and 19), and Saginaw Formation (no. 12-16) shales, on the other hand, show very good burning ranges, and being low in lime, are well suited in most instances for all kinds of brick and tile, sewer pipe, and other vitrified products or ware.

The 11 surface clays (no. 1-11) were selected for their long burning ranges and should be suitable for brick, tile, and some vitrified products.

PROSPECT FOR THE FUTURE

In general, Michigan glacial clays (morainic and lake clays) are less satisfactory for ceramic materials than are the Pennsylvanian, Mississippian and Devonian shales, but when leached of lime, the clays are generally satisfactory for brick and tile, pottery, and possibly some vitrified ware.

Possible new uses for the Michigan's clay and shale resources can only be surmised. Preliminary tests made by the U.S. Bureau of Mines during 1966-67 show that the Bell Shale of the Traverse Group will bloat and produce lightweight aggregate material by the rotary-kiln process. Shale from the Michigan Formation showed laminar expansion at 2000° F and warrants further

testing. The other shales tested have little promise for lightweight aggregate material although further investigation may prove otherwise. On the other hand, most of the surface clays will cinder when mixed in certain proportions with coke or grounded coal, and fired over a cindering grate. More clay deposits than the two presently being worked will undoubtedly be opened for this purpose in the future.

It is possible that some of the undeveloped shale deposits will eventually become valuable in the production of clay products and vitrified ware, as may some of the surface clay deposits having a wide burning range. Some of the very fine-grained, gritless plastic clays in Clare, Sanilac, and Ontonagon counties that show slip clay characteristics may eventually be worked on a small scale for that use. The clay deposit at Harrietta may have a use as a substitute for "Fuller's Earth".

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<u>Note</u>: Appendix consisting of Tables No. 3 and No. 4 follows on pages 154 and 155.

TABLE 3.--ALKALI AND SILICA/ALUMINA ANALYSES OF CLAY SAMPLES FROM GLACIAL DEPOSITS IN MICHIGAN

Note: An alkali content of 3%, or less, and a silica/alumina ratio of 3 or less, suggests clay suitable for manufacturing Porland cement.

(Analyses from Brown 1926)

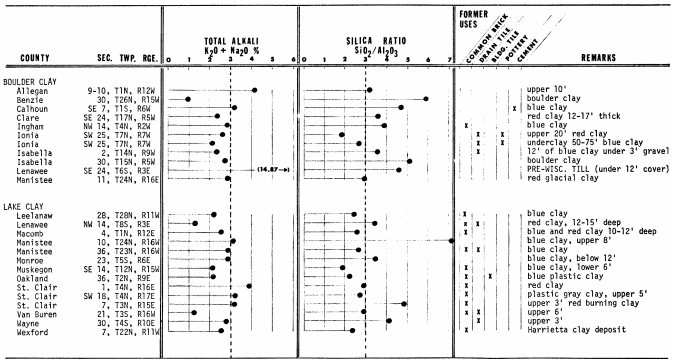

TABLE 4.--ALKALI AND SILICA/ALUMINA ANALYSES OF SELECTED SHALE DEPOSITS IN MICHIGAN

Note: An alkali content of 3%, or less, and a silica/alumina ratio of 3 or less, suggests shale suitable for manufacturing Portland cement.

(Analyses from Brown 1926)