Character. The quarry beds vary greatly in color, structure and texture but all are very high in calcium and correspondingly low in magnesia. The black limestone owes its color to 2% to 3% of organic matter. As a rule, all but the more fossiliferous and less bituminous portions of this bed are rejected. The vesicular structure is apparently due to solution from water. In portions of some of the beds, the solution channels are so numerous that the stone literally crumbles to pieces under the heel. Blasting reduces this stone to an unsalable mass of small fragments. The percentage of fine material is exceptionally large and ordinarily would be wholly waste. Lime is burned in a rotary kiln and the stone must be crushed into small fragments, hence much of the fine material can be directly utilized for lime.

Bed No. 3, on account of its exceptionally low percentage of impurities, particularly silica and magnesia, is especially adapted for sugar and paper making. It burns very easily and makes a most excellent lime, but owing to the demand by paper and sugar manufacturers for stone from this bed most of the stone used for lime is obtained from beds Nos. 8, 9 and 10, which burn less easily, though making an excellent hot lime.

The percentage of calcium carbonate in the different beds in the quarry ranges from about 93% to over 98% (bed No. 3) and the silica from a minimum of .24% in the upper beds to 1.75% for the lower beds as shown by analyses Nos. 177 to 181. The average of analyses (No. 184) made from every two feet of core, the top 38 feet of "light colored" limestone (below beds Nos. 1 and 2) gave 96.52 per cent of calcium carbonate and 2.10 per cent of silica. Below this depth the silica and magnesia increase, a similar average of analyses (No. 185) gave 3 to 5 per cent of silica and 6 to 9 per cent of magnesia. Analysis No. 182, said to be of black limestone, shows a surprisingly small amount of organic matter as compared with analysis No. 178 of bed No. 2.

The presence of the bituminous and the vesicular beds in the quarry requires hand sorting and loading. The product is burned for lime, and sold for a variety of purposes requiring high calcium limestone.

Black Lake Quarry. A number of years ago the Onaway Limestone Co. opened a quarry in sec. 2, T. 35 N., R. 1 E., in a bluff along the south side of Black Lake about 6 miles north of Onaway. The following section is exposed:

Section in Black Lake quarry.

		Thickness, feet.
1.	Dark bituminous, crystalline, and very fossiliferous beds, containing masses of corals and an abundance of brachiopods. The beds are present only at the east end of the quarry	0-6 +
2.	Light gray dense grained limestone with small disseminated calcite crystals	8 +
3.	Dense grained gray limestone with but few crystals of calcite	7
4.	Gray dense grained limestone with many small calcite crystals	9
5.	Dense grained gray to lithographic limestone with many small crystals of calcite. Lighter than beds Nos. 3 and 4	4
6.	Very fine grained, dark bituminous limestone	1 −
7.	Dense grained gray to lithographic limestone similar to No. 5	4
8.	Dense grained limestone with bituminous bands	1½
9.	Dense grained limestone with calcite crystals and dense cavities	1
10.	Dark argillaceous bituminous and fossiliferous limestone with druse cavities. Apparently the top of the Long Lake series	1 +

The dip is strongly to the southeast and the light gray fine grained beds of the quarry are overlain on the east by gray fossiliferous and more argillaceous beds.

An analysis, No. 186a, of a set of samples from the light gray fine grained beds gave 96.84 per cent of calcium carbonate, 2.03 per cent of magnesium carbonate and less than 1 per cent of impurities. The beds weather to a distinct buff or brown, indicative of the presence of iron. The stone was sold for sugar manufacture but apparently the percentage of magnesium is slightly too high. The low percentage of impurities make the stone suitable for blast furnace flux and for use in the chemical industries.

Legrand quarry. About three-fourths of a mile southeast of Legrand in the SE. ¼ sec. 28, T. 35 N., R. 1 W., the Campbell Stone Company opened a test quarry in a prominent ridge of limestone. The ridge extends in northwest-southeast direction and terminates on the north in a cliff or bluff, from 10 to 40 feet or more in height, along which exposures of limestone occur. The overburden at the brow of the cliff is thin but apparently it is much thicker to the south. The strata exposed in the quarry dip strongly to the south. The Legrand branch of the Detroit and Mackinac railroad passes directly in front of the quarry and affords favorable transportation facilities.

The section exposed in the quarry is identical with that at Afton, though the two places are nearly four miles apart, hence description of the beds is unnecessary. The section exposed is about 32 feet.

To the northwest the ridge is broken by a small stream but is continued in sec. 19, T. 35 N., R. 1 W. The record of a core drilling made on the SW. ¼ SE. ¼ of this section is as follows:

Core drilling Sec. 19, T. 35 N., R. 1 W.

	Thickness, feet.	Depth, feet.
Surface	2	2
Light colored limestone	5	7
Light colored limestone	8 6 in.	15 6 in.
White coral limestone	1 6 in.	17
Light limestone	4	21
White coral limestone	2 6 in.	23 6 in.
Light limestone	2	25 6 in.
White coral limestone	6 in.	26
Light limestone	4 6 in.	30 6 in.
Dark limestone	2	32 6 in.
Light limestone	6 6 in.	39
Dark rock	1	40
Blue shale	8 6 in.	48 6 in.
Gray shale	2	50 6 in.

An average (Anal. No. 186) of analyses made every two feet to the depth of 30 feet 6 inches gave 94.20 per cent calcium carbonate and 3.40 per cent of silica. Other core drillings were made on SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 25, T. 35 N., R. 2 W., also on NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ and SW. (?) $\frac{1}{4}$ SW. $\frac{1}{4}$ of sec. 13, T. 34 N., R. 2 W., and the results were very similar to those of the two records given above.

Marion Stone Co. quarry. Formerly the Marion Stone Company operated a small quarry in the S. $\frac{1}{2}$ NE. $\frac{1}{4}$ sec. 7, T. 35 N., R. 1 W., on the south side of a prominent ridge of limestone extending roughly in a NW-SE direction across the section and terminating on the southwest in a steep slope toward a small branch of Pigeon river. Rock is exposed along the brow of the ridge in a number of places. The overburden in the vicinity of the quarry varies from 1 to 3 feet. A branch of the Michigan Central railroad passes close to the quarry and affords ready facilities for marketing the product.

The opening is 300 to 400 feet long and very narrow. The beds dip strongly to the southeast and unfortunately quarrying was developed nearly in the direction of the dip. This made bad drainage conditions and a very rough floor. As quarrying progressed a 6-foot black bituminous limestone was encountered which contained so much organic matter and other impurities as to be unmarketable. These adverse conditions finally caused the abandonment of the quarry.

The section exposed is as follows:

Section in Marion Stone Co. quarry.

		Thickness, feet.
	Surface	1-3
1.	Densely crystalline limestone, fossiliferous in places	4
2.	Very fossiliferous limestone with bands of very fine grained limestone, showing "ribbon" structure on weathered surface	3½
3.	Dense grained to crystalline limestone with abundance of corals and brachiopods in places	5
4.	Gray crystalline limestone	1½
5.	Light gray densely crystalline and fossiliferous limestone	4
6.	Black bituminous limestone with scattering cup corals. Burns hard and larger pieces generally have a black carbonaceous core	6
7.	Vesicular limestone. Cavities due to solution. Lowest bed exposed in quarry	2½ +

According to analysis No. 187 made from a representative set of samples from the various beds with the exception of the black limestone, the average content of calcium carbonate is nearly 97 per cent. The vesicular beds when below the water table yield large quantities of water. For this reason quarrying operations must be confined largely to the bluffs where the strata are self draining.

Limestone is exposed on numerous ridges and hills in the vicinity of Afton and Legrand and apparently there are large areas where limestone is under very favorable conditions for quarrying.

Tower. At Tower, limestone is exposed in a series of ledges in the channel of Black river, giving rise to rapids. Twelve feet of dark gray, nodular to massive, crystalline and fossiliferous limestone resembling the Long Lake series of the lower Traverse are exposed on the south side of the stream. The area of limestone under light cover is apparently small. No analyses are available.

Durrell or Mill Creek quarry. Four miles southeast of Mackinaw City, in Private Claim No. 334, the Dundee limestone is exposed along the lower course of Mill Creek and old lake terraces rising about 80 feet above Lake Huron. The upper terrace is covered with drift from 4 to 30 feet or more in depth. Mill Creek has carved a relatively wide valley in the drift on the terrace and a very narrow one in the limestone below, thus exposing the limestone in the creek bed in narrow benches on the sides of the lower valley. Limestone is also exposed along the base of the upper terrace parallel to the lake shore.

The Cheboygan County Limestone Products Company have recently opened a small quarry near the mouth of the creek. The following section is exposed:

Section in Durrell quarry, Mill Creek.

		Thickness, feet.
	Surface clay	4-8 +
1.	Hard white limestone, top magnesian bed. $CaCO_3$ 82.62 per cent, $MgCO_3$ 16.97 per cent	1-2
2.	Buff to gray bituminous crystalline limestone with some very fossiliferous (Coralline) beds and bands of black bituminous limestone. $CaCO_3$ 98.45 per cent, $MgCO_3$ 1.24 per cent	12
3.	Buff to gray crystalline limestone, middle magnesian bed. $MgCO_3$ 5.98 per cent	3 ±
4.	Buff to gray bituminous and crystalline limestone with bituminous and fossiliferous bands. $CaCO_3$ 98.61 per cent, $MgCO_3$ 1.18 per cent	9½
5.	Buff to gray limestone $CaCO_3$ 96 ± per cent. Analyses available only from a portion of this section. Floor of quarry	10
6.	Light to dark buff bituminous and more or less friable and sugary limestone with gray crystalline spots. Locally very fossiliferous. Basal magnesian beds of the Dundee limestone. $CaCO_3$ 69.40 to 75.80 per cent. Thickness above lake level about	25

The area of limestone exposed or under light cover in Mill Creek valley and on the lower terrace is relatively small. Test holes indicate that the surface of the limestone is cut by valleys and gullies hence the total area of easily accessible high calcium stone is uncertain. The thickness of the stone above the basal magnesian beds is variable, ranging from nothing to probably over 50 feet. The average is probably between 30 and 40 feet.

The beds are characteristically gray to buff in color and very bituminous. Where fresh the stone is gray and crystalline, but where weathered it has a yellow or brown sugary appearance. Locally there are dark to black bituminous streaks. Most of the beds are sparingly fossiliferous but some are a mass of fossils, cup corals predominating. Locally the rock is fractured and the cracks are filled with bright red clay apparently the result of infiltration from the red surface deposits.

Analyses have been made of a large number of samples taken from the numerous exposures along the banks of Mill Creek from drill cores and from the quarry face and these show that most of the upper 45 feet averages over 98 per cent calcium carbonate with very little silica, iron and alumina or magnesia. The exceptional purity of these beds is shown by analyses Nos. 188, 190-193, 195-211, 213-216 and 218-227z. There are, however, magnesian bands, one near the top of the quarry and one near the middle as shown by analyses Nos. 194, 212, and 217. The basal beds of the Dundee, however, contain from considerable to large percentages of magnesia as shown by analyses Nos. 189 and 228.

On account of its exceptional purity, the stone is especially adapted for general fluxing purposes and for the manufacture of Portland cement, sugar, carbide and for use in the soda ash and chemical industries. The stone in the upper crystalline bed is generally hard and is suitable for road making, concrete and ballast.

The Michigan Central railroad runs directly in front of the quarry, affording favorable shipping facilities.

Limestone is exposed at various points along the high terraces to the northwest to McGulpins Pt. west of Mackinaw City. About two miles south of Mackinaw City in secs. 29 and 30, T. 39 N., R. 3 W., low ledges of Dundee limestone are exposed in the fields. Formerly lime was burned in small kilns at a number of places. The upper beds about 10 feet thick belong to the high calcium series at Mill Creek. Test holes show, however, that the basal magnesian limestone of the Dundee occurs at very shallow depths in the vicinity of the exposures. The upper lake terrace in these sections has in most places a heavy cover of drift.

Summary. Exposures of the Traverse formation are numerous in the central part of Cheboygan county in the form of relatively flat topped bluffs and ridges along river valleys. The extent of the accessible limestone is uncertain but apparently large. Test borings indicate that shale is very subordinate in amount and that the beds of limestone are uniformly high in calcium carbonate. Exposures of the Dundee limestone are small and limited to the narrow valley of Mill Creek and to the lake terraces between McGulpins Pt. and the mouth of Mill Creek.

Chippewa County.

Distribution. Chippewa county is underlain by three limestone formations, viz.: Beekmantown (Calciferous), Trenton, and Niagara.

The Beekmantown is exposed only in the vicinity of Neebish Island, the Trenton on St. Mary's river, Carp river south of Waiska bay, and in the hills extending northwest-southeast through Ts. 45 and 46 N., R. 1 W. The Niagara is exposed over large areas on Drummond Island, in the southeastern peninsula, and along the southern margin in the western part of the county.

Beekmantown (Calciferous) formation. Ledges of Beekmantown formation are exposed on the west shore of Neebish Island. The rock is described by Rominger* as a hard crystalline dolomite in beds 6 to 12 inches thick divided by vertical fissures into almost rectangular blocks. Apparently it would make a durable building stone. Analysis No. 229 by Rominger indicates that it is practically a normal dolomite, though siliceous. Exposures also occur on St. Joseph and Encampment d'Ours islands on the Ontario side of the river where limestone was formerly quarried on a small scale. The exposures of the Beekmantown are of little economic importance in this county.

Trenton Limestone. The exposures of the Trenton limestone are all

*C. Rominger, Vol. I, Pt. 3, p. 76, 1869-1873, Michigan Geological Survey.

on the Canadian side of the river, on St. Joseph, Encampment d'Ours, and Sulphur Islands. About 60 feet of shales and limestones belonging to the Trenton are exposed on Encampment d'Ours island. The lower portion is largely sandy calcareous shales, the middle part is thin bedded nodular limestone with shaly streaks, and the upper part is light colored brittle limestone with a conchoidal fracture. Analysis No. 230 by Rominger* indicates that the upper limestone though low in magnesia is siliceous. The beds exposed in the spur forming the northeast end of St. Joseph island are identical with those of Encampment d'Ours. Analysis No. 231 is from the blue middle argillaceous limestone and analysis No. 233 from the lower blue sandy portion.

Niagara Limestone. Exposures of all four members of the Niagara limestone, viz., the Engadine dolomite, the Manistique series, the Fiborn limestone, and the Hendricks series occur in Chippewa county. The principal exposures of the Engadine dolomite are in the northern third of T. 44 N., Rs. 4 and 5 W., the southwestern corner of T. 43 N., R. 1 E., the southern part of T. 43 N., R. 3 E., and in T. 42 N., Rs. 2, 3 and 4 E. This member caps most of the high bluffs, hence exposures of the underlying Manistique series are numerous along the basal portions of the bluffs. The most extensive exposures of the Manistique series are on Drummond Island. Exposures of the Fiborn limestone are doubtful but the Hendricks series is well exposed at Marble Head on the eastern shore of the island and also on some of the islands in St. Mary's river. The Fiborn limestone is exposed or under light cover at several places west of Trout Lake in the western part of T. 44 N., R. 6 W. Elsewhere the Fiborn limestone and Hendricks series are deeply buried under glacial drift.

Quarries and Localities.

Marble Head, Drummond Island. This locality was not visited by the writer, hence its description must rest upon the authority of Rominger† who has described it in detail. Marble Head is a promontory at the eastern end of Drummond Island rising about 100 feet above lake level. Its sides are steep with occasional vertical cliffs. Owing to the southward inclination of the beds, lower lying beds are brought to the surface on the north side of the hill along the shore. The following is the section as given by Rominger:

*C. Rominger, Vol. I, Pt. 3, pp. 64-68, Michigan Geological Survey.
†C. Rominger, Vol. III, pt. 3, pp. 33-36, Michigan Geological Survey.

Section at Marble Head, Drummond Island.

		Thickness, feet.	Depth, feet.
1.	Light colored irregularly bedded crystalline magnesian limestone	25	25
2.	Massive light cream colored obscurely bedded coarsely crystalline dolomite, filled with casts of Pentamerous oblongus	15	40
3.	Finer grained, more thinly and regularly bedded dolomite	4	44
4.	Drift covered	10	54
5.	Dark gray highly crystalline limestone with siliceous veins containing many fossils. Top of quarry	6	60
6.	Dull earthy light colored laminated limestone, becoming non-fossiliferous toward the bottom	15	75
7.	Dark gray crystalline limestone becoming earthy toward bottom of quarry	8	82
8.	Dark gray bituminous dolomites of nodular and unhomogenous structure. Seams of black carbonaceous matter wind about in the rock mass	10	92
9.	Flaggy layers, in various shadings of color and with nodular surface	6	98
10.	Ash colored fine grained acicular limestone in beds 4 to 8 inches thick, some of which are full of fissure-like cavities extending in all directions. Cavities apparently once occupied by tabular crystals of calcite $CaCO_3$ 95 per cent. (This may be the diminished representative of the Fiborn limestones)	3	101
11.	Dull earthy limestone, druse cavities filled with calc-spar or quartz. Some of the beds quarried on a small scale, but apparently do not resist the weather very well	8	109
12.	Dark gray bituminous and nodular limestone. The nodules are coated with a black film of bituminous shaly matter	5	114
13.	Light colored absorbent limestones, separating in thin slabs with uneven conchoidal surface. This exposure is one-fourth mile from Pirate Harbor	10	124

Beds Nos. 5 to 9 inclusive were exposed in an old quarry at Marble Head, analyses Nos. 234 to 236 by Rominger show that they approach normal dolomite. Bed No. 11, the acicular limestone below the floor of the quarry and the light colored absorbent limestones at the bottom of the section are high in calcium carbonate, as shown by analyses Nos. 237 and 238. Analyses No. 239 is from loose slabs thrown up by the water on the west side of Sitgreaves bay. These slabs are apparently from just above the Cincinnati (Hudson River) group.

Further exploration inland to the northwest along the strike of the beds might result in the discovery of important exposures of the high calcium beds.

Drummond. A double series of high terraces or bluffs occurs along the north shore of Drummond Island in the vicinity of Drummond. Limestone is exposed at several places in vertical cliffs. The upper terrace, 10 to 40 feet in height, is composed of an alternating series of buff crystalline and fossiliferous high magnesian limestone, and dense grained, thin bedded dolomite without fossils. The lower terrace, 30 to 40 feet in height, is composed of buff to gray, finely crystalline and massively bedded dolomite. Vertical fracture systems almost at right angles to each other result in natural rectangular blocks of large size.

Due to this fact and to the hardness of the rock large quarries have been operated for block stone for use in constructing the earlier ship canals at the "Soo" and in building breakwaters and piers on the Great Lakes. Formerly these dolomites were used extensively in burning magnesian lime one mile east of Drummond on the lake shore. According to local residents the stone burned hard and produced a gray lime, not well suited for ordinary purposes.

The area of easily accessible natural block stone is limited to a narrow bench from a few rods to several hundred feet in width between the lake shore and the upper terrace. The area underlain by the fossiliferous and non-fossiliferous limestones of the upper terrace is very large. Exposures are numerous at many places in the vicinity of Drummond.

The following section is exposed in the L. Seaman quarry and on the bluffs immediately back of the quarry:

Section in L. Seaman quarry, Drummond.

		Thickness.	
		Feet.	Inches.
	Surface	0 to 3	
1.	Light grayish buff crystalline and fossiliferous magnesian limestone. Abundant casts of Pentamerus oblongus. Only about 4 feet of rock exposed; basal portions of bed concealed by talus	8+	
2.	Similar rock composed largely of casts of Pentamerus forms. Only about 3 ft. of stone exposed; other beds may be present between this and the next succeeding	15±	.....
3.	Similar, but fossils less numerous and the stone less crystalline. Only about 5 ft. of rock exposed. Other beds may be present	15±	.....
4.	Buff very dense grained and thinly bedded dolomite, resembling novaculite and having a prominent conchoidal fracture. Much like some of the dense grained finely crystalline dolomites in the quarry below. Only upper 6 feet exposed. Other beds may be present. Top of quarry	25±	.....
5.	Buff to gray cherty, and massively fossiliferous dolomite	3	6
6.	Hard light gray to buff massive and crystalline dolomite, separated from No. 7 by a parting of very thin bedded dolomite	3	.....
7.	Hard light buff massive and crystalline dolomite similar to No. 6	4	8
8.	Hard buff densely crystalline dolomite—conchoidal fracture prominent in lower part of bed	8	.....
9.	Dark buff crystalline dolomite with a drusy fossiliferous zone in the center of the bed	3	6
10.	Hard light gray to buff finely crystalline banded dolomite with prominent bedding planes	7	8
11.	Hard bluish fine grained dolomite weathering to a pronounced blue color. Lowest bed quarried and floor of quarry is apparently a part of the same bed and just above lake level	2+	.....

A similar section is exposed in a large quarry on Quarry Point about one mile west of the above. This quarry, like the Seaman quarry, was formerly operated for block stone. The massive crystalline beds in the lower terrace are dolomite as shown by analysis No. 240.

Old Fort Drummond. In the vicinity of Old Fort Drummond at the southwest extremity of Drummond Island there are numerous exposures

of magnesian limestones belonging to the upper part of the Manistique series and probably the tops of some of the higher elevations are capped with Engadine dolomite. Large exposures of the Manistique series occur along the south shore of the island as at the head of Huron Bay and on the peninsulas between Huron Bay and Scammon's Cove.

Lime Island, St. Marys River. A few hundred feet north of the Pittsburgh Coal Co. docks on Lime Island a quarry was operated many years ago for burning lime. The stone was obtained from a narrow bench which rises 30 feet above the river level. Apparently hard rock forms part of an upper terrace rising 25 or 30 feet higher. The stone is white to buff finely crystalline normal dolomite as indicated by analysis No. 241. According to statements of local residents the stone burned hard and produced a gray slow setting lime not well suited for ordinary uses.

In digging a trench for the steam mains from the engine house to the company quarters many pieces of limestone identical in physical characteristics with the Fiborn limestone were observable in the drift. The angular uneven character of the fragments indicates the close proximity of this member and it is possible that it forms a portion of the upper terrace. The fact that the white to buff dolomites of the quarry in the lower terrace resemble those which occur beneath the Fiborn limestone in the Hendricks quarry in Mackinac County also tends to support such a possibility. No exposures, however, could be found.

Detour. Large exposures of Engadine dolomite occur in and about the village of Detour. Quarrying and transportation facilities are exceptionally favorable at this place. The dolomite is massive and coarsely crystalline and where fresh shows the peculiar bluish mottlings and streaks so characteristic of this member. Where weathered the rock is white. In the northern part of the village a small quarry was formerly operated for lime burning. The low percentage of silica, iron and alumina in analysis No. 242 made by Rominger in 1873 is characteristic of this dolomite.

Gatesville. Prominent ridges of bare limestone occur between Gatesville and Point Detour. The ridges are capped by Engadine dolomite, but the bases are formed of the upper very fossiliferous dolomite beds of the Manistique series. The high ridge of dolomite just east of Gatesville extends north almost to Raber on St. Marys River.

Rockview. Rockview is at the top of high northward facing bluffs capped with the typical bluish mottled and streaked and coarsely

crystalline dolomite of the Engadine member. The fossiliferous, thin bedded dolomites of the Manistique series form the base of the bluffs and are extensively exposed. Owing to the gentle southward dip of the strata the capping of Engadine dolomite extends southward to Cedarville, Mackinac County, on the lake shore.

Sec. 8, T. 43 N., R. 2 E. Ledges of very massive coarsely crystalline dolomite with the characteristic mottling and bluish colorations of the Engadine dolomite occur here and there in this and adjacent sections. Large tracts are covered with great boulders of this dolomite Analysis No. 243 shows the characteristic purity of this stone.

Haff P. O. (Dick). At Haff a line of limestone bluffs 10 to 80 feet or more in height extends south nearly to Kenneth, Mackinac County and eastward for many miles. The tops of the bluffs generally have only a light cover of drift and tracts covered with great boulders are characteristic. The upper 40 to 50 feet of the bluffs is composed of Engadine dolomite, extremely massive, coarsely crystalline, and mottled and streaked with blue. The base is composed of the thin bedded and very fossiliferous dolomites of the Manistique series.

The area underlain by easily accessible dolomite in the vicinity of Haff and in the southern portions of T. 44 N., Rs. 4 and 5 W., is apparently several square miles. Analysis No. 246 was made from a set of samples taken from the property of L. O. Poquin at Haff and may include samples from the underlying Manistique dolomites. The content of iron and alumina indicates this. Analyses Nos. 244 and 245 are respectively from the lower and upper parts of a 50 foot exposure of Engadine dolomite three-fourths of a mile south of Haff, where the road from Trout Lake to Ozark crosses the bluffs. Both of these analyses are characteristically low in silica, iron and alumina. Owing to the low percentage of these impurities this stone is particularly adapted for lining open hearth furnaces. Its porosity as well as purity also adapts it for use in the manufacture of paper by the sulphite process.

Sec. 19, T. 44 N., R. 6 E. About three miles west of Trout Lake in section 19 and adjoining sections, T. 44 N., R. 6 E., exposures of Fiborn limestone are reported. The writer found many boulders of lithographic limestone similar in every particular to the Fiborn limestone, but could not determine whether or not some very small ledges were actually in place. The Fiborn member occurs just across the county line to the west in Mackinac County, therefore it is probable that further search might result in the discovery of quarryable areas of this stone.

Summary. Large areas along the southern margin and in the southeastern part of Chippewa county are underlain by thick beds of exceptionally pure dolomite belonging to the Engadine member. Quarrying conditions are very favorable at many places. The stone on account of its purity is especially suitable for lining open hearth furnaces. Its purity and porous character also make it particularly adapted for paper manufacture. The supply of this stone is practically inexhaustable.

The beds of dolomite on Drummond Island are of great extent but they are less pure than those on the mainland. Further exploration between Maxton and Marble Head may result in the discovery of considerable, or even large areas of high calcium limestone, similar to that exposed immediately north of Marble Head.

Delta County.

Distribution. The Trenton limestone underlies the western part of the county, the Niagara formation the eastern part and the Cincinnati group the central part. The Trenton is well exposed in a narrow belt along the Ford and Escanaba rivers and widely exposed in the valley of Rapid River. In Garden Peninsula the Niagara limestone forms a series of high bluffs or an escarpment from Garden to the southern end of the peninsula. Limestone is also exposed at many places along the low eastern shore and in the interior of the peninsula. The Cincinnati group forms the prominent bluffs on the west side of the peninsula separating Little Bay de Noc and Big Bay de Noc.

Character. The exposures of the Trenton limestone are characteristically shaly or argillaceous, usually containing from 5 to 10 per cent of silica, iron, and alumina. The upper beds are generally dolomite but the lower ones are usually low magnesian limestone. As far as known all of the exposures of the Niagara belong to the Manistique series.

Though typically shale the Cincinnati group in Delta county also contains much argillaceous limestone and very calcareous shale.

Quarries and Localities.

John Bichler quarry, Groos. The Trenton limestone is exposed at various places along the lower course of the Escanaba River for a distance of about six miles. About four miles north of Escanaba, in the vicinity of Groos, limestone is exposed in the river channel and forms narrow benches on either side flanked by high hills of glacial drift. For a number of years John Bichler has been operating a quarry (Pl.

8 B) on the narrow bench on the west side of the river, chiefly for crushed stone and rough building block. The quarry consists of an upper and a lower bench. The maximum depth at the time of the writer's visit was about 23 feet. The depth of the upper portion was from 4 to 11 feet. Most of the limestone is bluish, argillaceous, and crystalline with thin wavy laminae and bands of blue and black shale and thin beds of very fossiliferous limestone. Some of the limestone is very thin bedded and some massively bedded. The more massive beds are used for rough building block but most of the stone is crushed for road making, concrete and ballast. Formerly the stone was burned locally for lime but it is said to burn hard and produce an inferior product. Analyses Nos. 247 and 248 are indicative of the argillaceous and low magnesian character of the beds. Analysis No. 249 by Rominger is from the highest exposed beds near the mouth of Escanaba River and shows that these, allowing for the impurities, are practically normal dolomite. The exposure from which Rominger obtained his sample is on the east bank of the river near the power plant and apparently almost directly across from Bichler's quarry. Analysis No. 250, also by Rominger, is from the ''wedge-shaped'' limestones directly below the dolomites. It is probable that these ''wedge-shaped'' limestones of Rominger belong to the group of low magnesian limestones exposed in Bichler's quarry.

According to Rominger* the ''wedge-shaped'' limestone series is underlain by very shaly and sandy dolomitic limestone containing over 20 per cent of silica. Analysis No. 251 by Rominger is from a ledge exposed in the river channel about six miles above its mouth.

The following test on the wearing quality of this stone was made by the Division of Tests, Office of Public Roads, U. S. Department of Agriculture, Washington, D. C., to determine its qualifications as a road material:

Specific gravity	2.80
Weight per cu. ft	175.00
Water absorbed per cu. ft	0.39
Per cent of wear	3.40
French co-efficient of wear	11.60
Hardness	16.50
Toughness	12.09
Cementing power	good

The sample was a ''dolomite of average hardness, slightly above the average in resistance to wear for dolomite and with good cementing value. Suitable for use on medium traffic roads.'' L. W. Page, Nov. 2, 1906.

Masonville. Trenton limestone is exposed one mile southwest of Masonville along Day's River for a half mile or more. Many years

*C. Rominger, Vol. III, Pt. III, pp. 58, 59.

ago a small quarry located on the east bank of the river about 600 paces from the ''Soo Line'' railroad was operated for burning lime. The quarry consists of an excavation about 250 feet long, 150 feet wide and 6 feet in depth to the level of the water in the stream adjacent. The stone is buff to gray crystalline and fossiliferous limestone. Analysis No. 252 is typical in that it shows the usual argillaceous character of the Trenton limestones. According to local residents, the lime was gray, slow setting, i. e., hydraulic, and did not keep well.

Rapid River. Exposures of the Trenton limestone are almost continuous from the village of Rapid River northward for six or seven miles along the west side of the valley of the stream of the same name. The exposures are in the form of low ridges of no particular orientation, though those having a northeast-southwest direction apparently predominate. The exposures are buff to gray, crystalline, fossiliferous low magnesian limestone with an argillaceous content characteristic of the Trenton limestone, as shown by analysis No. 253. Analysis No. 254 by Rominger is from an exposure of coarsely crystalline dolomite of the Upper Trenton above the mill pond near the mouth of Whitefish River. According to Rominger* Whitefish River flows over ledges of similar dolomite and dolomitic limestone as far north as section 2, T. 43 N., R. 20 W. It is probable, however, that many of the more northerly exposures are low magnesian limestone rather than dolomite. The lower course of Whitefish River is largely through swamps and the exposures along the channel of the river are under very unfavorable quarrying conditions.

Bark River. Trenton limestone is exposed in the vicinity of Bark River and recently a quarry has been opened to supply crushed stone for local road building. Judging from hand samples the stone is similar in every way to the Trenton as exposed elsewhere in the county.

Garden Peninsula. As previously stated the Manistique series of the Niagara formation is exposed at many places on Garden Peninsula, especially along the west shore where it forms bluffs or cliffs from 10 to over 200 feet in height. Of the three most conspicuous bluffs, the most northerly is known as Garden Bluff, the central as Middle Bluff, and the most southerly as Burnt Bluff.

Middle Bluff. At Fayette the cliffs rise vertically to heights 70 to 90 feet above lake level. The upper receding portion carries the height probably to between 125 and 150 feet above the water. These cliffs are known as Middle Bluff. The old Jackson Furnace Co. was

*C. Rominger, Vol. I, Pt. III, pp. 62-64.

located here and used the limestone in smelting iron until the available supplies of wood were exhausted. The following section is exposed at the old quarry:

Section at Middle Bluff, Garden Peninsula.

		Feet.
	Surface	0–3 +
1.	Thin bedded densely crystalline dolomite	15 +
2.	Buff fossiliferous high magnesian limestone or dolomite with druse cavities. The line of separation between No. 1 and No. 2 was concealed by talus	4 +
3.	Very hard buff to gray thin bedded cherty dolomite	9
4.	Hard, thin-bedded, and very cherty dolomite. Many seams and nodules of chert or flint similar to the chert horizons at Manistique	10
5.	Hard light bluish densely crystalline dolomite	2
6.	Very massive, fossiliferous and high magnesian limestone, with wavy laminations and druse cavities. Weathered into nodular masses	16
7.	Bluish very thin bedded densely crystalline dolomite	8
8.	Buff massive, fossiliferous and high magnesian limestone, with druse cavities	5
9.	Hard buff massive dolomite with a parting of very thin bedded and densely crystalline dolomite in the center	6
10.	Coarsely crystalline dolomite with an irregular fracture and bluish mottlings distributed more or less parallel to the bedding	3
11.	Light colored, hard, very thin bedded, and densely crystalline dolomite. Breaks into very thin plates and weathers bluish	4
12.	Buff finely crystalline dolomite with a pronounced conchoidal fracture. This is the lowest bed exposed in the quarry	1
13.	Buff very massive, very fossiliferous (coral) and high magnesian limestone	5
14.	Bluish hard thin bedded and densely crystalline dolomite	4 –
15.	Alternating series of massive crystalline and densely crystalline layers of high magnesian limestone and dolomite. Weathers bluish	11
16.	Buff thin bedded densely crystalline and finely laminated dolomite	3 –
17.	Buff sandy appearing dolomite with dark buff and brown streaks, very brittle and breaks with a very pronounced but granular conchoidal fracture. A thin but extremely persistent bed easily traceable for a long distance along the lake shore	1
18.	Buff, massive, fossiliferous and high magnesian limestone with druse cavities	3 –
19.	Hard bluish, thin bedded, and densely crystalline dolomite	2
20.	Buff, massive high magnesian limestone with druse cavities	1
21.	Hard light buff thin bedded densely crystalline dolomite	1
22.	Buff massive, fossiliferous (coral), heavy magnesian limestone with druse cavities	5
23.	Hard crystalline and high magnesian limestone with bluish stripes. This ledge occurs beneath the water	3 +

Bed No. 12 is the lowest exposed at the quarry but owing to the gentle southeasterly dip of the strata beds Nos. 14 to 23 are brought above lake level at the north end of the bluff about a half mile north of the quarry.

At Fayette a reef of limestone 15 to 30 feet in height extends out into Big Bay de Noc in the shape of a fish hook, forming a small but very deep nearly landlocked harbor. The height and extent of the exposure and the presence of a natural harbor give exceptionally favorable conditions for development, but unfortunately the stone is not of the quality now demanded for general fluxing or chemical purposes. Many of the beds undoubtedly would burn easily and make very good mild lime. The finely crystalline beds, however, generally burn very hard.

Burnt Bluff. Burnt Bluff is on the lake shore about three miles southwest of Middle Bluff. This is the largest and highest of the bluffs. It rises about 235 feet above the water and extends along the shore for about two miles. In places it has a sheer face of 60 feet or more. The surface of the bluff gradually slopes southeastward in the

general direction of the dip of the strata and it is only lightly covered with drift, rock ledges being exposed at numerous places in the fields.

The strata are essentially buff to gray, crystalline to densely crystalline, heavy magnesian limestones and dolomites very similar to those of Middle Bluff at Fayette. The section as given by Rominger* is as follows:

Section at Burnt Bluff, Garden Peninsula.

		Feet.
1.	Siliceous (high magnesian) limestones with nodules of hornstone and many silicified but poorly preserved fossils. Top of hill	20–30
2.	Even-bedded (high magnesian) limestones. Top of the vertical cliffs	15–20
3.	Thick-bedded crystalline dolomite alternating with thin and unevenly bedded nodular limestones. Several of the layers contain silicified corals	20?
4.	Cellulose brecciated limestone with the rock fragments incrusted with yellow calc and dolomite spar	2
5.	Thick-bedded crystalline and fossiliferous dolomites containing spherical masses of Stromatopora and lenticular masses of snow white calc spar	10
6.	Thin-bedded dolomitic limestones with smooth conchoidal fracture	50

Analysis No. 254 by Rominger in 1873 was made from the lower 60 feet of Burnt Bluff and is indicative of the high magnesian character of these beds.

Near the south end of Burnt Bluff at Sac Bay bed No. 4, the cellulose, brecciated limestone 60 feet above the water at the north end of the bluff is at water level. The nominal dip is apparently 40 to 50 feet per mile to the south-southeast hence the dip along the strike of the beds is due to local undulations, which may be observed at many places in the Niagara in the Northern Peninsula. Cliffs of similar limestone also form most of the shore of Summer island at the south end of Garden Peninsula.

Garden Bluff. This bluff is at the entrance to Garden Bay about four miles north of Middle Bluff. Vertical cliffs of limestone, 20 to 40 feet in height, occur along the shore for a mile or more. The exposed beds are buff to gray crystalline to densely crystalline, high magnesian limestones and dolomites very similar to those at Middle and Burnt bluffs.

Point Detour. This locality was not visited by the writer but according to Rominger† the cliffs at Point Detour are about 8 feet high and are composed of the same massive beds of crystalline dolomite which forms Seoul Choix and Epoufette points. Crystalline dolomite of the Engadine member of the Upper Niagara is typically exposed on Seoul Choix Point, therefore it should occur at Point Detour and probably at other places on the eastern shore of Garden Peninsula, if Rominger's correlation is correct.

*C. Rominger. Vol. I, Pt. III, p. 47, 1869-1873.
†C. Rominger, Vol. I, Pt. III, p. 46, 1869-1873.

Rominger considered the massive dolomite at Detour and Seoul Choix points as lying below the fossiliferous beds on the higher western portion of Garden Peninsula, but it is unquestionably on top of them instead of below them.

Stonington. The bluffs in the vicinity of Stonington on the east side of Little Bay de Noc are formed of strata belonging to the Cincinnati series of shales, which at this place are very calcareous as shown by the following partial analyses made by Prof. G. A. Koenig of the Michigan College of Mines:

Analyses of beds near Stonington.

Analysis number.	Number of sample.	Per cent $CaCO_3$.	Thickness of bed in inches.
255	1	42.4	.....
256	2	50.4	.....
257	3	63.3	30
258	4	52.8	.....
259	5	40.0	19
260	6	50.8	.....
261	7a	57.3	4
262	7b	46.0	.....
263	8a	49.6	6
264	8b	49.6	.....
265	8c	51.6	5 spotted
266	9	66.4	5 spotted
267	10	42.4	3
268	11	45.2	6
269	12a	50.4	10
270	12b	43.2	.....
271	13	44.0	6
272	14	54.0	8
273	15a	42.0	13
274	15b	44.0	.....
275	16a	42.0	.....
276	16b	43.6	30
277	16c	40.0	.....
278	16d	40.0	.....
279	17	34.0	7
280	18	36.0	30
281	18	32.0	.....

It is possible that these argillaceous limestones and calcareous shales may be adapted for the manufacture of cement though the variable composition would require careful mixing in order to produce a uniform product.

Alton Postoffice. Extremely fossiliferous limestone is exposed in a bluff 70 to 80 feet in height along a small stream one and a half miles west of Alton, section 10, T. 40 N., R. 21 W. Black bituminous shale with thin and extremely fossiliferous beds of limestone is exposed in the creek bed. The soil is filled with masses of Stromatopora; a stone

fence 10 to 15 feet wide and several feet high is composed chiefly of masses of fossils. These fossiliferous beds apparently belong to the Cincinnatti group. The siliceous character of the upper beds and the shaly character of the lower ones make them of little or no commercial importance.

Summary. The extensive exposures of Trenton limestone in the western part of the county are chiefly of very argillaceous low magnesian character; the upper beds in some of the exposures are argillaceous dolomite. The limestone is unsuitable for most purposes, excepting crushed stone for road making, concrete, and railway ballast.

The very large exposures of the Manistique series of the Niagara formation are all heavily magnesian limestones and dolomites. Some of the beds burn easily and make very good mild lime. Other beds are burned with difficulty. As a whole the beds are more impure than those of the overlying Engadine dolomite, hence are less satisfactory for paper manufacture, or for use as a basic lining in open hearth furnaces. Their generally hard and resistent character make them suitable for road metal, concrete, and railroad ballast. In brief, the limestone resources of Delta county, though of great extent, are unimportant as compared with Schoolcraft and Mackinac counties.

Eaton County.

Distribution. The Bayport limestone occupies a narrow belt along the west side of Eaton county but it is exposed only at Bellevue. The area of limestone under light drift cover is probably not above 200 acres. It lies along the south side of Battle Creek just southwest of the village. The exposures are in the form of low bluffs, but limestone is said to occur beneath the low level bench along the creek. The limestone is relatively thin and in many places it has been completely removed by erosion.

Quarries.

Bellevue. At a very early date small quarries were opened for burning lime at Bellevue. Due to the exhaustion of wood fuel these were abandoned many years ago. At present the Burt Portland Cement Co. is operating a quarry and using the limestone and underlying shale in the manufacture of cement. The following is a more or less generalized section by Rominger* of the beds as formerly exposed in the old quarries now more or less filled with debris:

*C. Rominger, Vol. III, Pt. I, pp. 112-114.

Section in old quarries at Bellevue.

		Thickness, feet.
1.	Light colored thin-bedded limestone. (Present only on the highest rock elevations)	1
2.	Brown ferruginous dolomite either in continuous layers wedging out at both ends or in seams of irregular shaped septaria surrounded by calcareous shale. (Present only on the higher rock elevations)	1
3.	Light colored (high calcium) limestones with smooth, conchoidal fracture in beds of variable thickness	3–4
4.	Brown ferruginous dolomite ($MgCO_3$, 23 per cent) with a dull earthy fracture	2
5.	Light colored limestone ($CaCO_3$, 96 per cent) with a smooth conchoidal fracture in beds of variable thickness, interlaminated with concretionary seams of limestone (chert or flint); fossils not generally abundant, but certain seams are crowded with them over widely extended areas	8–10
6.	Greenish white calcareous sandstone (SiO_2, 69 per cent; $CaCO_3$, 30 per cent) grading upward into pure limestone but with occasional thin seams of quartz sand. Locally this strata is brecciated. (Disconformity between the Bayport and the Michigan series below	

The section exposed in the Burt Portland Cement Co. quarry is as follows:

Section in the Burt Portland Cement Co. quarry, Bellevue.

		Thickness, feet.
	Surface	2–3
1.	White, light gray, and yellowish gray high calcium ($CaCO_3$, 94.78 per cent) limestone with a smooth conchoidal fracture and containing pockets and seams of yellow ferruginous sand and red clay. In one part of the quarry this bed contains a thin lens of gray sandstone	12
2.	Blue and green argillaceous (Al_2O_3, 4.04 per cent) limestone of variable thickness and with a breccia of limestone and sandstone. This represents the disconformity between the Bayport limestone and the Michigan Series	1–4
3.	Soft greenish blue calcareous (CaO, 13.45 per cent) shale or clay	2+

The limestone and shale are blasted down together, and loaded by steam shovel into tram cars which are hauled by steam power to the crushers. The occurrence of the shale and limestone together is a great advantage in the manufacture of cement. A part of the necessary mixing of the shale and limestone is done in the quarry; about ten parts of the upper white limestone is taken to one of the blue shale and argillaceous limestone beneath.

Analysis No. 282, made from a representative set of samples from the high calcium bed in the Burt quarry, and also analyses Nos. 283 to 286 are indicative of its average composition. Analysis No. 287 by Rominger is of the brown, ferruginous, magnesian limestone locally present in the vicinity of Bellevue.

Most of the area of quarryable limestone in the vicinity of Bellevue is owned by the Burt Portland Cement Co., but A. J. Zipp of Bay Shore has a deposit about a mile southwest of Bellevue on the south side of the Grand Trunk railroad. Formerly a quarry was operated on this deposit for burning lime and plans are reported to be under way to reopen the quarry for crushed stone products and for ground limestone for agricultural purposes. The hardness and general purity of the limestone makes it very suitable for such purposes. Quarrying conditions and shipping facilities are favorable.

Summary. The limestone deposits of Eaton county though of insignificant size in comparison with those of other counties in the northern part of the state are of very considerable economic importance on account of their high calcium character and the absence of other deposits of commercial size and similar grade in central and western Michigan.

Emmet County.

Distribution. The Dundee limestone underlies the extreme northern part of the county but, so far as the writer is aware, it is not exposed. The Traverse formation occupies the remainder of the county with the exception of a narrow belt across the western part underlain by the Antrim black shale. The Traverse limestone is exposed in a double line of bluffs or lake terraces on the south side of Little Traverse Bay from Kegomic westward into Charlevoix county. The principal exposures are along the lower bluff close to the water's edge. This bluff apparently averages between 40 and 50 feet in height. The upper terrace is of similar height but in places, owing to the uneven surface of both the rock and the glacial deposits, it is considerably higher. Due to surface deposits there are but few exposures along the upper bluff.

Quarries and Localities.

Kegomic. Formerly a quarry was operated at Kegomic in the SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ section 27, T. 35 N., R. 5 W. The writer did not visit this quarry but the following is a section from a description and a set of samples furnished by Mr. W. E. Smith of Cadillac, Michigan:

	Thickness, feet.	Inches.
Dark gray crystalline and argillaceous limestone	2	
"Rotten" shale	2	6
Dark bituminous crystalline and very fossiliferous (brachiopods) limestone	0	10
Blue shale	2	
Buff and gray coarsely crystalline limestone	2 ±	
Gray and buff very fossiliferous coarsely crystalline (brachiopods) limestone	2+	

Petoskey. At Petoskey the lower terrace is between 40 and 50 feet in height and varies in width from a few hundred feet to a quarter of a mile or more. The upper terrace is nearly as high but, owing to the irregular surface of the glacial drift at the top, it is much more variable in height.

Northern Lime Co. quarries. In the eastern part of the city the Northern Lime Co. operate three closely connected quarries in the

lower terrace close to the lake shore for burning lime. Only a narrow strip is available for quarrying, due to the encroachment of buildings. The following is a section of Quarry C located farthest west:

Section in Quarry C.

		Thickness, feet.
	Sand	4–6
1.	Dark friable "sandy" magnesian limestone. Not used	6
2.	Very white earthy magnesian limestone. Burns black; not usable	2½
3.	White friable magnesian limestone. Usable but not of very good quality	3
4.	Gray earthy limestone with bands and mottlings of lithographic limestone. Beds apparently much alike but becoming less magnesian toward the bottom ($MgCO_3$, 16.30 per cent)	22
5.	Buff porous friable and extremely coralline limestone. Floor of quarry	1
6.	Dark earthy "magnesia" stone	1
7.	Gray to very light gray lithographic to dense grained high calcium limestone ($CaCO_3$, 96.36 per cent) with bituminous streaks. Smells strongly of bitumen when struck with the hammer. Thickness to lake level	8

In Quarry B, only about 250 paces east of C, the section is considerably different.

Section in Quarry B.

		Thickness, feet.
	Surface	3–6+
1.	Mass of white Stromatopora and coral in a matrix of buff friable sugary magnesian limestone. Burned for common lime. ($MgCO_3$, 36.41 per cent)	15–20
2.	Buff semi-crystalline limestone with dark crystalline streaks	5
3.	Dark, brittle and laminated limestone. Breaks up into a fine mass when blasted	2
4.	Bluish dense grained limestone. Very good quality	3
5.	"Sandy" limestone. Poor quality	3
6.	Densely crystalline to earthy limestone. Burned for chemical lime ($CaCO_3$, 94.78 per cent)	7–
7.	Laminated limestone with dark bituminous streaks	3
8.	Buff, soft, and very porous coralline limestone. Too soft for lime; left for floor of quarry	1+

Quarry A, a short distance farther east, was not in operation but the beds are more or less similar in character and composition to those of quarry B.

The beds in the upper part of all three quarries are more or less completely dolomitized, but in general the magnesia decreases downward though not regularly. The beds near lake level are very pure high calcium limestone. This is illustrated by the following partial analyses of the stone in Quarry C from the top downward:

Quarry C.

Analysis of beds from top down.

Number analysis.	Number of bed.	$CaCO_3$.	CaO.	$MgCO_3$.	MgO.
288	1	69.04	38.66	30.85	14.75
289	2	66.88	37.45	32.23	15.41
290	3	92.36	51.72	6.92	3.31
291	4	89.50	50.12	8.05	3.84
292	5	90.96	50.94	5.65	2.70
293	6	89.04	49.86	9.47	4.53
294	7	97.36	54.52	1.69	.81

A. H. Koch, Michigan College of Mines, Sept. 20, 1913.

The same general decrease downward is also shown by analyses Nos. 295 to 197. In Quarry B, however, the magnesia increases slightly nearly to the bottom of the quarry where it suddenly drops to less than 2 per cent.

Quarry B.

Analysis of beds at east end of quarry from top down.

Number analysis.	Number of bed.	$CaCO_3$.	CaO.	$MgCO_3$.	MgO.
298	1	89.00	49.84	8.93	4.27
299	2	88.04	49.30	10.56	5.05
300	3	87.64	49.08	10.50	5.02
301	4	84.82	47.50	13.24	6.33
302	5	94.57	52.96	3.99	1.91

Analysis No. 303 was made from a representative set of samples from the lower 22 feet (bed No. 4) of gray earthy limestone in Quarry C. This analysis and also Nos. 293 to 297 show the magnesian character of the stone in the lower part of the quarry and also the low content of siliceous and argillaceous impurities. Analysis No. 304 is from the high calcium lithographic beds exposed in a test pit in the bottom of Quarry C. These beds are very pure but are not used for lime on account of their tendency to "pop" or break to pieces in the kiln, thus clogging the draft. Analysis No. 305 made from samples from all of the beds in Quarry B except No. 5 gave 16.30 per cent of magnesian carbonate. Analysis No. 306 shows the high calcium character of bed No. 7, which is sorted out for burning chemical lime. The top coralline and stromatoporoid bed, according to analysis No. 307, is a high magnesian limestone. The analyses in general indicate that the composition of the beds is variable horizontally as well as vertically. Analysis No. 308 is apparently from the dark lithographic beds near lake level, No. 309 from the upper beds of the quarry, and No. 310 from the lower beds. Owing to the variable character and composition of the beds hand sorting is necessary. The company burns a large amount of both commercial and chemical lime, and also grind limestone for agricultural purposes. Owing to the soft friable character of the stone it is unsuitable for crushed stone purposes.

Antrim Lime Co. quarry. The quarry of the Antrim Lime Co. is the only one operating in the upper terrace in the vicinity of Petoskey. The floor of the quarry is said to be 85 feet above lake level, or about 40 feet above the highest beds exposed in the lower bluff. Since the section in the quarry has a maximum thickness of about 25 feet, the top

of the highest exposed ledge in the vicinity of Petoskey is apparently about 110 feet above lake level. The overburden, largely of sand, is becoming very thick, averaging from 8 to 10 feet or more and the area of easily quarryable stone is apparently small. It is owing chiefly to the high average purity of much of the stone and its easy burning qualities that profitable operation is possible.

The following section is exposed in the quarry:

Section in Antrim Lime Co. quary.

		Thickness feet.
	Sand and gravel	8+
1.	More or less broken ledges of light buff or white sugary limestone. Parting of shale at the base	3
2.	White earthy and very brittle limestone. Parting of black bituminous and laminated shale at the base	8
3.	White earthy limestone with darker laminations toward the base	7
4.	Buff porous earthy and coralline limestone	1–
5.	Buff sugary and laminated limestone	2
6.	Buff dense grained limestone. Bottom bed quarried	1
7.	Dark buff limestone with numerous fine dark bituminous bands. Floor of quarry	1+

The upper 12 feet of white earthy limestone contains (Anal. No. 311) over 97 per cent of calcium carbonate but the lower 12 feet of white and buff limestone contains (Anal. No. 212) over 11 per cent of magnesium carbonate, and is similar to the buff sugary limestones in the upper part of the lower bluff.

By a comparison of the sections in the different quarries it appears that in the vicinity of Petoskey there are an upper high calcium horizon as exposed in the Antrim Lime Co. quarry, a middle very thick (75 feet) magnesian horizon, and a lower darker colored high calcium one extending from just above lake level to an unknown depth below. These horizons appear to extend westward into Charlevoix County. The differences in the character of the stone in the different quarries in the lower bluff westward from Petoskey apparently is due largely to undulations along the strike of the beds. At one point the lower darker high calcium beds are elevated above lake level, forming the lower bluff, but at another they are depressed, bringing the upper yellow or buff magnesian horizon down to or even below lake level.

Petoskey Crushed Stone Co. quarry. There are numerous quarries along the lake shore westward from Petoskey but all are idle or abandoned except that of the Petoskey Crushed Stone Co., located about four miles west of Petoskey (S. E. $\frac{1}{4}$ Sec. 2, T. 35 N., R. 6 W.) This company has opened a large quarry (Pl. III B) in the lower terrace which at this point is a quarter of a mile in width. Most of the limestone is hard, crystalline, and high calcium in contrast to that in the Petoskey quarries. As a consequence it is largely disposed of for Portland cement, flux, road metal, concrete, ballast, etc., for which it is said to be very suitable. The uniformity in the character of the beds

permits the use of steam shovels and locomotives in handling the quarry product. There are two quarries separated by the Pere Marquette railroad, but only one is operated. In the larger northern quarry about 10 acres of stone had been quarried at the time of the writer's visit, to depths varying from 8 to 25 feet. A second bench had been started on the east side of the quarry at practically lake level. The maximum height of the two benches was about 40 feet.

The area of stone under light overburden in the vicinity of the quarry, though of uncertain extent, is considerable. On the west, however, the stone is cut out by a drift filled ravine.

The following is a more or less generalized section of the stone exposed near the east end of the quarry:

Section at east end of Petoskey Crushed Stone Co. quarry.

		Thickness, feet.
	Surface	0–3
1.	Coralline and Stromatoporoid limestone with a buff crystalline matrix	6
2.	Hard tough gray crystalline high calcium limestone	2–
3.	Dark lithographic high calcium limestone adapted for sugar manufacture	3–
4.	Hard tough gray crystalline high calcium limestone. Said to average above 90 per cent calcium carbonate. Lower ledges concealed by a heavy blast of stone	25+

Analysis No. 313, from the upper 12 feet gave 93 per cent calcium carbonate and nearly 5 per cent of magnesium carbonate. The lower beds were concealed and representative samples could not be obtained.

W. E. Smith quarry. Immediately on the west of the property of the Petoskey Crushed Stone Co. in sections 9 and 10, T. 34 N., R. 6 W., W. E. Smith, et. al., own about 210 acres of limestone land of which about 150 acres is under light overburden. The property lies chiefly on the lower terrace which has a maximum width of about a third of a mile. At the edge of the terrace near the lake the rock surface is from about 15 to 35 feet above lake level, but it gradually rises away from the lake until at the base of the upper terrace it is from 65 to 75 feet above the lake.

Near the west end of the property the Petoskey Stone & Lime Co formerly operated a small quarry and lime kiln. The section exposed is as follows:

Section in W. E. Smith, et. al., quarry.

		Thickness, feet.	Inches.
	Surface. The quarry is located along a narrow high ridge of sand and gravel.	0–10	
1.	Broken ledge of light buff gray magnesian ($MgCO_3$, 14.38 per cent) limestone	3–4	
2.	Buff to dark buff gray crystalline limestone. Fossiliferous shale seam at the base	4	
3.	Buff to dark buff gray crystalline limestone. Black shaly parting in the middle	2	
4.	Black and extremely fossiliferous shale filled with brachiopods.	0	6
5.	Dark gray finely crystalline limestone	2	
6.	Dark bituminous and fossiliferous shale	0	6
7.	Dark lithographic to finely crystalline limestone	3 ±	
8.	Dark gray densely crystalline limestone with many large heads of Stromatopora and corals. Owing to the fossil masses the contact between No. 7 and No. 8 is very wavy	3 ±	
9.	Dark lithographic and very brittle high calcium limestone	1	
10.	Crystalline to dense grained fossiliferous (coral, brachiopods) limestone. Bottom bed quarried	1 –	
11.	Dark lithographic brittle high calcium limestone. The base of the bed is concealed. Average analyses of beds Nos. 2, 3, 5, 7-11 inclusive gave 93.96 per cent $CaCO_3$	2 +	
12.	Gray earthy to crystalline thin bedded magnesian ($MgCO_3$, 14.84 per cent) limestone	1	
13.	Fine grained earthy magnesian ($MgCO_3$, 14.84 per cent) limestone. Exposed at the foot of the trestle	3	
14.	Next lower beds concealed by talus but at a little distance lakeward from the quarry dark lithographic and dark gray crystalline limestones are exposed in low ledges just above lake level	?	

Beds Nos. 1, 12, and 13 contain (Anal. Nos. 314 and 316) between 14 and 15 per cent of magnesium carbonate, but beds Nos. 2, 3, 5, 7-11 inclusive contain (Anal. No. 315) nearly 94 per cent of ~~magnesium~~ calcium carbonate.

Similar beds are exposed along a dry run a short distance to the southeast and also in a test pit 6 feet deep on the east end of the property as shown by the following section:

Section in Test Pit near S. ¼ post of sec. 3, T. 35 N., R. 6 W.

		Thickness, feet.
	Surface	2
1.	Dark lithographic high calcium limestone with corals and brachiopods in lower part. This shale seam at base of the bed	2
2.	Hard light gray dense grained limestone	2
3.	Dark crystalline and fossiliferous (corals and brachiopods) limestone. Bottom of pit filled with rubble	1+

An analysis (No. 317) of a composite of samples taken about one foot apart in the test pit gave nearly 95 per cent of calcium carbonate and only about 2 per cent of magnesium carbonate.

It is to be noted that none of the white and buff sugary limestones quarried at Petoskey appear to be present on this property or in the quarry of the Petoskey Crushed Stone Co., and that the dark lithographic and gray crystalline beds are similar to those exposed near

lake level in the test pit in the bottom of Quarry C of the Northern Lime Co. at Petoskey. Westward from Petoskey, due to an undulation, this series is brought above lake level and forms all of the lower terrace for a considerable distance in sections 1, 2, and 10, T. 34 N., R. 6 W.

The W. E. Smith property apparently contains the largest area of easily quarryable limestone in the vicinity of Petoskey. From lake level to bed No. 1 in the old quarry the stone is chiefly high calcium. Higher beds are exposed in a gulley southeast of the quarry and they are similar in general appearance and probably in composition to the lower beds. The highest beds, probably 25 to 30 feet in thickness, occur in front of the upper terrace but are not exposed and little is known of their physical or chemical characteristics.

Bell quarry. About one-half mile west of the W. E. Smith property (N. ½ N. ½ sec. 9, T. 34 N., R. 6 W.) there is an old quarry and kiln, known locally as the Bell quarry and formerly operated by the Elk Cement & Lime Co. It fronts directly on Little Traverse Bay and is composed of an upper and a lower portion. The working face in the upper is about 25 feet and the lower about 20 feet. The section is as follows:

Section in Bell quarry.

		Thickness, feet.
	Surface	1–3+
1.	Dense grained gray limestone	5
2.	Weathered blue and very fossiliferous shale containing an abundance of brachiopods and crystals of gypsum. Talus concealed the lower portion of the shale but its thickness is said to be about	6
3.	Dark gray to buff gray crystalline to dense grained fossiliferous limestone with cup corals and heads of Stromatopora and Acervularia and other corals. Bottom of bed concealed by talus. Floor of upper quarry	13 ±
4.	Dark gray dense grained to finely crystalline and fossiliferous limestone, containing cup corals, heads of Acervularia, and brachiopods	2
5.	Dark buff gray lithographic limestone containing disseminated calcite crystals and with heads of Acervularia and Stromatopora at the bottom	2
6.	Dense grained buff dark gray limestone with mottlings and with a black bituminous fossiliferous phase at the top and a shale parting at the bottom	4½
7.	Dark bituminous and lithographic limestone with a few corals. Black bituminous shale parting at the bottom	3
8.	Dark bituminous lithographic limestone with a black bituminous shale parting at the bottom	1
9.	Light gray lithographic limestone with a very thin shale parting at the bottom	1
10.	Gray to buff dense grained to crystalline and fossiliferous (brachiopods) limestone with a lithographic texture and a thin shale parting at the base	2
11.	Gray to buff limestone, lithographic near the top and crystalline and fossiliferous near the bottom. Bottom of the exposed portion of this bed is practically at lake level	3+

No analyses of the stone in this quarry are available but according to persons acquainted with the quarry most of the stone is high calcium, especially the lithographic stone of the lower bench. The dark gray crystalline or lithographic character of the beds indicates that they are to be correlated with similar beds occurring near water level at Petoskey. Toward the west, however, the strata descend so that at Bay Shore, Charlevoix county, about two miles distant, the upper buff to yellow, friable limestone of the Petoskey section extends below

the level of the bay. The last exposure of the dark lithographic beds according to Rominger's description is apparently about one mile east of Bay Shore and consists of two ledges extending from water level to 6 or 8 feet above. The stone as analyzed (Anal. No. 174) by him contains 98 per cent of calcium carbonate.

Summary. The limestone resources of Emmet county are of relatively small extent, being confined chiefly to narrow terraces along the shore of Little Traverse Bay. The total thickness of the section exposed along the lake shore is apparently about 135 feet.

The upper white earthy limestones 15 to 20 feet in thickness are high calcium, the middle buff to gray sugary limestones about 75 feet in thickness range in composition from low to high magnesian, and the lower dark crystalline to lithographic limestones 40 feet or more in thickness are largely high calcium. In the vicinity of Petoskey, the middle magnesian portion forms all of the lower and the base of the upper terrace. Westward the dark crystalline and lithographic beds exposed near the level of the bay at Petoskey, gradually rise and, four or five miles west of the city, form most of the lower terrace. Farther west they descend until at Bay Shore they are below lake level. The three different horizons and the undulations of the beds along the lake shore are very vital factors in determining the commercial possibilities of deposits in Emmet county.

Huron County.

Distribution. The Bayport limestone forms several relatively small areas in the western part of Huron county and is exposed or near the surface in two oval shaped areas (fig. 13) southeast of Bayport and on some of the islands in Saginaw Bay. One of the ovals extends southeast from Bayport for about three miles into the eastern part of section 5, T. 16 N., R. 10 E. The other extends from the southeastern part of section 8 southeast into the northwestern part of sec. 15, T. 16 N., R. 10 E., a distance of about two miles. The ovals, especially the larger, are marked on the northeast side by a prominent ridge and low bluffs.

Quarries and Localities.

Bayport quarry. This quarry (Pl. IV A) though commonly referred to as the Bayport quarry, is located about three miles southeast of Bayport in section 5, T. 16 N., R. 10 E., and near the southeast end of the larger oval. It is a large quarry operated by the Wallace Stone Co. chiefly for crushed stone, the general hardness and toughness of the stone adapting it for road metal, concrete and ballast. The quarry,

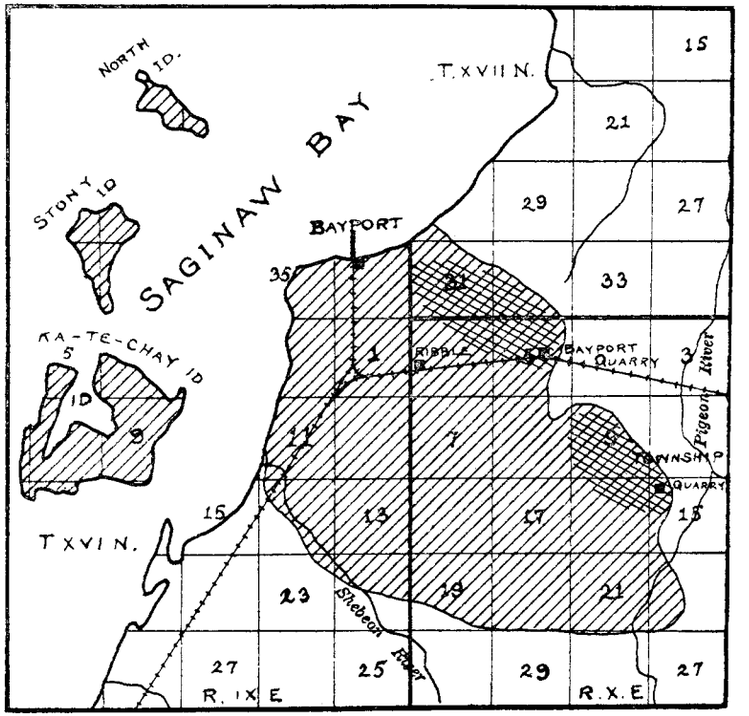


Figure 13. Map showing distribution of the Bayport limestone in the vicinity of Bayport, Huron county. Double hachured areas indicate thinly drift covered areas.

which has been in operation for over thirty years, consists of two openings, 8 to 12 feet in depth and with a combined area of over 80 acres. This, however, is only a small fraction of the area of easily quarryable stone remaining. The section below was exposed in the quarry:

Section in Bayport quarry.

		Thickness, feet.
	Surface	½–2
1.	Thin bedded fossiliferous limestone. Locally weathered to a soft yellowish mass at the top. Hard and sandy near the bottom. Mass of corals in lower part of bed	3
2.	Hard gray dense grained magnesian limestone with a thin sandy layer near the bottom. Upper and lower part suitable for lime but hand sorting is necessary. Chert nodules numerous in upper portion of the bed	3½
3.	Hard gray dense grained to crystalline sandy and magnesian limestone. Samples apparently from No. 2 and No. 3 together gave 14.5 per cent $MgCO_3$ and 20.85 per cent SiO_2	3
4.	Black bituminous and shaly limestone locally called "Black shale"	0½
5.	Dark gray lithographic limestone with a smooth conchoidal fracture. Formerly used for building stone	1 –

Formerly there was an upper high calcium layer which was burned for lime but this bed, according to Mr. R. N. Wallace, manager of the Wallace Stone Co., has disappeared with the progress of quarrying.

Most of the lower beds are sandy or cherty and magnesian and this unfits them for lime burning or for fluxing and chemical purposes. Except where locally weathered at the surface the stone is hard and, being situated in the broad flat belt of lake clays of eastern Michigan, almost wholly lacking in suitable road or concrete materials, it is used extensively for road building and concrete. The section below the floor of the quarry is composed largely of very sandy limestones and calcareous sandstones.

An analysis, (No. 318) from the upper high calcium bed formerly present, gave over 91.5 per cent of calcium carbonate and shows that it was similar in composition to the Bayport limestone in Arenac (see analyses Nos. 141-144) county on the western side of Saginaw Bay. Analysis No. 319 is indicative of the sandy and magnesian character of the lower beds.

The following tests were made by the Office of Public Roads, U. S. Department of Agriculture, Washington, D. C.:

Number of test.	Rock.	Weight lbs. per cu. ft.	Absorption lbs. per cu. ft.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.	Cementing value.
1287.....	Limestone	165	1.34	2.7	14.8	15.1	12	49
1288.....	Dolomitic limestone	165	1.35	.....	.....	15.3	12	50
4063.....	Limestone	165	1.60	3.3	12.0	15.4	11	48

A test* made at the Water Town Arsenal by Capt. Butler gave a crushing strength of 26 110 lbs. This is very high for limestone. The specimen tested was 2.61 inches thick with a compression surface of 29.65 square inches.

A quarry has been opened near the southeast end of the smaller oval in the N. W. $\frac{1}{4}$ sec. 15, T. 16 N., R. 10 E., Windsor Township, for road material. At the time of the writer's visit the quarry was about 150 feet in length and 8 to 10 feet in depth. The area of stone under light cover is apparently two to three hundred acres. The beds exposed were very similar to those of the Wallace or Bayport quarry as may be seen from the following section:

		Thickness, feet.
	Surface	
1.	Hard grayish buff fine grained limestone with numerous cup corals at top and bottom	1–2 +
2.	Hard grayish buff dense grained to finely crystalline limestone with some chert nodules. Suitable for lime. According to Mr. R. N. Wallace, Manager of the Wallace Stone Co., this bed contains about 65 per cent of $CaCO_3$	4
3.	Black bituminous shaly limestone "Black shell"	3
4.	Hard light gray dense grained to finely crystalline limestone with many small crystals of pyrite	0.6 in.
		2

*A. C. Lane, Geology of Huron County, Vol. VII, Pt. II, 1900, p. 215.

Charity Islands. The Bayport limestone is exposed on Charity Islands, North, and Stony (or Heistermann) islands and according to Winchell's*, Rominger's†, and Lane's‡ descriptions the exposures are in the form of low ledges near the water level and the beds, characteristic of the Bayport, are sandy or cherty or are replaced by sandstone. On North Island a small quarry was formerly operated many years ago. The beds are cherty and very fossiliferous.

Summary. The limestone resources of Huron county are confined largely to a ridge extending southeast from Bayport for five or six miles. Quarrying conditions are most favorable in the oval areas, one at the northeast end of the ridge and the other at the southeast end. The thickness of the commercial stone is small, being generally from 8 to 16 feet. Most of the stone is hard, siliceous, and magnesian and is chiefly adapted for road making, concrete, and railroad ballast. Owing to their location in a region largely devoid of other suitable material for such purposes, the deposits are of large local importance.

Jackson County.

Distribution. The Bayport limestone is present largely as a capping on the tops of pre-Coal Measure hills. The deposits are generally very thin and small. The coal deposits more or less completely fill up the valleys between the hills and lap upon the edges of the Bayport limestone. During the Pleistocene, portions of the hills were dislodged, carried away by the ice, and buried in the glacial debris. According to Rominger§ there are many of these large masses of Bayport limestone, with attached portions of the underlying shaly Michigan series, more or less completely buried in the drift in Jackson county. These masses simulate exposures of the rock in place but generally the uptilted position of the beds betray their character.

As in Arenac, Eaton, and Huron counties, the Bayport limestone is generally cherty, sandy, or magnesian and the proportion of high calcium stone in the formation is small.

Quarries and Localities.

Formerly many small quarries were operated in Jackson county for burning lime but these, due to the exhaustion of suitable wood or to the siliceous character of the beds, have been abandoned for many years. Some of the quarries are being reopened for road material.

*A. Winchell, First Biennial Report, 1860, p. 102.
†C. Rominger, Vol. III, 1873-1876, p. 119.
‡A. C. Lane, Vol. VII, Pt. II, 1900, p. 105.
§C. Rominger, Vol. III, Pt. I, 1873-1876, p. 114.

Parma. About a mile northeast of Parma in sections 29 and 30, T. 2 S., R. 3 W., the Bayport limestone* underlies an area of probably about 300 acres. Several quarries were once operated in this deposit. The upper bed† is a brown ferruginous dolomite and the lower a dark, bluish, high calcium limestone full of sparry and siliceous veins. The upper bed contains (Anal. No. 320) about 18 per cent of iron and alumina and 11 per cent of magnesium carbonate, the lower bed from nearly 3 to 14 per cent of silica (Anal. Nos. 321-2).

South of Parma in Spring Arbor township (T. 3 S., R. 2 W.) there are many small exposures of Bayport limestone. A quarry was operated in section 17 in the early 30's for burning lime. The upper bed in the old quarry, as at Parma and Bellevue, is a brown ferruginous magnesian limestone. The lower bed 8 to 10 feet in thickness is high calcium limestone. Analysis No. 323 is from a small exposure of high calcium limestone along the road in section 11 or 12 of this township. Analysis No. 324 is from a small exposure of dolomite, probably the upper bed, on the road between sections 24 and 25. Analysis No. 325 is of another small exposure of high calcium limestone, the location of which is given by Rominger as "three miles south of Jackson on Mr. Shoemaker's farm." At this place the high calcium bed is overlain by 4 or 5 feet of brown ferruginous dolomite. All of the above exposures are directly underlain by green sandy shales and sandstones of the Michigan series. Analysis No. 326 is from a mass of drift limestone in a railroad cut about 3 miles south of Jackson on the Cincinnati and Northern Railroad.

Portage River. A prominent east and west ridge of Bayport limestone occurs about four miles north of Jackson on the north side of Portage River in sections 1 and 2, T. 2 S., R. 1 W., and section 6, T. 1 S., R. 1 E. The limestone forms a more or less continuous capping along the top of the ridge for more than a mile. Several small quarries were formerly operated in this ridge. On the east side of section 2, T. 2 S., R. 1 W., an old quarry has been reopened for road material. The upper four or five feet in the quarry is a light gray dense grained high calcium limestone. This is underlain by a conglomerate of limestone and sandstone pebbles and boulders in a matrix of green sandy shale. This undoubtedly represents the disconformable contact between the Bayport limestone and the Michigan series. From 8 to 10 feet of light gray, dense grained, high calcium limestone similar to that at Bellevue, Eaton County, is exposed in an old quarry in the SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ section 1, T. 2 S., R. 1 W., five to six feet in another quarry in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ of the same section, and about seven feet in a third

*C. Rominger, Vol. III, Pt. I, 1873-1876, pp. 114, 115.
†C. Rominger, Vol. III, Pt. I, 1873-1876, pp. 114, 115.

quarry in the NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ section 6, T. 2 S., R. 1 E. This limestone contains (Anal. Nos. 327-332) from about 92 to 97 per cent of calcium carbonate, 1.25 to 2.80 of silica and but very little magnesium carbonate.

Summary. Jackson county contains numerous small areas of Bayport limestone which generally caps hills and ridges. The high calcium beds are thin, more or less sandy and cherty, and are associated with ferruginous dolomite or sandy green shale. The resources are of little economic value except as a source of road material, concrete, etc., for local use.

Kent County.

Distribution. The Bayport limestone and the Michigan series underlie a large portion of Kent county but the formations are deeply buried under glacial drift except along the valley of Grand River from Grand Rapids to Grandville. Formerly the Bayport limestone was exposed along the river banks in Grand Rapids but now most of the exposures are concealed by dams and buildings.

Luce County.

Distribution. The Trenton limestone, the Beekmantown (Calciferous), and the Niagara formations occupy parallel belts across the southern part of Luce county. Exposures of the first two are few and unimportant. The Niagara is exposed along a high bluff extending through the extreme southern part of the county in section 31, T. 45 N., R. 8 W., and section 36, T. 45 N., R. 9 W.

D. N. McLeod Lumber Co. quarry. At the time of the writer's visit (1913) a railroad spur along the base of the bluff was under construction preliminary to the opening of a quarry. The bluff, apparently 80 to 100 feet in height, is about a half mile north of Hendricks quarry and is composed of similar beds. (See Hendricks quarry, Mackinac county). The upper portion of the bluff is formed by the Fiborn limestone, which on the weathered surfaces shows the presence of numerous fossils. The lower part of the bluff is largely concealed by talus but the beds belong to the Hendricks series.

A number of core drillings were made by the Union Carbide Co. of Sault Ste. Marie in section 36, T. 45 N., R. 9 W., and also in the sections adjoining on the south. The analyses of the core from the deepest hole in section 36 is given below:

Test Hole North of Hendrick's Quarry.

Analysis of Drill Core SE. ¼ sec. 36, T. 45 N., R. 9 W., Luce County. Analysis furnished by Joseph Scales, Supt. Union Carbide Co., Sault Ste. Marie, Mich.

Analysis No.	Sample No.	Core. Thickness, feet.	Core. Depth, feet.	Silica. SiO_2. %	Iron-Alumina. Fe_2O_3-Al_2O_3. %	Calcium carbonate. $CaCO_3$. %	Calcium oxide. CaO. %	Magnesium carbonate. $MgCO_3$. %	Magnesium oxide. MgO. %	Carbon de-oxide and water. CO_2-H_2O. %	Remarks.
334	1	1'- 8"	5'- 8"	1.51	0.25	*93.07*	52.08	*1.40*	0.68	45.48	
335	2	6'- 0"	11'- 8"	1.96	0.23	*94.71*	53.08	*1.55*	0.74	43.99	Fiborn Limestone.
336	3	2'-10"	14'- 6"	0.78	0.19	*96.84*	54.27	*1.23*	0.59	44.17	Bed No. 3 of section in Hendricks quarry.
337	4	4'- 3"	18'- 9"	0.52	0.35	*95.94*	53.77	*1.34*	0.64	44.72	
338	5	2'- 0"	20'- 9"	1.14	0.32	*96.72*	54.21	*1.44*	0.69	43.64	Upper part of bed No. 4?
339	6	6'- 9"	27'- 6"	2.59	0.23	*91.18*	51.10	*4.16*	1.99	44.09	
340	7	6'- 3"	33'- 9"	1.78	0.41	*89.06*	49.91	*8.72*	4.17	43.73	Lower part of bed No. 4?
341	8	4'- 3"	38'- 0"	3.79	0.76	*69.20*	38.78	*24.44*	11.69	45.08	Compare beds Nos. 4 to 9 in test pit in bottom of quarry.
342	9	3'-10"	41'-10"	1.28	0.45	*79.03*	44.29	*22.40*	10.16	43.82	
343	10	3'- 2"	45'- 0"	1.11	0.17	*89.52*	50.17	*8.86*	4.24	44.31	
344	11	3'- 6"	48'- 6"	0.90	0.34	*91.60*	51.34	*7.65*	3.66	43.76	
345	12	6'- 0"	54'- 6"	5.57	0.25	*86.43*	48.44	*2.03*	0.97	44.77	
346	13	8'- 0"	62'- 6"	1.82	0.21	*92.62*	51.91	*2.72*	1.30	44.76	Lower high calcium horizon.
347	14	7'- 3"	69'- 6"	0.49	0.14	*97.26*	54.51	*1.07*	0.51	44.45	
348	15	5'-11"	75'- 8"	0.93	0.19	*91.02*	51.01	*7.34*	3.51	44.36	
349	16	5'- 4"	81'- 0"	1.47	0.23	*80.42*	45.07	*18.84*	9.01	44.22	
350	17	12'- 8"	93'- 8"	6.76	1.55	*62.40*	34.97	*26.95*	12.89	43.83	
351	18	9'-10"	103'- 6"	2.68	0.37	*80.42*	45.07	*14.36*	6.87	45.01	

Note.—Numbers in italics are calculated from original analyses.

Summary Analysis Covering Limestone Deposit in Township 45, Sec. 36, N. Range 9 West.*

Laboratory Union Carbide Co., Sault Ste. Marie, Mich.

Number of analysis.	Sample number.	SiO_2. %	$Fe_2O_3+Al_2O_3$. %	$CaCO_3$. %	CaO. %	$MgCO_3$. %	MgO. %
352	1	2.70	.44	92.96	*52.00*	1.21	*.58*
353	2	3.49	.41	94.74	*53.09*	1.32	*.63*
354	3	1.39	.34	96.87	*54.29*	1.14	*.54*
355	4	.93	.62	95.88	*53.72*	1.14	*.54*
356	5	2.03	.57	96.76	*54.23*	1.22	*.58*
357	6	4.62	.41	91.21	*51.12*	3.54	*1.69*
358	7	1.61	.61	91.64	*51.35*	6.53	*3.12*
359	8	3.25	.37	92.66	*51.93*	2.32	*1.11*
360	9	.87	.24	97.03	*54.38*	.91	*.43*
361	10	1.66	.34	91.05	*51.03*	6.27	*3.00*
362	11	3.37	.62	90.96	*50.98*	3.99	*1.91*
363	12	2.03	.55	95.35	*53.44*	1.14	*.54*
364	13	2.18	.55	93.67	*52.49*	2.59	*1.24*
365	14	3.07	.46	92.36	*51.76*	3.19	*1.52*
366	15	.84	.41	97.92	*54.87*	.96	*.46*
367	16	.85	.48	97.92	*54.87*	.98	*.47*
368	17	1.75	.78	95.77	*53.67*	1.46	*.70*
369	18	2.35	.91	92.45	*51.81*	2.91	*1.39*
370	19	2.46	.52	94.80	*53.13*	1.80	*.86*
371	20	3.09	.55	94.46	*52.94*	1.51	*.72*
372	21	2.28	.48	95.91	*53.75*	1.37	*.65*
373	22	1.82	.55	96.55	*54.11*	1.41	*.67*
374	23	2.39	.50	95.51	*53.53*	1.85	*.88*
375	24	2.74	.54	92.72	*51.96*	3.62	*1.73*
376	25	2.51	.20	95.02	*53.25*	1.32	*.63*
377	26	2.23	.66	95.44	*53.49*	1.41	*.67*
378	27	2.46	.34	93.03	*52.14*	3.80	*1.82*
379	28	3.24	.32	93.91	*52.63*	2.70	*1.29*
380	29	2.76	.18	95.60	*53.58*	1.26	*.60*
381	30	2.73	.09	95.98	*53.79*	1.30	*.62*
382	31	1.98	.43	96.50	*54.08*	1.04	*.50*
383	32	1.80	.27	96.80	*54.25*	1.24	*.59*
384	33	3.30	.30	93.73	*52.53*	2.82	*1.35*
385	34	3.53	.45	92.93	*52.08*	3.05	*1.46*
386	35	1.55	.32	96.63	*54.15*	1.20	*.57*
387	36	9.67	.50	88.11	*49.38*	1.04	*.50*
388	37	7.57	.20	89.42	*50.11*	2.55	*1.22*
389	38	1.82	.71	95.93	*53.76*	1.23	*.59*
390	39	1.43	.42	97.26	*54.51*	.99	*.47*
391	40	2.25	.30	95.80	*53.69*	1.37	*.65*
392	41	2.02	.36	95.10	*53.30*	2.48	*1.18*
393	42	2.30	.48	96.56	*54.11*	2.48	*1.18*
394	43	4.05	.25	93.77	*52.55*	1.06	*.51*

*Analyses furnished by D. N. McLeod Lumber Co., Garnet.
Figures in italics are calculated from original analyses.

Analyses Nos. 352 to 394 are the summary of results from the shallow holes in section 36 which penetrated only to the bottom of the Fiborn limestone. According to these analyses the content of calcium carbonate generally is between 91 and 97 per cent, the magnesian carbonate between 1 and 4 per cent, and the silica between 1 and 3 per cent.

The analyses of the core from the deep test hole show that the Fiborn limestone extends to the depth of about 27 feet. It is underlain by about 14 feet of magnesian limestone which is followed by 35 feet or more of high calcium limestone. Beds belonging to this horizon are

not exposed anywhere as far as known. A nearly complete section of the magnesian horizon above, however, is exposed in a test pit in bottom of Hendrick's quarry a half mile to the south. (See section in Hendrick's quarry, Mackinac county.)

The height of the bluff on the north is from 80 to 100 feet, hence conditions are favorable for quarrying down to the bottom of the lower high calcium horizon

Summary. The high calcium limestone resources of Luce county are confined to a very narrow strip along the southern edge of the county, chiefly in section 31, T. 45 N., R. 8 W., and section 36, T. 45 N., R. 9 W.

Mackinac County.

Distribution. The Hendricks series and Fiborn limestone of the lower Niagara underlie the northwestern part of the county, the Manistique series and the Engadine dolomite of the upper Niagara the remainder of the county (fig. 14) with the exception of St. Ignace peninsula

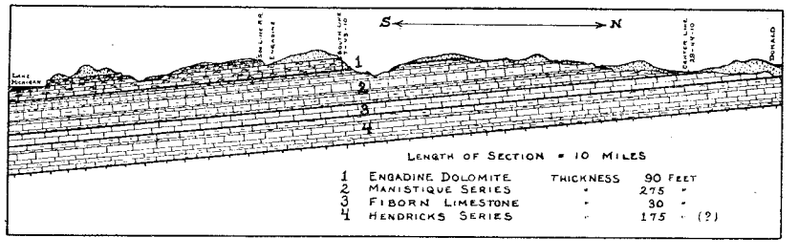


Figure 14. Section from Donald, Mackinac county, south to Lake Michigan.

and adjacent islands, which are underlain by the Monroe-Salina series.

Exposures of all of the members of the Niagara limestone, with the exception of the Hendricks series, are very large and numerous. The Engadine dolomite forms a prominent though broken northward facing escarpment extending from east to west across the county. The Fiborn limestone also terminates on the north in an escarpment, though much less prominent and continuous. It is exposed or is under light drift cover in several large areas throughout a belt extending from the west side of Lake Ella northeast to Hendricks quarry and then southeast through Fiborn quarry into Chippewa county, where it disappears beneath thick deposits of lake clay. The most important areas of exposures are on the west side of Lake Ella, near Gould City, and in the vicinity of Hendricks and Fiborn quarries. A large exposure is reported to occur between these quarries. The Fiborn limestone is near the surface about one mile south of Donald but the extent of the

area is uncertain. The Engadine dolomite is widely exposed from its escarpment south to the shores of lakes Michigan and Huron. Very large exposures of the Monroe-Salina formation occur in the vicinity of St. Ignace and on the adjacent islands.

Character. The Hendricks series is composed of a variety of limestones ranging in composition from high calcium to high magnesian. They are not well exposed in the county and knowledge concerning their general character has been gained largely from a shallow test pit in Hendricks quarry and from drill cores in its vicinity. The thickness of the series is unknown but it is certainly over 100 feet. The Fiborn limestone, 18 to 30 feet in thickness, is uniformly a buff to dark gray lithographic to densely crystalline high calcium limestone breaking with a perfect conchoidal fracture and generally containing an abundance of small calcite crystals. The Manistique series, probably over 275 feet in thickness, is composed of a variety of limestones varying greatly in texture, structure, and composition. The series, however, is largely high magnesian limestone or dolomite. The Engadine dolomite is everywhere an extremely massive very crystalline bluish or white dolomite with mottlings and streaks of distinct blue and containing many druse cavities. It is generally very pure, the impurities usually being less than 2 per cent. The Monroe-Salina is composed chiefly of argillaceous and siliceous dolomites with intercallated beds of gypsum.

Quarries and Localities.

Fiborn quarry. The Fiborn Limestone Co. have a large quarry in section 16. This quarry (Pl. IV B) was formerly known as the Osborn quarry and was the first to be opened in the Fiborn limestone. In this vicinity limestone is exposed in sections 15, 16, 21, and 22, T. 44 N., R. 7 W. In 1901 A. C. Lane described* some caves in section 16 and incidentally made reference to the purity of this bed. In a later report† he published the following section:

Section in Fiborn Quarry.

	Thickness, feet.
"Limestone with Orthoceras, a loose Favositid, a small gastropod, but most abundant fragments of heads of Stromatoporoids	3
Greenish sandy looking limestone with greenish tubes running into each other (anastomosing), with corals and Stromatoporoids which show well on the green surface	1
Very massive	6
Mottled brown and light with Stromatopora heads	4
Finely banded mud rock (calcilutite) with quite persistent bands of holes, empty gastropod cavities half way down. These have calcite crystals lining them. Aleperdita and stylolitic suture occur and this lower part has a more porcelanic and less sugary appearance than the upper part containing the coral and Stromatoporoid heads. A notable thing is the absence of Pentamerus"	9

*Ann. Report, Mich. Geol. Surv., 1901, p. 146.
†Ann. Rept., Mich. Geol. Surv., 1907, p. 20.

The *Fiborn limestone* has been traced from a point two or three miles west of Trout Lake nearly to Manistique River, a distance of about 50 miles. Fragments identical with the Fiborn limestone are abundant in the drift on Lime Island (St. Marys River), indicating its eastward extension from Trout Lake.

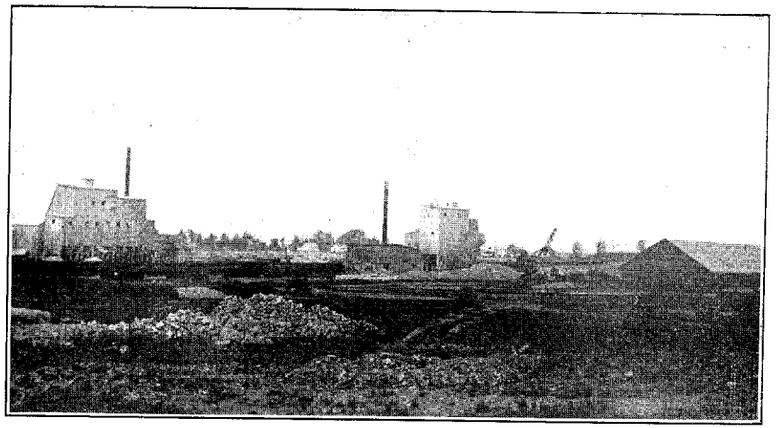
The thickness of the bed in the quarry is variable but the maximum is about 30 feet. The average height of the quarry face is probably about 25 feet. A large acreage of stone has been quarried out but this is only a small fraction of the area of easily quarryable stone. The stone is stripped and handled by steam shovel. The stripping is generally thin but locally it is several feet in thickness.

The beds in the quarry are, on the whole, gray to buff gray, lithographic to dense grained, high calcium limestone, very brittle and breaking with a smooth conchoidal fracture and generally containing small disseminated calcite crystals. Locally the stone is finely banded and free from calcite crystals. All of the stone is high calcium but near the bottom of the bed the percentage of magnesia is slightly higher. The floor of the quarry is white or light colored crystalline limestone containing more or less magnesia.

An analysis (No. 395) of a representative set of samples of the Fiborn limestone gave 55.19 per cent of calcium oxide and 1.12 per cent of magnesia. An analysis (No. 396) of a sample from the magnesian basal portion of the bed gave 51.46 per cent of calcium oxide and 4.30 per cent of magnesia. Analyses Nos. 397 to 399 are of the marketable product. These analyses indicate the high average purity of the limestone which is extensively used for flux, chemical lime, the manufacture of calcium carbide, sugar, etc., and for road material, concrete, and railway ballast.

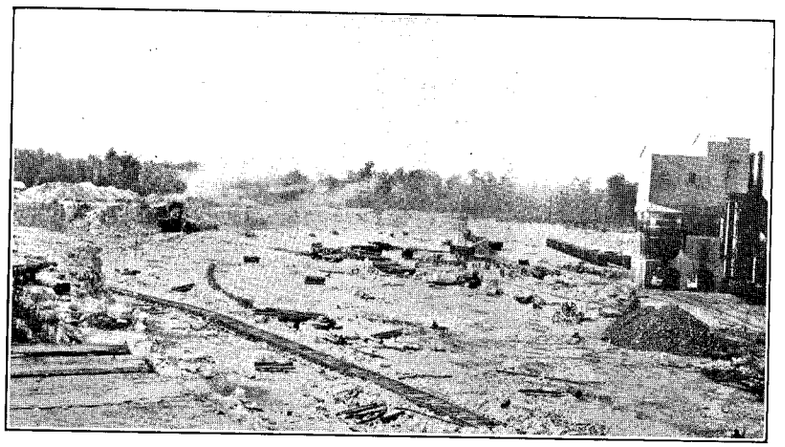
Hendricks quarry. A large area of Fiborn limestone occurs in sections 1 and 2, T. 44 N., R. 9 W., and portions of adjoining sections. The portion of the area extending into the sections on the north is terminated by a bluff 80 to 100 feet in height (see McLeod Lumber Co. quarry, Luce county.) The Union Carbide Co. have opened a large quarry (Pl. V A) at Hendricks near the eastern end of the area in the edge of section 6, T. 44 N., R. 8 W.

The quarry at the time of the writer's visit was an elongated opening over an eighth of a mile in length and from 8 to 25 feet in depth. The section exposed in the quarry and in a test pit (Pl. V B) in the floor of the quarry is as follows:



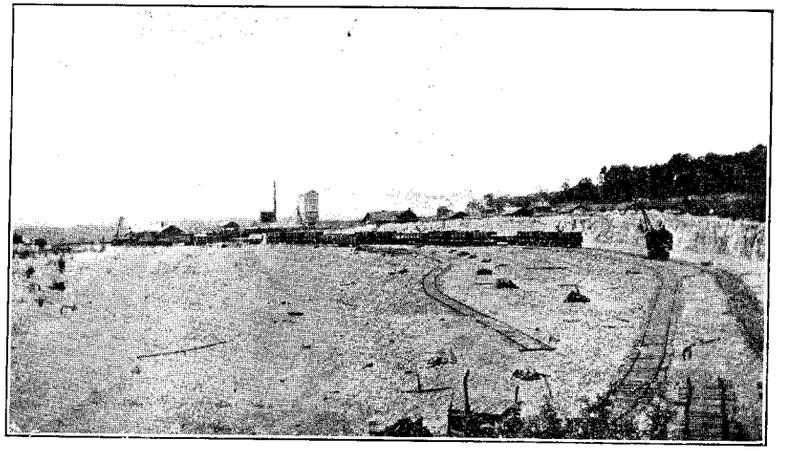
A. CRUSHING PLANTS OF THE BAYPORT QUARRY OF THE WALLACE STONE COMPANY, NEAR BAYPORT, HURON COUNTY.

Worked out portions are shown in the foreground. The present quarries are beyond the crushing plants.

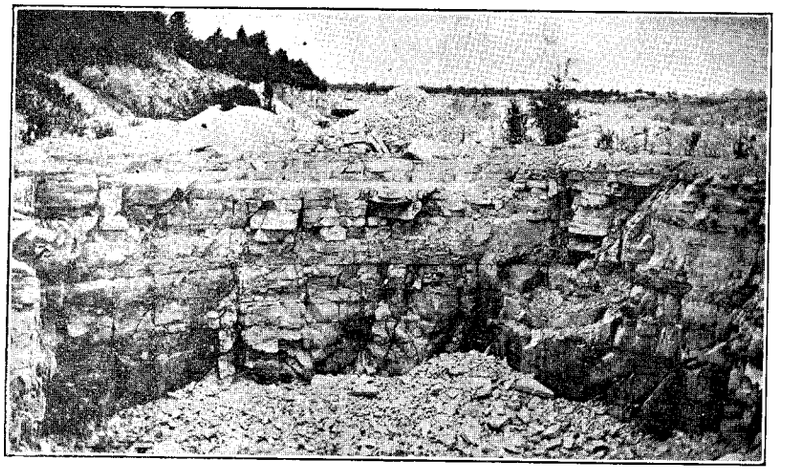


B. FIBORN QUARRY AND CRUSHING PLANT OF THE FIBORN LIMESTONE COMPANY, MACKINAC COUNTY.

The Fiborn limestone has a maximum thickness of nearly 30 feet in this quarry.



A. HENDRICKS QUARRY OF THE UNION CARBIDE CO., MACKINAC COUNTY.
The Fiborn limestone in this quarry averages about 18 feet in thickness.



B. TEST PIT IN THE FLOOR OF HENDRICKS QUARRY, SHOWING THE UPPER BEDS OF THE HENDRICKS SERIES.

Section in Hendricks quarry.

		Thickness, feet.
1.	Hard light gray, porous and thin-bedded magnesian limestone. Stone badly leached. Bed present only in places. Not used	4
2.	Hard white to light gray, crystalline to dense grained, porous, cherty, and magnesian limestone. Bed not used. (Anal. No. 400 of beds Nos. 1 and 2 gave 12.71 per cent of MgO)	3½
3.	Gray to grayish buff lithographic to dense grained high calcium limestone with a smooth conchoidal fracture and with small disseminated calcite crystals. Top portion is light gray, well bedded and crystalline. (CaO, 55.05 per cent; MgO, 0.81 per cent; Anal. No. 401)	18
	Test pit in bottom of quarry.	
4.	Hard white dense grained to finely crystalline high calcium limestone, becoming more magnesian toward the base (CaO, 53.89 per cent; MgO, 1.35 per cent. Anal. Nos. 403-4)	8
5.	Dark buff gray dense grained high calcium limestone (CaO, 55.29 per cent; MgO, 1.05 per cent. Anal. No. 405)	1
6.	Hard white thin-bedded high calcium limestone (CaO, 51.39 per cent; MgO, 4.19 per cent. Anal. No. 406)	2
7.	Hard white crystalline dolomite (MgO, 20.46 per cent. Anal. No. 407)	2½
8.	Brownish crystalline dolomite with drusy cavities. (MgO, 20.15 per cent. Anal. No. 408)	6
9.	Yellowish earthy high calcium limestone (CaO, 55.75 per cent. Anal. No. 409)	1

As may be noted from the above section the Fiborn limestone is locally overlain by beds of light colored magnesian limestone. These beds were encountered only in the southwestern portion of the quarry. The rock suface is more or less corroded and eroded and apparently these magnesian beds are present only in the higher places in the vicinity of the quarry. Some of the corrosion hollows are very deep extending nearly to the bottom of the Fiborn limestone. The hollows or "pockets" are filled with drift and give more or less trouble in stripping.

The thickness of the Fiborn member averages about 18 feet which is considerably less than in the Fiborn quarry, Mackinac county, or in the Blaney quarry, Schoolcraft county. The stone, however, is very similar in character and composition in all of the quarries. Analysis No. 400 indicates that magnesian character of the white limestone overlying the Fiborn limestone on the south. An analysis (No. 401) of a set of samples from the Fiborn limestone gave 55.05 per cent calcium oxide and only 0.81 per cent of magnesian oxide. Generally the basal portion is more magnesian but analysis No. 402 from near the bottom of the bed gave 55.29 per cent of calcium oxide and 0.82 per cent of magnesium oxide. The white underlying limestone, which, in the Fiborn and Blaney quarries is magnesian, also is low in magnesia. Analyses Nos. 403 to 409 are of the beds exposed in the test pit and these show that the beds range in composition from very pure high calcium limestone to heavy magnesian limestone or dolomite.

A number of core drillings were made in the vicinity of the quarry and the following analyses are of the core from one over 145 feet in depth:

Test Hole Near Hendrick's Quarry.

Analyses of drill core, sec. 1, T. 44 N., R. 9 W., Mackinac County. Analyses furnished by Joseph Scales, Supt. Union Carbide Co., Sault Ste. Marie, Mich.

Analysis No.	Sample No.	Core. Thickness, feet.	Core. Depth, feet.	Silica. SiO_2. %	Iron-Alumina. Fe_2O_3-Al_2O_3. %	Calcium carbonate. $CaCO_3$. %	Calcium oxide. CaO. %	Magnesium carbonate. $MgCO_3$. %	Magnesium oxide. MgO. %	Carbon di-oxide and water. CO_2-H_2O. %	Remarks.
410	1	9'- 6"	23'- 0"	2.16	1.10	*83.97*	47.06	*12.27*	5.87	43.81	Compare beds Nos. 1 and 2 of section in Hendrick's quarry.
411	2	11'- 0"	34'- 0"	3.88	0.45	*84.56*	47.39	*9.34*	4.47	43.81	
412	3	5'- 6"	39'- 6"	1.02	0.17	*96.69*	54.19	*1.05*	0.50	44.12	Fiborn limestone. Compare bed No. 3.
413	4	10'- 0"	49'- 6"	1.79	0.26	*93.94*	52.65	*2.24*	1.07	44.23	
414	5	6'- 3"	55'- 9"	1.40	0.16	*90.93*	50.96	*6.65*	3.18	44.30	Compare beds Nos. 4-9 of test pit in bottom of quarry.
415	6	6'- 3"	62'- 0"	1.94	0.74	*73.46*	41.17	*22.45*	10.74	45.41	
416	7	9'- 0"	71'- 0"	1.02	0.44	*91.04*	51.02	*5.29*	2.53	44.99	Lower high calcium horizon.
417	8	13'- 6"	84'- 6"	1.57	0.56	*95.34*	53.43	*.29*	0.14	44.30	
418	9	12'- 0"	96'- 6"	1.48	0.36	*91.55*	51.31	*3.74*	1.79	45.06	
419	10	19'- 6"	116'- 0"	3.46	0.57	*86.97*	48.74	*4.70*	2.25	44.98	
420	11	5'- 6"	121'- 6"	2.04	0.40	*91.09*	51.50	*4.01*	1.92	44.59	
421	12	12'- 6"	134'- 0"	3.91	1.27	*66.52*	37.28	*27.55*	13.18	44.36	
422	13	11'-10"	145'-10"	5.72	1.71	*65.07*	36.47	*24.85*	11.89	44.21	

Note.—Numbers in italics are calculated from original analyses.

The exact location of this hole is not given but judging from the magnesian character of the top 20 feet (13 ft. 6 in. to 34 ft.) it is south of the quarry where the overlying white magnesian limestones (Beds Nos. 1 and 2) should be expected. Core samples Nos. 3 and 4 (34 ft. to 49 ft. 6 in.) represent the Fiborn bed but it is probable that a part of the bed is included in samples Nos. 2 and 5. Samples Nos. 5 to 7 (49 ft. 6 in. to 62 ft.) represent the magnesian series exposed in the test pit. Samples Nos. 8 to 11 are of a lower high calcium bed or beds 35 to 50 feet in thickness and comparable in purity with the Fiborn limestone above.

The name Hendricks series has been provisionally given to this series of high calcium and magnesian limestones below the Fiborn limestone. It is possible, however, that the Hendricks series should also include the Fiborn limestone. A large section of this series would be exposed along the high bluff a half mile to the north if the base of the bluff was not covered by debris.

A large part of the quarry product is used by the Union Carbide Co. at Sault Ste. Marie for the manufacture of calcium carbide. The remainder of the product is disposed of for a variety of purposes.

Donald. The Fiborn limestone is near the surface in section 29, T. 44 N., R. 10 E. It is exposed at the depth of about five feet in a shallow open well on the farm of August Wandtland near the center of the section. It was also found at depth of 28 inches in holes dug for telephone poles in the road along the east side of the section. The overburden, however, appears to be heavy in most places and the area of easily quarryable stone is very uncertain. An analysis (No. 423) of a sample blasted from the well on the Wandtland farm gave only 47.72 per cent of calcium oxide and 5.93 per cent of magnesium oxide. The percentage of magnesia is higher than is usual for the Fiborn limestone.

Gould City. Just north and west of Gould City the Fiborn limestone is exposed or near the surface in sections 30 and 31, T. 43 N., R. 11 W., also in the eastern part of sections 25 and 36, T. 43 N., R. 12 W. Fire has removed the timber and soil mold exposing a large area of bare rock on each side of the road. The area of easily quarryable stone is uncertain but apparently it is several hundred acres.

The stone is a light gray, lithographic, high calcium limestone, very brittle, breaking with a smooth conchoidal fracture and containing small disseminated calcite crystals. An analysis (No. 424) of sample taken from a small pit near the road in section 31 gave 54.30 per cent of calcium oxide and 1.63 per cent of magnesium oxide. The light

drift cover and the nearness to the Minneapolis and St. Paul railroad make very favorable conditions for development.

Hunt Spur. Two miles north of Hunt Spur the Fiborn limestone is exposed over an area of several square miles in extent. Fire has removed much of the timber and original soil mold, and exposures are numerous from the vicinity of Lake Ella westward into section 4, T. 42 N., R. 13 W., Schoolcraft county, a distance of about six miles. This is the largest area of exposures of the Fiborn limestone. The principal exposures in Mackinac county are in sections 5 and 6, T. 42 N., R. 12 W., and in sections 31 and 32, T. 43 N., R. 12 W. The rock surface is generally flat but locally there are rock ridges from 4 to 20 feet in height. The thickness of the Fiborn limestone in the eastern portion of the area is variable but uncertain, but in the Blaney quarry at the west end it is at least 26 feet. Quarrying conditions are favorable in much of the area but drainage in some portions would be difficult. An analysis (No. 425) of limestone from a rock ridge 15 to 20 feet in height in section 6, T. 42 N., R. 12 W., was made by the Lake Superior Iron & Chemical Co. and this gave 53.70 per cent of calcium oxide and 1.74 per cent of magnesium oxide. Other analyses from the western portion of the area also show the high average quality of the limestone.

Another area of exposures is reported to occur between Fiborn and Hendricks quarries. About four miles northwest of Trout Lake in section 24, T. 44 N., R. 7 W., small exposures of the Fiborn limestone occur and it is probable that with further search and exploration a considerable area of high calcium limestone may be developed. Most of the locality is covered by morainic deposits, therefore the areas of limestone under light overburden may be small.

Ozark quarry. The Ozark Stone Co. has opened a quarry (Pl. VI A) at Ozark in the edge of the prominent escarpment of Engadine dolomite which extends northward to Haff postoffice (Dick) in Chippewa County. This dolomite is exposed or is at shallow depth in many places in an area of many square miles in extent east and north of Ozark. The amount of available dolomite in this area alone is practically inexhaustible. The dolomite is distinctly bluish with mottlings and streaks of blue, very crystalline, massively but poorly bedded, and very porous, locally containing many druse cavities, apparently the molds of a large species of Pentamerus. The jointing is very irregular and upon blasting the stone breaks into large irregular masses. At the time (1913) of the writer's visit, the quarry was about 100 feet in length and 20 feet in depth but the bottom of the bed had not been reached. The rock surface is very uneven and the thickness of the bed is variable

and uncertain. Three or four miles north, however, it is over 50 feet. The stone is very pure dolomite, suitable for use as a basic lining in open hearth furnaces and for the manufacture of paper by the sulphite process. Analysis No. 426 indicates that at Ozark the impurities average less than one-half per cent.

Kenneth. Exposures of Engadine dolomite occur at and in the vicinity of Kenneth and formerly a small quarry was operated here for burning lime. The dolomite is similar to that at Ozark, though judging from analysis No. 428 it is slightly less pure, containing 1.40 per cent of impurities.

Large areas of Engadine dolomite occur in the eastern part of the county, especially in T. 42 N., R. 1 W., and 43 N., R. 2 W. The northern limit of these areas is generally marked by high rock bluffs.

Caffey. A considerable area of Engadine dolomite occurs a mile southeast of Caffey. Dolomite is exposed in a number of places and quarrying conditions are favorable.

Garnet. A small exposure of Engadine dolomite occurs at the top of a low elevation a short distance north of the railroad at Garnet, but judging from the great number of large boulders the dolomite is near the surface in an area of at least two or three hundred acres.

Engadine. About one mile west of Engadine the Minneapolis, St. Paul and Sault Ste. Marie railroad crosses a large exposure of bluish very crystalline extremely massive and poorly bedded dolomite, locally containing numerous druse cavities, apparently the molds of a large Pentamerus. Exposures extend for two miles south of the railroad and apparently southwestward for several miles. The rock surface slopes gently to the south, apparently in accordance with the general southward dip of the beds, but north of the railroad the area terminates in a series of low bluffs. About one mile south of the railroad there is an east and west valley locally bordered by perpendicular rock walls 8 to 12 feet in height on the north and south. One mile north of the railroad the massive dolomite terminates in a high bluff with an exposure at the base of very fossiliferous and thin bedded magnesian limestone, belonging to the underlying Manistique series. The name Engadine dolomite has been given to this massive dolomite from its prominent and extensive exposures west of the village of Engadine.

According to analyses Nos. 429 to 431 the rock is a normal dolomite containing about 1.25 per cent of impurities. The amount of available dolomite in the Engadine area is practically inexhaustible but unfortunately dolomite finds but limited use in the industries. The large

area of exposures, a natural face, and the proximity to railroad transportation offer especial advantages for development.

St. Ignace. Large exposures of the Monroe dolomites occur in the vicinity of St. Ignace, on Mackinac Island and other adjacent islands. Formerly the dolomite was burned for lime at a number of places. Due to the exhaustion of suitable fuel and to the impure character of the dolomite these quarries and kilns were abandoned many years ago. Much of the Monroe dolomite in the vicinity of St. Ignace and on Mackinac Island is brecciated.

Summary. Mackinac county contains several of the largest areas and also the largest reserves of high calcium limestone in the Northern Peninsula, but unfortunately most of these are located in the northwestern part of the county at considerable distance from trunk line railroads. Only two of the areas have been developed, though the limestone is suitable for almost every purpose for which high calcium limestone may be used. The county has also practically inexhaustible supplies of the purest dolomite, much of which is near railroad transportation. The exceptional purity of the dolomite makes it especially adapted for use as the basic lining in open hearth furnaces and for use in paper manufacture by the sulphite process.

Marquette County. Exposures of the Trenton limestone and the Beekmantown (Calciferous) sandstone occur along the Escanaba River in the extreme southern part of the county. Analyses Nos. 437 to 439 are indicative of the sandy character of the Beekmantown and Nos. 440 and 441 of the siliceous and argillaceous character of the Trenton limestone.

Menominee County.

Distribution. The Trenton limestone underlies the much larger eastern portion of Menominee county and the Beekmantown (Calciferous) forms a narrow belt along the western side. The Trenton is exposed about 2 miles north of Menominee and also in the bed of Menominee River near its mouth. The Beekmantown sandstone is exposed in the vicinity of Hermansville and along the Grand rapids on Menominee River. Rominger* gives the following section from this place:

*C. Rominger, Paleozoic Rocks of the Upper Peninsula, Vol. I, Pt. III, p. 72, 1869-1873.

Section of the Calciferous sandstone at Grand rapids, Menominee River.

		Thickness, feet.
1.	Fine grained crystalline even-bedded limestone with argillaceous partings. (SiO_2, 18 per cent, Anal. No. 442)	4
2.	Nodular limestone of peculiar concentrically laminated structure much resembling irregularly contorted nodular masses of Stromatopora	3
3.	Compact dolomites, partly arenaceous, partly of oolitic structure	2
4.	Fine grained argillaceous arenaceous limestones banded with red stripes or variegated with irregular blotches in thin and even bedded layers. (SiO, 23 per cent, Anal. No. 443)	3
5.	Hard dolomitic limestones and oölite beds mixed with a greater or smaller proportion of quartzose sand granules	4
6.	White coarse grained sandstone variable in hardness and with seams of arenaceous shales. Numerous angular fragments of limestone and pieces of shale in the upper layers	5

The siliceous, argillaceous, and magnesian character of the limestone beds is indicated by the analyses by Rominger, No. 442 of the upper bed, No. 443 of bed No. 4, and No. 444 of bed No. 5.

Hermansville. Sandy limestone belonging to the Beekmantown (Calciferous) is exposed in the vicinity of Hermansville, Iron Mountain, and Waucedah, and has been locally designated* by Rominger as the Hermansville limestone. Its general character as described by him is "that of a coarse grained sandstone with abundant calcareous cement in alternation with pure dolomite or sometimes öolitic beds." It is of little economic importance, the stone apparently being suitable only for road material, concrete, common building stone, etc.

The principal exposure of the Trenton limestone is about 2 miles north of Menominee where a small quarry has been opened by the Menominee Stone Crusher Co. The area of easily quarryable stone is apparently only 10 or 15 acres but perhaps further exploration may result in the development of a considerable larger area.

The stone is a buff to gray, argillaceous, low magnesian stone weathering to bluish color. The argillaceous matter is chiefly in very fine wavy laminations more or less parallel with the bedding. Only four or five feet of rock were exposed but according to the foreman of the quarry the rock is similar to the depth of about 34 feet. The rock is used chiefly for concrete paving and for road making in the vicinity of Menominee.

Analysis No. 445 is indicative of the argillaceous and low magnesian character of the beds in the quarry. Analysis No. 446 from the field notebook of N. H. Winchell is apparently from the upper dolomite beds, the so-called "Menominee marble," exposed along Menominee river. The impurities, however, in this bed are abnormally low for the Trenton limestone.

Summary. Menominee county apparently has limited limestone

*C. Rominger, Paleozoic Rocks, Mich. Geol. Surv., Vol. I, Pt. III, 1873, p. 81.

resources and these are generally siliceous, argillaceous, and magnesian. The limestone is adapted chiefly for road making, concrete, railroad ballast, or rough building stone.

Monroe County.

Distribution. The Monroe formation and the Dundee limestone occupy all but the extreme southwestern portion of the county. In Monroe county the Monroe formation consists of three divisions, viz., the Lower Monroe or Bass Island series, the Middle Monroe or Sylvania sandstone, and the Upper Monroe or Detroit River series. The members of the Monroe formation and the Dundee limestone form parallel belts extending across the county in a northeast-southwest direction. The Lower Monroe occupies the southeastern belt along Lake Erie and the others follow in order to the northwest.

Character. The Lower Monroe is composed of argillaceous and locally bituminous dolomite, anhydrite, celestite, and native sulphur; the Sylvania, of white sandstone and sandy dolomite; the Upper Monroe, chiefly of argillaceous dolomite with anhydrite, celestite, and sulphur; the Dundee, high calcium and magnesian limestone. The dolomite of the Monroe is locally much brecciated.

Quarries and Localities.

The surface deposits are generally thin in the eastern part of the county and gradually increase in thickness westward. Because of this, exposures decrease in number from near the lake westward. The lower Monroe dolomite of the eastern belt is exposed at many places but the Dundee limestone of the western belt is exposed at but three places.

Lower Monroe.

Monroe quarries. Formerly numerous limestone quarries were operated in the eastern portion of Monroe county but only three quarries are now in operation and these are at Monroe.

The quarry of the Shore Line Stone Company is about one mile north of the city near the Shore Line Railroad. The following section was exposed:

		Thickness, feet.	Inches.
	Stiff lake clay	4–6	
1.	Blue and buff dolomite	2–4	
2.	Dark gray, buff, brown, bituminous, argillaceous and massively bedded dolomites	18	
3.	Dark gray drusy and argillaceous dolomite. Light colored dolomitic oölite	1+	
4.	Light to dark gray and dense grained brittle dolomite with bluish mottlings and streaks resembling castile soap. The upper 8 to 10 inches has a gnarled pattern, the middle 6 inches is mottled, and the lower 3 or 4 feet streaked. The lower portion is very argillaceous	5	
5.	Dark gray densely crystalline dolomite with delicate bituminous laminations	2	
6.	Buff very earthy argillaceous and massively bedded dolomite	3	
7.	Dark gray densely crystalline dolomite	2	
8.	Thin seam of oölitic dolomite	0	6
9.	Brittle light colored dolomite with black mottlings and streaks and a blue shale seam at the bottom	1	6
10.	Dark buff gray crystalline and sandy appearing dolomite with a shale seam at the bottom	2	
11.	Thin seam of oölitic dolomite	0	4–6
12.	Brittle fine grained light colored argillaceous dolomite with bluish streaks and mottlings. Lower portion very argillaceous	1+	

Much of the dolomite is argillaceous though analyses (Nos. 447-449) of samples taken at 2, 7, and 10 feet from the top of the quarry gave an average of only 0.75 per cent iron and alumina and 1.35 per cent of silica. The sulphur is locally high and the generally impure character of the dolomite unfits it for general fluxing and chemical purposes. In the early days it was used for lime burning and building stone but now it is used chiefly for road making, concrete, and railroad ballast.

The quarry of the France Stone Co., formerly the Monroe Stone Co., is on the southeast side of Plum Creek in the southern part of Monroe. This is the largest quarry in the county and the company have recently installed a modern crusher plant (Pl. VI B). The area of available stone is said to be about 90 acres. The section exposed is as follows:

Section in the France Stone Co. quarry.

		Thickness, feet.
	Surface	0–4+
1.	Light yellowish earthy dolomite with brown mottlings with oölite at the top	3
2.	Light bluish gray densely crystalline dolomite	2
3.	Buff gray very fine grained, laminated and bituminous dolomite	5
4.	Dark gray bituminous and densely crystalline dolomite with drusy cavities	2
5.	Massive gray dolomite	3
6.	Dolomite breccia; angular fragments very large and many of the original interstitial openings partially filled with dolomite spar and large crystals and masses of calcite or dog-tooth spar	6
7.	Buff sandstone	2
8.	Brittle yellowish white and buff dolomite with mottlings and streaks	
9.	Dark buff gray dense grained to crystalline and bituminous dolomite with druse cavities	2
10.	Dolomite breccia, fragments very small	1
11.	Massive crystalline dolomite resembling brown sugar	1+

The maximum depth of the quarry is about 40 feet but a complete section could not be obtained at any place on account of a large blast of limestone. Some of the beds are much brecciated. In some places

the brecciation is confined to one bed, in others it extends through all. The brecciation is of two types, one in which rearrangement of the fragments has occurred and one in which it has not. In the first type the fragments are large and are inclined at all angles. In the second type they are generally small and are difficult of recognition. Usually a very hackley fracture of the stone is indicative of this type of brecciation.

Many of the beds are argillaceous and bituminous. An average of five analyses (No. 450) of the gray dolomite beds gave 3.08 to 6.08 per cent of impurities. The stone is crushed for concrete, road making and railroad ballast.

Immediately north of the France quarry on the opposite side of Plum Creek there is a small quarry operated by J. Morris for rough building stone, concrete, and road material. The beds are similar to those in the France quarry.

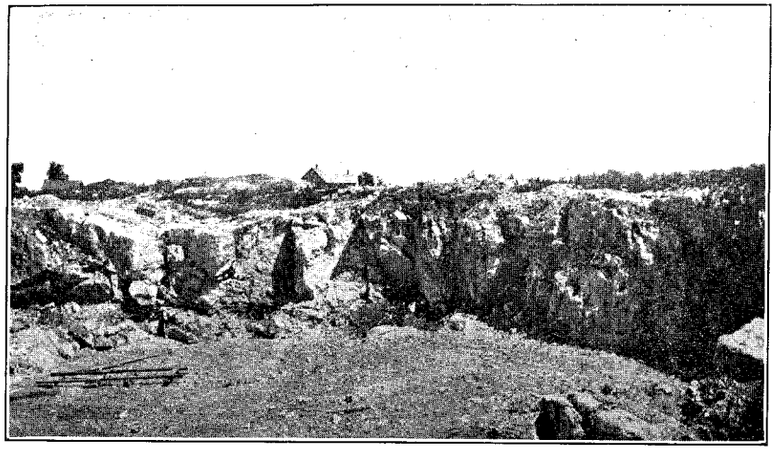
According to Sherzer* stone was formerly quarried near Newport Center and Brest, claim No. 529, south of Swan Creek, in the bed of the River Raisin for three or four miles above Monroe, a half mile south of Plum Creek quarries, in the bed of Otter Creek for a mile up stream from the Pere Marquette railroad bridge, along the south branch of Otter Creek in sec. 20, T. 7 S., R. 8 E., along Muddy Creek in secs. 29, 32, and 33 of the same township, in secs. 1 and 12, T. 8 S., R. 7 E., in sec. 15 in the vicinity of Little Lake, in secs. 10, 16 and 21 of the same township, in sec. 25, T. 8 S., R. 6 E., and sec. 4, T. 9 S., R. 6 E. Nearly all of these quarries were small and were operated for building stone for local use. Lime, however, was burned at some. All of the quarries are abandoned or idle and full of water. The area of easily quarryable stone is reported to be considerable in some of the localities. The beds are chiefly gray argillaceous dolomite with öolitic horizons, similar in general character to the beds exposed in the Monroe quarries.

Upper Monroe.

The exposures of the Upper Monroe are numerous and many small quarries have been opened at one time or another, chiefly for building stone. Lime was burned but much of the dolomite is too sandy or impure for this purpose.

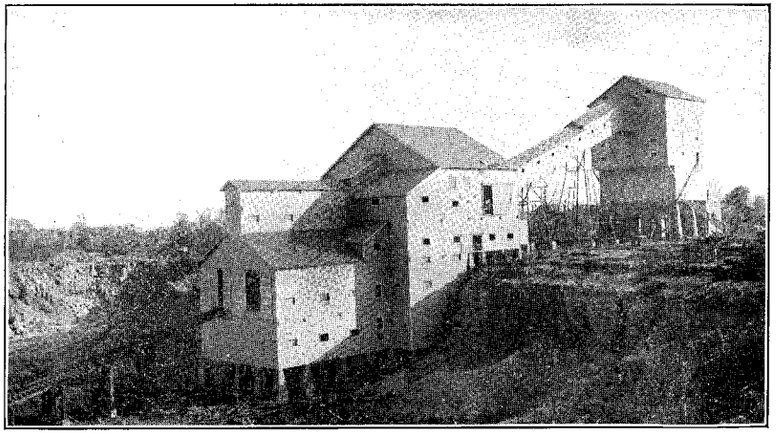
Woolmith† *quarry.* The Woolmith quarry is between Maybee and Scofield and is the largest in the Upper Monroe. The quarry is full of water but according to Sherzer the section formerly exposed was as follows:

*W. H. Sherzer, Geology of Wayne Co., Vol. VII, Pt. I, pp. 92-100, Mich. Geol. Surv., 1900.
†W. H. Sherzer, Geology of Monroe County, Vol. VII, Pt. I, 1900, pp. 78-82.



A. QUARRY OF THE OZARK STONE COMPANY AT OZARK, MACKINAC COUNTY.

The massive bedding and the irregular jointing are characteristic of the Engadine dolomite.



B. NEW CRUSHING PLANT OF THE FRANCE STONE COMPANY, MONROE, MONROE COUNTY.

The beds belong to the Raisin River dolomite of the Lower Monroe and are locally much brecciated.

		Thickness, feet.
	Blue boulder clay	2–8 +
A.	Light colored finely laminated dolomite blotched and streaked with brown	2–4
B.	Dolomitic oölite with small cavities containing celestite, calcite, and sulphur	3½
C.	Drab to brown dolomite with the upper surface very hummocky with cavities containing celestite, calcite, and sulphur. A thin seam of impure asphaltum is at the top and bottom of this bed	1–3
D.	Dark brown to gray dolomite more or less impregnated with oil	1–5
E.	Brown porous dolomite impregnated with oil and containing cavities with celestite, calcite, and sulphur. "Sulphur bed"	1–3
F.	Sandy bluish dolomite and bituminous limestones blotched with brown toward the bottom	2–3
G.	Gray very sandy dolomite	3–4
H.	Light gray sandy and massive dolomite with streaks of "glass sand" and iron oxide. (Insoluble residue 24.4 per cent, chiefly white sand). Used for building blocks	16
I.	Compact gray and massively bedded dolomite. This bed rests on the Sylvania sandstone	15

Most of the beds are very sandy and portions of the lower beds are pure sandstone. The dolomite also contains sulphur. It is suitable chiefly for rough building stone, road material, concrete, and railroad ballast. Blocks of almost any size may be quarried from the 16 ft. bed. Analyses Nos. 451-452 are indicative of the siliceous character of the beds.

There are six old quarries in the vicinity of Raisinville. The exposed beds correspond to the lower beds in the Woolmith quarry. Lime was burned at one of the quarries. Analysis No. 453 is indicative of the general character of the beds.

Lulu quarry. This quarry is located in the NW. ¼ NW. ¼ sec. 16, T. 7 S., R. 7 E. The beds include both sandstone and gray dolomite more or less mottled and streaked with blue. Building stone was quarried here more than 75 years ago. Analysis No. 454 by Rominger is from one of the beds of dolomite and No. 455 from a sandy stratum.

Little Sink quarry. In Little Sink quarry, SE. ¼ SE. ¼ sec. 2, T. 8 S., R. 6 E., 6 to 8 feet of gray dolomite overlies pure white sandstone. The beds were quarried for building stone and for burning lime.

Ottawa Lake quarries. Several small quarries were formerly operated near the north end of Ottawa Lake for building stone, lime, and road material. The beds formerly exposed are as follows:

		Thickness, feet.
A.	Compact buffish brown siliceous dolomite	0–?
B.	Cherty dolomite	1–1½
C.	Compact dolomite similar to A but blue in color	9 +
D.	Buff to gray compact dolomite with carbonaceous films	2

Ida quarries. In some quarries one and one-half miles west of Ida there are two beds of gray dolomite. The upper is oolitic and has a gashed or acicular structure. Analysis No. 457 is from the upper bed. The gashed structure is apparently due to tabular crystals of celestite which have been leached out.

Analysis No. 456 is from material from a drill hole in the Upper Monroe dolomite just north of Carleton.

Dundee Limestone.

Quarries have been opened in the Dundee limestone at Dundee and near the mouth of Macon River about 2 miles northeast of Dundee.

Dundee quarry. This quarry is located on the north bank of the River Raisin back of the National Hotel. It consists of a rectangular opening about 90 feet wide and 240 feet long, and is only a few feet above normal river level. It is abandoned and full of water. According to local residents all of the available stone has been removed. The section as determined by Sherzer* is as follows:

		Thickness, feet.
A.	Gray fossiliferous limestone impregnated with oil	2½
B.	Grayish brown limestone, weathering bluish	4½
C.	Dark brown and bituminous limestone, cherty toward the bottom	6½
D.	A massively bedded bluish limestone, lighter colored toward the bottom	5

Macon quarry. The Macon quarry has been known at various times as the Christiancy, Nogard, and Bullock quarry, corresponding with its various owners. It is near the mouth of Macon River and in the former channel of the river, from which the water has been deflected by an embankment. It extends for a considerable distance along the north bank of the stream. It is now abandoned and full of water, hence its description rests upon the authority of Sherzer†.

		Thickness, feet.
	Surface	4–6 +
A.	Gray fossiliferous limestone. ($CaCO_3$, 90.80 to 98.10 per cent; $MgCO_3$, 6.87 to 0.63 per cent; Anal. Nos. 458 and 463)	1–2
B.	Compact brownish and bituminous limestone, weathering bluish; cherty toward the bottom with a seam of chert between beds B and C. ($CaCO_3$, 86.80 per cent; $MgCO_3$, 11.60 per cent; Anal. No. 459)	4–4½
C.	Soft dark gray limestone. ($CaCO_3$, 77.60 per cent; $MgCO_3$, 17.41 per cent; Anal. No. 460)	7–8
D.	Similar but higher in calcium carbonate. ($CaCO_3$, 95 per cent; $MgCO_3$, 3.86 per cent; Anal. No. 461)	8

The area under relatively thin drift is apparently between 100 and 200 acres but definite data is lacking though the property has been more or less completely tested by the drill. The area of thin overburden lies between the Macon and River Raisin on the southwest and Saline river on the east and northeast. The surface is only a few feet above the level of these streams which are subject to floods, especially in the spring. To control the flood waters of the Macon a canal from 4 to 6 feet in depth was cut out of solid limestone from the mouth of the

*W. H. Sherzer, Geology of Monroe County, Vol. VII, Pt. I, pp. 77-78, Mich. Geol. Surv. 1901.

†W. H. Sherzer, Geology of Monroe County, Vol. VII, Pt. I, pp. 75-76, Mich. Geol. Surv., 1900.

stream up for a half mile or more. This will doubtless lessen the violence of the floods but it is very probable that flood waters will give more or less trouble in quarrying operations. Beds A and B and a portion of C are well exposed along the banks of the canal.

In composition Beds A and D are high calcium containing from about 90 to 98 per cent of calcium carbonate, (Anal. Nos. 458 and 463) but B and C contain from about 10 to over 17 per cent (Anal. Nos. 459, 460, 462) of magnesium carbonate.

Petersburg. Stone has been removed from the bank of Raisin River and in digging ditches, though no real quarry has been developed. Limestone is said to have been struck at a depth of 4 or 5 feet on the river flats in the SE. ¼, NW. sec. 4 (T. 7 S., R. 6 E.) and at 15 to 24 inches in NW. ¼ NW. ¼ sec. 31. Apparently the limestone at the latter place is highly magnesium.

Summary. In Monroe county there are numerous exposures and areas of easily quarryable stone in the belts underlain by the Upper and Lower Monroe dolomites. The dolomite is generally more or less argillaceous and siliceous, and locally brecciated and contains much sulphur. The harder beds are quarried for rough building stone and crushed for road making, concrete, and railway ballast. The Dundee limestone is exposed or near the surface in only a few places and apparently the most important of these is at the mouth of the Macon river. The beds include both high calcium and low magnesium lime. stone.

Presque Isle County.

Distribution. In Presque Isle county, the Dundee limestone underlies a belt skirting the shore of Lake Huron from False Presque Isle northwest into Cheboygan county. The Bell shale, the Long Lake series, the Alpena limestone and the Upper Traverse or Thunder Bay series of the Traverse formation form belts parallel to the Dundee limestone and occupy the remainder of the county excepting the southwestern corner. The Dundee is extensively exposed in the vicinity of Rogers City and Adams Point. The Long Lake series forms a belt of prominent but broken escarpments across the county more or less parallel to the shore of Lake Huron.

The Alpena limestone forms a broad broken ridge extending from the vicinity of Onaway southeast into Alpena County. The exposures are very numerous and many of them very large. The Upper Traverse series is buried under the thick drift deposits of the southwestern portion of the county.

Quarries and Localities.

Dundee Limestone.

Rogers City. The largest and most important exposures of the Dundee limestone occur in the vicinity of Rogers City. The chief exposure is a high ridge of limestone extending parallel to the shore of Lake Huron from near Swan river west-northwest to beyond Rogers City, a distance of about 5 miles. The eastern portion of the ridge is thinly drift covered and rock is exposed over considerable areas. In places, there are old lake beaches of sand and gravel. The west end of the ridge is partially covered by drift.

A prominent bluff extends along the shore. The top of the bluff is from 50 to 80 feet above the lake. The surface rises gradually toward the south to the maximum height of 160 feet or more at the distance of a little more than a mile. The surface then slopes into a valley on the south parallel to the ridge. The slope is apparently more or less in accordance with the inclination of the beds which is about 40 feet per mile toward the south-southwest. According to the records of wells the bottom of the valley is underlain by shale apparently the Bell shale. Limestone, typical of the Lower Traverse, is exposed in shallow wells on the south side of the valley in sections 2 and 3, T. 34 N., R. 5 E.

Limestone breccias occur at several places along the lake shore at and below water level. These belong to what Grabau* has termed the Mackinac limestone. These breccias were formerly included in the Monroe formation. The section of the Dundee limestone extends from water level to a height reported to be 160 feet above Lake Huron. If allowance is made for a dip of 40 feet per mile, the total thickness would be approximately 200 feet. The maximum thickness is probably greater than this for the top of the ridge has suffered considerable erosion. Figure 15 shows the general geological relations in the vicinity of Rogers City.

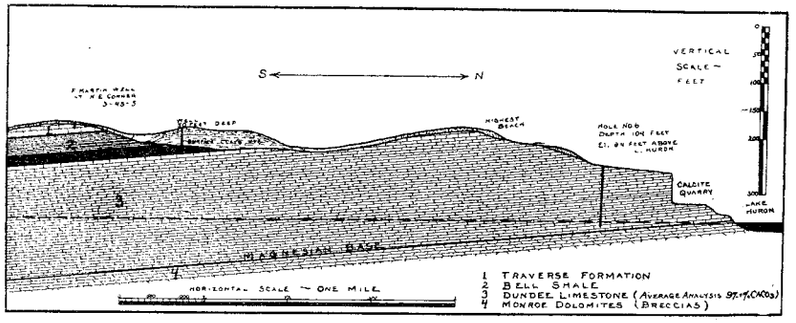
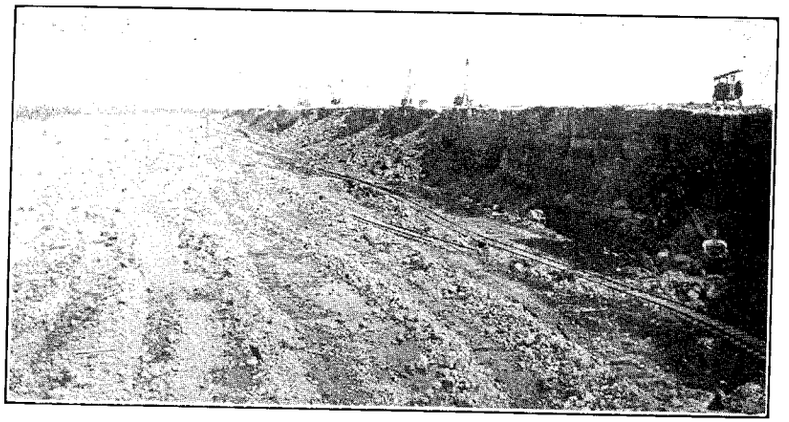


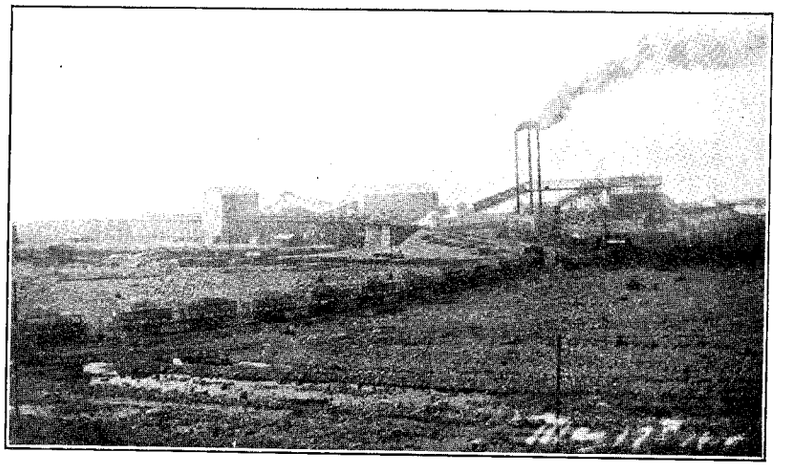
Figure 15. Cross section, Calcite quarry, Presque Isle county to section 3, T. 43 N., R. 5 E.

*A. W. Grabau. The Devonian Formations of Michigan. Unpublished Mss.



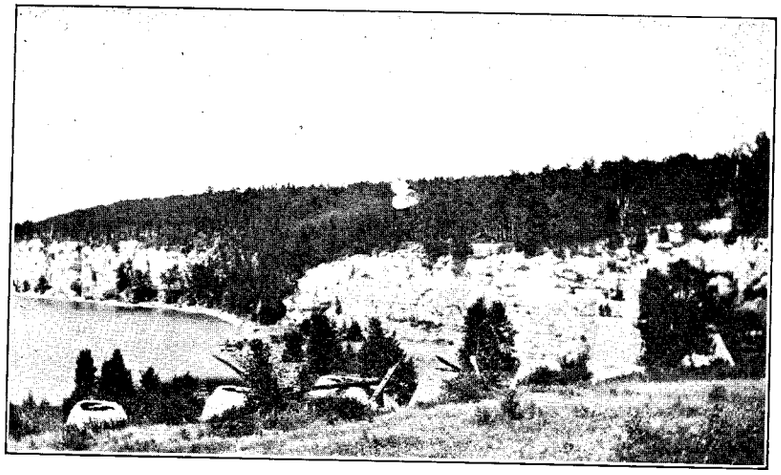
A. QUARRY OF THE MICHIGAN LIMESTONE AND CHEMICAL COMPANY AT CALCITE, PRESQUE ISLE COUNTY.

This is probably the largest quarry in the world. The quarry face is more than a mile in length and in places fifty feet in height.



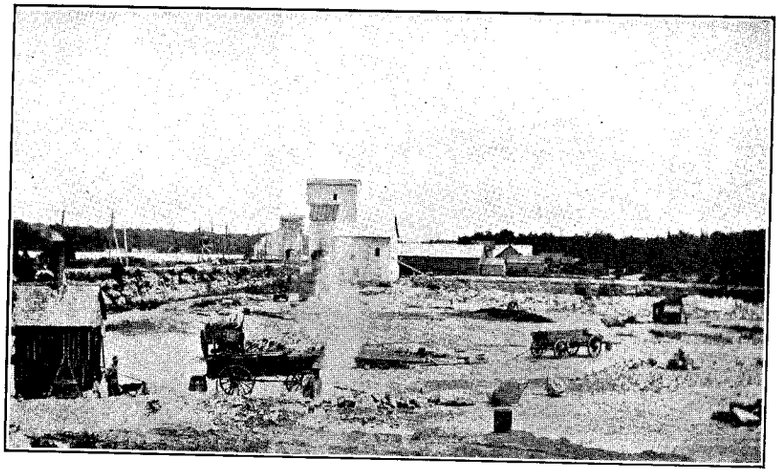
B. PLANT OF THE MICHIGAN LIMESTONE AND CHEMICAL COMPANY AT CALCITE, PRESQUE ISLE COUNTY.

This is one of the largest and most modern plants in the world.



A. MIDDLE BLUFF, FAYETTE, GARDEN PENINSULA, DELTA COUNTY.

The bluff, about 125 feet in height, is composed of heavy magnesian limestone of the Manistique series. Formerly the Jackson Iron Company utilized the limestone in smelting iron. The old quarry face is shown at the right center and the tops of old charcoal kilns in the foreground.



B. JOHN BICHLER QUARRY, FOUR MILES NORTH OF ESCANABA, DELTA COUNTY.

The beds exposed belong to the Trenton formation and are low magnesian argillaceous limestones.

Calcite quarry. The Michigan Limestone and Chemical Co. of Rogers has opened a very large quarry (Pls. VII A and B) in the eastern portion of the ridge at Calcite. The quarry was developed in the bluff along the lake. It extends from Calcite westward for more than a mile.

The floor of the quarry is from 30 to 35 feet above the lake and the working face is from 30 to over 50 feet in height. The face increases in height as quarrying progresses toward the south because of the increase in the elevation of the rock surface and, at the distance of about a mile from the present face, will be more than a hundred feet high, the floor of the quarry remaining at the present elevation. The quarry is one of the largest, if not the largest, and most modernly equipped quarries in the world.

The beds of the Dundee are dark gray to buff, or ''chocolate colored,'' very bituminous and crystalline, high calcium limestone. Most of them are exceptionally pure. Mr. C. D. Bradley, General Manager, kindly placed at the disposal of the writer a large number of analyses of cores from test holes in the vicinity of Rogers City. The average (see Anal. No. 464) of 235 analyses of the upper 50 feet of cores gave 97.85 per cent of calcium carbonate, 1.26 per cent of magnesium carbonate and 0.34 per cent of silica. Certain thin beds however contain from 3 to 10 per cent of magnesium carbonate and locally the percentage of magnesia for a series of beds is from 3 to 6 per cent. The basal beds of the Dundee contain from 5 to 13 per cent or more of magnesium carbonate (Anal. Nos. 486-7, 527, 594-597 and 664).

Hole No. 5.

1350′ N. 50′ W. of S. ¼ post Sec. 23, T. 35 N., R. 5 E.
Elevation 86.2 feet above Lake Huron.

No. of Anal.	Depth.	$CaCO_3$.	SiO_2.	$MgCO_3$.	$FeAl_2O_3$.	$CaSO_4$.
469	5- 8 ft.	98.30	0.32	1.11	0.16	trace
470	8-11 ft.	97.81	0.26	1.42	0.32	trace
471	11-14 ft.	97.50	0.53	1.59	0.31	trace
472	14-17 ft.	96.92	0.45	1.98	0.25	.057
473	17-22 ft.	96.78	0.35	2.61	0.18	.080
474	22-24 ft.	97.28	0.36	1.46	0.63	trace
475	24-31 ft.	97.12	0.41	2.28	0.15	.073
476	31-37 ft.	96.47	0.46	2.59	0.20	.061
477	37-40 ft.	96.14	0.37	3.33	0.15	.075
478	40-48 ft.	89.30	0.41	9.80	0.21	.060
479	48-52 ft.	95.33	0.37	3.87	0.19	.061
480	52-55 ft.	91.56	0.45	7.57	0.22	.061
481	55-61 ft.	95.36	0.23	4.16	0.16	.061
482	61-63 ft.	93.11	0.13	5.37	0.15	.050
483	Average 0-40′	97.09	0.39			
484	Average 40-58′	92.55	0.33			
485	Average 0-58′	95.29	0.37	3.58	0.23	
	Washings.					
486	70- 80 ft.	86.54	3.40	7.34	0.99	.200
487	80- 90 ft.	81.25	3.02	13.88	0.64	.160
488	90-100 ft.	62.70	2.64	32.98	0.62	.190
490	90-100 ft.	68.54	2.85	26.54	0.81	.220

Drill Hole No. 6.

Calcite quarry, Michigan Limestone and Chemical Co., Rogers City, Presque Isle Co.
S. ¼ post of Sec. 23, T. 35 N., R. 5 E.
Elevation 105.4 ft. above Lake Huron.

No. of Anal.	Depth.	$CaCO_3$.	SiO_2.	$MgCO_3$.	$FeAl_2O_3$.	$CaSO_4$.
	Surface rock.	98.76	0.01	0.98	0.15	0.022
491	6-8 ft.	98.82	0.24	1.11	0.17	0.010
492	8-10 ft.	97.50	0.17	0.94	0.13	0.040
493	10-12 ft.	97.37	0.26	0.98	0.11	0.050
494	12-14 ft.	98.39	0.21	0.94	0.11	0.040
495	14-16 ft.	97.23	0.25	0.94	0.14	0.040
496	16-18 ft.	98.46	0.21	1.21	0.22	0.015
497	18-20 ft.	98.49	0.33	0.96	0.21	0.029
498	20-22 ft.	98.77	0.08	0.95	0.11	0.050
499	22-24 ft.	98.56	0.13	1.06	0.16	0.060
500	24-26 ft.	98.42	0.17	1.11	0.20	0.070
501	26-28 ft.	98.77	0.12	1.06	0.19	0.070
502	28-30 ft.	98.47	0.08	1.25	0.11	0.060
503	30-32 ft.	98.02	0.22	1.43	0.16	0.070
504	32-34 ft.	98.27	0.22	1.04	0.17	0.060
505	34-36 ft.	98.13	0.34	1.06	0.12	0.070
506	36-38 ft.	98.49	0.26	1.13	0.15	0.070
507	38-40 ft.	98.54	0.25	1.04	0.16	0.080
508	40-42 ft.	95.76	0.38	3.16	0.31	0.070
509	42-44 ft.	97.39	0.29	1.70	0.19	0.070
510	44-46 ft.	97.89	0.28	1.21	0.20	0.150
511	46-48 ft.	97.47	0.23	1.08	0.16	0.060
512	48-50 ft.	97.82	0.27	1.38	0.13	0.050
513	50-52 ft.	97.68	0.27	1.51	0.17	0.060
514	52-54 ft.	97.71	0.34	1.13	0.12	0.070
515	54-56 ft.	96.16	0.25	1.13	0.12	0.050
516	56-58 ft.	90.58	0.67	7.21	0.30	0.070
517	58-60 ft.	97.06	0.47	1.34	0.17	0.050
518	60-62 ft.	97.54	0.43	1.02	0.12	0.070
519	62-64 ft.	97.37	0.30	0.87	0.08	0.080
520	64-66 ft.	97.41	0.35	1.44	0.16	0.090
521	66-72 ft.	97.32	0.34	1.55	0.14	0.060
522	72-76 ft.	95.05	0.36	3.80	0.20	0.050
523	76-82 ft.	93.00	0.32	6.56	0.19	0.060
524	82-88 ft.	88.43	0.22	10.89	0.24	0.080
525	88-104 ft.	90.95	0.23	7.70	0.34	0.050
526	Average 82′	97.18	.27	1.93	.16	loss .46
527	Average 82-104′	90.26	.23	8.57	.31	86.76
528	Average 104′	94.85	.26	3.47	.19	91.26

Drill Hole No. 7.

On section line 1320′ E. of S. W. cor. Sec. 23, T. 35 N., R. 5 E.
Elevation 110 ft. above Lake Huron.

No. of Anal.	Depth.	$CaCO_3$.	SiO_2.	$MgCO_3$.	$FeAl_2O_3$.	$CaSO_4$.
529	4- 6 ft	98.21	0.34	1.13	0.18	0.03
530	6- 8 ft	98.30	0.27	1.08	0.16	0.04
531	8-10 ft	98.23	0.30	1.04	0.17	0.05
532	10-12 ft	98.42	0.29	1.00	0.14	0.05
534	12-14 ft	98.21	0.19	0.87	0.09	0.05
535	14-16 ft	96.92	0.16	2.12	0.09	0.07
536	16-18 ft	97.68	0.20	0.98	0.15	0.05
537	18-20 ft	98.48	0.18	0.72	0.11	0.05
538	20-22 ft	98.13	0.20	0.95	0.24	0.12
539	22-24 ft	98.64	0.11	0.95	0.17	0.06
540	24-26 ft	98.08	0.18	1.23	0.13	0.08
541	26-28 ft	98.39	0.23	0.78	0.09	0.11
542	28-30 ft	98.39	0.27	1.02	0.12	0.06
543	30-32 ft	97.41	0.27	1.44	0.11	0.09
544	32-34 ft	97.14	0.26	1.48	0.13	0.10
545	34-36 ft	97.14	0.53	1.17	0.17	0.09
546	36-38 ft	98.02	0.20	1.42	0.10	0.07
547	38-40 ft	98.35	0.24	1.32	0.10	0.10
548	40-42 ft	98.45	0.23	1.19	0.11	0.09
549	42-44 ft	98.06	0.46	1.06	0.13	0.08
550	44-46 ft	97.66	0.33	1.15	0.15	0.09
551	46-48 ft	97.61	0.28	1.17	0.19	0.09
552	48-50 ft	97.55	0.46	1.40	0.16	0.11
553	50-52 ft	97.89	0.27	1.34	0.13	0.07
554	Average	98.00	.27	1.16	.14	.075

Drill Hole No. 8.

On west side of section 26, T. 35 N., R. 5 E.
Elevation 130 ft. above Lake Huron.

No. of Anal.	Depth.	$CaCO_3$.	SiO_2.	$MgCO_3$.	$FeAl_2O_3$.	$CaSO_4$.
555	0-20 ft	96.32	.22	1.68	.36	.....
556	20-35 ft	96.57	.23	1.68	.34	.....

Drill Hole No. 9.

Near S. ¼ post, sec. 22, T. 35 N., R. 5 E.
Elevation 94 ft. above Lake Huron.

No. of Anal.	Depth.	$CaCO_3$.	SiO_2.	$MgCO_3$.	$FeAl_2O_3$.	$CaSO_4$.
557	0- 9 ft	98.36	0.14	1.40	0.12	0.05
558	9-11 ft	98.56	0.26	1.36	0.13	0.06
559	11-13 ft	98.17	0.33	0.95	0.17	0.07
560	13-15 ft	98.20	0.27	1.46	0.17	0.07
561	15-17 ft	98.63	0.20	1.34	0.16	0.04
562	17-19 ft	98.67	0.16	1.22	0.19	0.05
563	19-21 ft	98.70	0.17	1.08	0.16	0.05
564	21-23 ft	98.78	0.18	1.02	0.16	0.05
565	23-25 ft	98.57	0.15	1.21	0.20	0.05
566	25-27 ft	98.93	0.13	0.83	0.11	0.05
567	27-29 ft	98.79	0.19	0.91	0.14	0.07
568	29-31 ft	98.84	0.30	0.79	0.12	0.05
569	31-33 ft	98.88	0.39	0.72	0.13	0.08
570	33-35 ft	98.82	0.31	0.87	0.11	0.06
571	35-37 ft	98.52	0.40	0.98	0.20	0.08
572	37-39 ft	98.48	0.37	0.87	0.20	0.07
573	39-41 ft	98.29	0.57	0.98	0.27	0.08
574	41-43 ft	98.78	0.24	0.85	0.16	0.07
575	43-45 ft	98.61	0.44	0.79	0.16	0.07
576	45-47 ft	98.46	0.44	0.85	0.15	0.07
577	47-49 ft	98.17	0.36	1.32	0.15	0.06
578	49-51 ft	98.34	0.21	1.25	0.10	0.07
579	51-53 ft	98.20	0.33	1.31	0.14	0.08
580	53-55 ft	98.46	0.22	1.17	0.18	0.06
581	55-57 ft	98.21	0.47	0.95	0.14	0.05
582	57-59 ft	96.65	0.41	2.72	0.19	0.07
583	59-61 ft	90.85	0.60	8.02	0.28	0.08
584	61-63 ft	97.81	0.32	0.91	0.16	0.07
585	63-65 ft	97.81	0.39	0.98	0.21	0.08
586	65-67 ft	98.26	0.25	1.28	0.17	0.07
587	67-69 ft	97.99	0.24	1.70	0.10	0.07
588	69-71 ft	98.12	0.35	1.57	0.14	0.06
589	71-73 ft	98.48	0.30	0.91	0.13	0.06
590	73-75 ft	97.86	0.34	1.36	0.12	0.06
591	75-77 ft	98.48	0.31	1.13	0.15	0.06
592	77-79 ft	98.12	0.31	1.24	0.15	0.06
593	79-84 ft	97.85	0.38	1.51	0.15	0.06
594	84-86 ft	92.23	0.16	6.88	0.19	0.06
595	86-88 ft	91.34	0.14	7.91	0.21	0.05
596	88-90 ft	94.55	0.11	4.65	0.13	0.04
597	90′ 5″-102′ 6″	86.43	0.75	12.14	0.34	0.17
598	Average 84′	98.14	0.33	1.16	0.16	0.06
599	Average 90′	97.77	0.31	1.51	0.16	0.06

Shot Drill Hole No. 11.

Elevation 90 ft. above Lake Huron.

No. of Anal.	Depth.	$CaCO_3$.	SiO_2.	$MgCO_3$.	$FeAl_2O_3$.	$CaSO_4$.
600	0-4′ 6″	97.20	0.49	1.46	0.62	trace
601	4′ 6″-8′ 6″	98.18	0.30	1.47	0.33	trace
602	8′ 6″-12 ft	98.45	0.30	1.13	0.40	0.09
603	12-15 ft	98.34	0.11	1.19	0.27	0.09
604	15-18 ft	97.80	0.38	1.34	0.31	trace
605	18-20 ft	98.25	0.29	1.13	0.12	trace
606	20-24 ft	98.03	0.22	1.78	0.20	0.09
607	24-28 ft	96.11	0.45	2.50	0.41	0.23
608	28-32 ft	91.64	0.30	7.87	0.36	0.27
609	32-37 ft	96.11	0.32	3.34	0.33	0.29
610	37-40 ft	95.61	0.25	3.97	0.34	0.35
611	40-44 ft	97.82	0.28	2.19	0.34	0.12
612	44-56 ft	96.80	0.41	2.16	0.42	trace
613	56-60 ft	97.80	0.22	2.04	0.43	0.07
614	60-63 ft	95.35	0.33	3.82	0.33	0.09
615	77-79 ft	98.03	0.18	1.76	0.50	0.05
616	Average	96.79	0.32	2.48	0.35	.....
617	79-85 ft	62.58	0.37	38.02	0.50	.....

SHOT DRILL HOLE NO. 12.

Property of Michigan Limestone and Chemical Co.

Near section line about 1600′ W., S. E. cor. Sec. 23, T. 35 N., R. 5 E.

Elevation 100 ft. above Lake Huron.

Number of analysis.	Depth.	$CaCO_3$.	SiO_2.	$MgCO_3$.	$FeAl_2O_3$.	$CaSO_4$.
618	0- 4 ft	97.99	0.27	2.07	0.37	trace
619	4- 6 ft	98.38	0.42	1.23	0.29	trace
620	6- 8 ft	97.81	0.32	2.49	0.11	trace
621	8-10 ft	98.38	0.31	1.65	0.27	trace
622	10-12 ft	98.10	0.37	1.23	0.13	trace
623	12-14 ft	97.81	0.35	2.49	0.22	trace
624	14-16 ft	97.02	0.59	2.49	0.41	trace
625	16-18 ft	98.24	0.14	2.07	0.24	trace
626	18-20 ft	97.10	0.14	2.30	0.14	trace
627	20-22 ft	96.61	0.19	2.10	0.19	trace
628	22-24 ft	96.61	0.11	2.30	0.11	trace
629	24-26 ft	98.90	0.11	2.10	0.11	trace
630	26-28 ft	97.70	0.10	2.10	0.10	trace
631	28-30 ft	97.01	0.31	2.32	0.31	trace
632	30-32 ft	97.70	0.24	2.52	0.24	trace
633	32-34 ft	97.10	0.32	2.73	0.32	trace
634	34-36 ft	97.10	0.41	1.57	0.74	trace
635	36-38 ft	97.60	0.35	1.89	0.52	trace
636	38-40 ft	97.60	0.31	1.47	0.48	trace
637	40-42 ft	98.10	0.26	1.47	0.46	trace
638	42-44 ft	98.45	0.28	0.52	0.35	trace
639	44-46 ft	97.75	0.24	1.26	0.39	trace
640	46-48 ft	97.45	0.26	1.68	0.52	trace
650	48-50 ft	97.85	0.23	1.47	0.55	trace
651	50-52 ft	95.87	0.42	3.16	0.27	0.27
652	52-54 ft	96.12	0.29	2.09	0.25	0.33
653	54-56 ft	96.37	0.20	2.72	0.33	0.13
654	56-58 ft	94.25	0.11	1.88	4.56	0.07
655	58-60 ft	96.12	0.26	1.88	0.35	0.25
656	60-62 ft	96.12	0.25	1.88	0.25	0.29
657	62-66 ft	97.60	0.25	1.67	0.22	0.16
658	66-79 ft	92.62	0.33	5.87	0.25	0.25
659	70-74 ft	97.11	0.42	1.89	1.00	trace
660	74-78 ft	92.13	0.35	6.51	0.80	trace
661	78-80 ft	91.13	0.08	5.25	3.94	trace
662	80-84 ft	97.61	0.05	1.68	1.30	trace
663	84-88 ft	92.88	0.18	4.20	1.50	trace
664	88-92 ft	92.62	0.37	4.83	1.17	trace
665	Average 60-92′	94.53	0.26	3.77	1.04	0.06
666	Average 92′	96.32	0.27	2.59	0.64	0.044
667	Average 92-100′	65.99	0.34	33.40	1.16	.....

The amount of magnesian limestone above the basal beds, however, is insignificant as compared with the amount of high calcium limestone, and does not appreciably affect the average composition of the quarry product. According to Mr. Bradley, the average of cargo analyses (Anal. No. 465) for 1914 gave 97.38 per cent of calcium carbonate and only 1.81 per cent of magnesium carbonate. The above core analyses (Nos. 469-667) show the exceptional purity of the Dundee

limestone in the vicinity of Rogers City. Analyses of cores from a number of relatively shallow holes gave similar results.

Exposures of the Dundee limestone occur at several points along the lake for fifteen miles eastward from the Calcite quarry. The most important are in the vicinity of Adams Point. Exposures also occur near Thompsons Harbor. The extent of the areas of Dundee limestone under thin drift cover, however, has not been fully determined in the region east of Calcite.

The exceptionally high average content of calcium carbonate and the low content of silica make the Dundee limestone in the vicinity of Rogers City especially adapted for flux and for general use in the chemical industries.

Traverse Formation.

Long Lake Series.

Exposures of the Long Lake or Lower Traverse series are very large and numerous in the northern part of the county where they commonly occur in the form of prominent bluffs, ridges and hills. A discontinuous line of bluffs extends from sec. 6, T. 33 N., R. 8 E., on the west side of Grand Lake, northwest through sections 19 and 20, T. 34 N., R. 7 E., to the vicinity of Liske, sec. 16, T. 34 N., R. 6 E. Apparently this line of bluffs reappears about 3 miles south of Rogers. A parallel line of bluffs extends from section 10, T. 33 N., R. 7 E., northwest of Long Lake toward Hagensville. Detached areas of the Long Lake series occur on the east side of Grand Lake. Some of the beds are very pure but the series is more or less argillaceous and bituminous and contains seams and beds of shale and magnesian limestone. Development of exposures of Long Lake limestones should be preceded by careful testing with the drill.

Limestone is exposed in a gorge of the East Branch of Rainy river, (S. E. $\frac{1}{4}$ sec. 26, T. 35 N., R. 2 E.) and is near the surface over a considerable area adjacent. The section exposed is as follows:

Section on E. Branch of Rainy river.

		Thickness, feet.
1.	Gray fossiliferous limestone containing numerous Atrypa and Gypidulas	2
2.	Very dark bituminous and fossiliferous limestone with an abundance of Acervularia, Stromatopora, and crinoid stems	3
3.	Dark gray crystalline limestone	4
4.	Gray argillaceous and fossiliferous limestone with many Atrypa and Gypidulas.	2+

An analysis of a set of samples from this exposure gave 92.97 per cent of calcium carbonate, 2.84 per cent of silica, 1.65 per cent of iron and alumina, and 2.27 per cent of magnesium carbonate.

Dark gray crystalline and bituminous limestone is also exposed a half mile north at the falls of Rainy river back of the schoolhouse in sec. 25.

At the falls of the Ocqueoc river in S. W. $\frac{1}{4}$, S. E. $\frac{1}{4}$, sec. 22, T. 35 N., R. 3 E., the following section is exposed:

Section at Ocqueoc Falls.

No. of bed.		Thickness, feet.
1.	Gray crystalline magnesium limestone	6
2.	A mass of cup corals and Stromatopora in a matrix of dark bituminous limestone	1
3.	Massive dark crystalline and bituminous magnesium limestone	3½
4.	Banded dark bituminous and crystalline magnesium limestone with Acervularia near the top	4
5.	Banded dark bituminous and mottled and streaked magnesium limestone with numerous cavities, very fossiliferous in the upper portion	8

An analysis of a set of samples from the section gave 34.74 per cent of magnesium carbonate. The very bituminous and magnesian character of the limestone apparently makes it of little economic value.

Grand Lake. A bluff of limestone about 40 feet in height occurs on the west side of Grand Lake in N. E. $\frac{1}{4}$ sec. 6, T. 33 N., R. 8 E. The following section is exposed:

		Thickness, feet.
	Drift	0–2+
1.	Dark bituminous and fossiliferous limestone with crinoid stems, acervularia, and brachiopods	2½
2.	Gray to dark bituminous limestone with scattered corals and crinoid stems	6
3.	Dark beds of bituminous limestone alternating with seams of coral, Stromatopora	10
4.	Talus	15+

The lower part of the bluff is covered with talus but according to reports shale was struck in a core drilling at 35 feet. The thickness of the shale is unknown but the Bell shale forms the floor of the deeper portions of the lake.

Core drillings put down east of Thompson's harbor in secs. 11, 12, 13, and 14, T. 34 N., R. 7 E., penetrated more or less magnesian limestone. Shale, apparently the Bell, was struck at shallow depths in a number of core drillings near the south end of Grand Lake in sec. 11, T. 33 N., R. 8 E.

Alpena Limestone.

The exposures of the Alpena limestone are large and very numerous from the south end of Black Lake southeast into Alpena county. A series of limestone ridges cross the road from Onaway north to Black Lake. The upper beds are generally gray, crystalline and fossiliferous with some very dark bituminous beds. The lower beds, as exposed in

Black Lake quarry (see Cheboygan county), are light gray, fine grained to lithographic limestone, locally with small disseminated calcite crystals. A nearly continuous bluff extends from Black Lake for several miles along the south bank of Rainy river.

Numerous exposures also occur in the vicinity of Posen. Their character has not been carefully investigated but most of the limestone is high calcium and probably of commerical grade.

Summary. Presque Isle county has large limestone resources but they have been carefully investigated, only in the vicinity of Rogers City, Black Lake, Thompsons Harbor, and on the east and west sides of Grand Lake. The exposure of the Dundee limestone at Rogers City is the largest, purest and most important of any in the state.

Schoolcraft County.

Distribution. The Engadine dolomite underlies the extreme southeastern part of Schoolcraft county along the shore of Lake Michigan. The Manistique series forms a belt extending from Garden Peninsula E-NE across the county. The Fiborn limestone and the Hendricks series form successive belts north of the Manistique series. The Cincinnati shales and the Trenton limestone cross the northern and northwestern parts of the county.

Exposures of limestone are very large and numerous in the southern part and rock is thinly drift covered over large areas. The exposures of the Engadine dolomite are usually in the form of bold cliffs. Those of the Manistique series are in a succession of ridges and small escarpments usually extending in a general E-W direction. At or near the northern limit, the series terminates in bluffs 20 to 90 feet in height. The Fiborn limestone is exposed over an area of two or three square miles in the eastern part of the county but westward it is drift covered. The Hendricks series lies almost wholly within the area of deep drift in the northern and western portions of the county.

Quarries and Localities.

Engadine dolomite.

Mouth of Bull Dog river. Massive beds of Engadine dolomite are exposed in bluffs near the mouth of Bull Dog river and form the lake bottom for a considerable distance off shore. The dolomite is very massive, crystalline and bluish white with mottlings and streaks of blue where fresh. Where altered the mottlings have become yellow

and brown. The crystalline character and bluish colorations led to considerable core drilling near the mouth of the river a number of years ago in an attempt to prove up a marble deposit.

The dolomite probably would make common building stone. The color is not permanent. Exposure to the weather for a few years is generally sufficient to alter the color to white, yellow, or brown.

Bluffs of Engadine dolomite occur on Seoul Choix Pt. and north of McDonald and Gulliver lakes. The bluff north of the lakes is near the Minneapolis, St. Paul & Ste. Marie Railroad.

Manistique. The Manistique series is exposed in the bed of Manistique river in a bluff in the eastern part of Manistique and at many places northwest from Manistique to "Big Hill" bluff in secs. 21 and 22, T. 42 N., R. 16 W., a distance of about five miles. The name of the series was taken by the writer from Manistique because of the numerous exposures in its vicinity.

Manistique quarry. The White Marble Lime Co. has operated a quarry in the bluff in the eastern part of Manistique for many years. Quarrying began near the south end of the bluff in very cherty limestone. Later operations were begun farther north where these beds are absent. The section exposed in the old and new quarries is as follows:

Section in Manistique quarries.

	Old quarries.	Thickness, feet.
	Sand and gravel	0-3
1.	Light buff crystalline, thin bedded magnesian limestone with many seams of chert nodules 2 to 6 inches in thickness	9-12
2.	Light buff massive magnesian limestone	1 8 in.
3.	Light buff crystalline, thin bedded and magnesian limestone with many nearly continuous seams of chert	8
	New quarry.	
4.	Hard bluish dense grained well bedded dolomite used chiefly for road material, concrete, and railroad ballast	10 6 in.
5.	Soft yellowish to white limestone very free from impurities. Used for burning lime	1 8 in.
6.	Light yellowish to buff cherty limestone similar to beds Nos. 1 and 3, but thicker bedded. Used for burning lime. The chert is chiefly in two beds and is readily sorted out	7 6 in.
7.	Hard, very massive bluish and fine grained dolomite. Used chiefly for road making, concrete, etc	4 6 in.
8.	Buff crystalline magnesian limestone with some chert and dense cavities. Used for burning lime	8

Experience has shown that the bluish dense grained dolomites generally burn hard and that the light colored crystalline and fossiliferous limestones burn easily.

The stone is blasted down, loaded by hand, and trammed by horse power to the foot of an incline where it is hauled to the crushing plant by cable. The better quality of stone is burned for magnesian lime

and the inferior is used for road making, concrete and railroad ballast. Much of the stone for lime burning is obtained from other quarries operated by the company.

All of the beds are either dolomite or high magnesian limestone. Analysis No. 671 and probably No. 672 are from the upper blue dolomite in the new quarry, Nos. 673-4 from the beds (Nos. 5, 6, and 8) burned for lime.

Marblehead quarry. Marblehead quarry is located about 6 miles northeast of Manistique in S. E. ¼ sec. 35, T. 42 N., R. 15 W. The quarry is opened along the southeastern side and near the top of a ridge. The workings at the time of the writer's visit (1913) were about 2000 feet long and the face about 8 feet in height. The beds are bluish and very crystalline and resemble the Engadine dolomite. The floor of the quarry is composed of soft yellowish, earthy, fossiliferous and very cherty limestone. It is locally termed "rotten" limestone and is of little value for any purpose.

The upper bed is a pure dolomite as shown by analyses Nos. 675-679. It is burned for lime and is adapted for paper manufacture.

A bluish dense grained dolomite forms the cap rock on a hill about 40 rods east of Marblehead quarry and is underlain by a light yellowish, cherty, "rotten" limestone as in the Marblehead quarry. The blue dolomite is quite different in physical qualities from that in the latter quarry. It can not be satisfactorily burned for lime.

For several miles north and east from Marblehead ridges of limestone are exposed in the fields and in road cuts. The exposures show the same alternating series of bluish, fine grained dolomites and white or light buff, crystalline, magnesian limestones, locally very cherty and fossiliferous as at Manistique. The northern edge of this area of exposures terminates in a line of bluffs on the south side of Manistique river.

"Ninety-foot" Bluff. The highest portion of this line of bluffs is in sec. 8, T. 42 N., R. 14 W., and is locally called the "Ninety-foot" bluff. The section exposed is as follows:

Section at "Ninety-foot" Bluff.

		Thickness, feet.
	Surface	0–1 +
1.	Light colored coarsely crystalline magnesian limestone. Thickness not determinable because of talus	4 ±
2.	Light buff porous, finely crystalline magnesian limestone	6 +
3.	Light buff porous finely crystalline magnesian limestone similar to bed No. 2	12 ±
4.	Hard, light buff gray densely crystalline and delicately banded dolomite, breaking with a smooth conchoidal fracture	6 ±
5.	Buff gray nodular and fossiliferous limestone, containing cup corals, favosites	5
6.	Light buff finely crystalline magnesian limestone	8 +

The lower 30 or 35 feet of the bluff is concealed by talus.

Similar but higher beds are exposed in another bluff called the "Sixty-Foot" bluff near the west quarter post of section 9, T. 42 N., R. 14 W. Analysis No. 700 is from white crystalline dolomite at the top, No. 701 from thin-bedded, light gray, crystalline dolomite 20 feet below, and No. 702 from light gray massive crystalline, dolomite 30 feet from the top. The lower 30 feet of the bluff is drift covered.

"Big Hill" Bluff. "Big Hill" bluff extends through secs. 14 and 15, T. 42 N., R. 16 W., and forms the northern limit of exposures of the Manistique series in this township. The following section was exposed:

Section at "Big Hill" Bluff.

		Thickness, feet.
	Surface	0–6 +
1.	Hard brittle white to light buff finely crystalline magnesian limestone	2–6
2.	Buff crystalline limestone having a sugary appearance. Lower part of bed concealed by talus	8 +
3.	Hard buff gray, densely crystalline, thin bedded dolomite with a smooth conchoidal fracture	6
4.	Buff nodular magnesian limestone with fossils, coral and drusy cavities. Bed partially concealed by talus	8 ±
5.	Hard brittle buff gray thin-bedded, densely crystalline dolomite	7 ±
6.	Hard buff thin-bedded, densely crystalline limestone with a smooth conchoidal fracture. The centre of the bed was concealed by talus	14 ±
7.	Soft crystalline magnesian limestone resembling brown sugar	3
8.	Buff earthy to crystalline magnesian limestone with druse cavities and fossils, chiefly corals. Weathers to a nodular mass	5
9.	Hard gray, porous crystalline and laminated magnesian limestone	8 +

The lower 25 feet of the bluff is drift covered.

Cooks Station. Similar facies of magnesian limestone and dolomite are exposed at many places for several miles northeast of Cooks Station. Formerly lime was burned in this locality. The stone used was from the densely crystalline beds and was said to burn hard.

Analysis No. 698 is from the upper, densely crystalline, beds used for burning lime and No. 699 from the underlying white, coarsely crystalline beds.

A quarry was opened for local building purposes in a low bluff near the center of sec. 28, T. 42 N., R. 17 W. The section exposed was as follows:

		Thickness, feet.
	Surface	0–6 +
1.	Cherty very fossiliferous (cup corals) limestone	2
2.	Hard buff gray finely crystalline limestone with some fossils in the upper part and many fossils, chiefly cup corals and Stromatopora in the lower part	2½
3.	Hard buff gray finely to densely crystalline and very fossiliferous (cup corals) limestone	1 +

Limestone is exposed at many places in the northeastern part of Garden Peninsula. The beds are similar in general character to those on the west shore of the peninsula (see Delta County.)

Fiborn Limestone.

Blaney quarry. The White Marble Lime Co. of Manistique operates a quarry located in section 3, T. 42 N., R. 13 W., on the Blaney and Southeastern Railroad. It is near the west end of low flat ridge of Fiborn limestone, nearly a mile in width. The ridge extends eastward through sections 1 and 2 into Mackinac county. The overburden is absent or very thin over much of the area. This is the largest area of Fiborn limestone under thin drift cover in the state.

The Fiborn limestone in the Blaney quarry has a maximum thickness of 26 feet. The stone is poorly bedded. It is gray to buff, very brittle, dense grained to lithographic, high calcium limestone, with a smooth conchoidal fracture, and containing numerous small crystals of calcite. The content of calcium carbonate generally is between 95 and 98 per cent (Anal. Nos. 680-8) and the magnesium carbonate between 1 and 2 per cent. Locally the basal portion of the bed contains more than 2 per cent of calcium carbonate.

The floor of the quarry is a white, coarsely crystalline, heavy magnesian (Anal. No. 689) limestone.

Analyses Nos. 690-1 are from a ridge about 4 feet in height in the S. W. $\frac{1}{4}$, S. W. $\frac{1}{4}$ sec. 1, and Nos. 692-3 from a cave near the center of this section.

Whitedale. A small exposure of buff to gray fine grained to lithographic, high calcium limestone occurs about five miles north of Whitedale in the road 40 rods west of the N. E. cor. of sec. 11, T. 42 N., R. 14 W. It is similar in every respect to the Fiborn limestone. Small exposures occur in the fields adjacent. The bed is overlapped on the south by gray, crystalline dolomite of the Manistique series which is exposed at a higher level in the fields and in a shallow quarry about 60 rods southeast. The exposures are only a few feet above the level of a swamp and apparently the area of this stone under favorable quarrying conditions is small. An analysis (No. 695) of a hand specimen of the buff lithographic limestone gave 55.35 per cent of calcium oxide and only 1.24 per cent of magnesian oxide.

Several small quarries have been opened north of Whitedale by the local highway officials for road material. The largest of these is in a ridge in the S. E. $\frac{1}{4}$ sec. 6, T. 42 N., R. 13 E. The quarry is about 14 feet in depth. The beds here are white crystalline limestone. The top stratum is poorly bedded but the lower ones are well bedded. The bottom bed is laminated. The area of quarryable stone could not be ascertained because of heavy timber.

The beds resemble the white crystalline low magnesian beds below the Fiborn limestone in Hendricks quarry, Mackinac county. Analysis No. 696 is of a composite sample from the upper 8 feet and No. 697 of the laminated portion at the bottom.

Summary. Schoolcraft has almost inexhaustible reserves of high magnesian limestone and dolomite. It also has very large reserves of high calcium limestone in the eastern part of the county.

Wayne County.

Distribution. The Dundee limestone occupies that portion of Wayne county south of a line drawn from Detroit southwest to the southwestern corner of the county with the exception of a small area in the southeastern corner which is underlain by the Monroe formation. There are only a few exposures, most of the county being heavily drift covered.

Quarries and Localities.

Monroe Formation.

Gibralter quarry. A knoll of Upper Monroe dolomite occurs about a mile northeast of Gibralter in sec. 35, T. 4 S., R. 10 E. For a number of years a quarry was operated at this place for building stone, road material, concrete, and railroad ballast. The quarry is about 20 feet* in depth but was full of water at the time of the writer's visit in 1913. According to Lane† all but the upper bed contain crystals of strontium sulphate. They are similar in general character to the Upper Monroe beds in Monroe county as shown by analyses Nos. 703 to 706.

Formerly a quarry was operated near the south end of Grosse Isle. Exposures also occur on Stony Island. A large amount of dolomite from the Upper Monroe series has been removed from Detroit river at Lime Kiln Crossing by the United States government in deepening the river channel. Stone companies utilize this stone for road making, concrete and railroad ballast.

Dundee limestone.

Sibley quarry. A knoll of Dundee limestone occurs at Sibley. This is the only exposure of the Dundee in Wayne county. A large quarry is operated at this place by the Solvay Process Co. of Detroit. The section‡ exposed in the quarry is as follows:

*W. H. Shuzer and A. W. Grabau, The Monroe Formation, Pub. 2, Geol. Ser., p. 52, Mich. Geol. & Biol. Surv., 1909.
†A. C. Lane, Ann. Rept.
‡W. H. Sherzer, Geology of Wayne Co. Pub. 12 Geol. Ser. 9, p. 202 Mich. Geol & Biol. Surv. 1911.

Section in Sibley quarry.

		Thickness, feet.
1.	Yellow brown to gray thin bedded and very fossiliferous limestone ($CaCO_3$, 91%; MgCO, 2.52%; Anal. No. 707)	6
2.	Thin bedded gray to bluish limestone ($CaCO_3$, 92%; $MgCO_3$, 4.62%; Anal. No. 708)	7
3.	Compact gray very fossiliferous limestone ($CaCO_3$, 94.50%; $MgCO_3$, 3.36%; Anal. No. 709)	2
4.	Compact crystalline limestone, bluish where weathered	5
5.	Compact gray to blue fossiliferous limestone ($CaCO_3$, 87%; $MgCO_3$, 9.45%; Anal. No. 711)	6
6.	Brittle bluish gray cherty limestone with some fossils. Locally termed the "14-inch flint" bed	1 2 in.
7.	Gray to bluish limestone, more heavily bedded ($CaCO_3$, 85.75%; $MgCO_3$, 10.29%; Anal. No. 712)	6
8.	Very brittle impure chert with some fossils (SiO_2, 30.87%; Anal. No. 713)	2
9.	Compact heavily bedded blue to gray fossiliferous limestone ($CaCO_3$, 93.50%; $MgCO_3$, 2.73%; Anal. No. 714)	9
10.	Oily compact heavily bedded blue to gray magnesian limestone. Less fossiliferous than No. 9. Locally called the "6-foot magnesian" bed ($CaCO_3$, 74%; $MgCO_3$, 20.58%; Anal. No. 715)	6
11.	Thin bedded gray fossiliferous limestone ($CaCO_3$, 87%; $MgCO_3$, 9.66%; Anal. No. 716)	8
12.	Light to dark gray fossiliferous and magnesian limestone "12-foot lower magnesian" bed	12
13.	Thin bedded siliceous limestone, poor in fossils	7

Two core drillings were made at Sibley quarry. The following analyses are of the core from the drilling on the west side of the quarry where beds No. 1 to 8 inclusive are absent.

Analysis of drill core, hole No. 2, Sibley quarry.

Number of analysis.	Depth, feet.	Silica. SiO_2.	Iron-Alumina. Fe_2O_3-Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Remarks.
725	0- 5	1.98	1.67	87.63	49.11	8.72	4.17	Bed 9. Quarry beds 1-8 not represented in hole.
726	5-10	1.90	1.82	87.26	48.90	9.02	4.31	Bed 10.
727	10-16	2.78	1.67	83.99	47.07	11.56	5.53	Bed 11.
728	16-20	2.39	1.89	81.08	45.44	14.63	6.99	Bed 11.
729	20-25	0.73	1.19	93.26	52.26	4.82	2.30	Fossils.
730	25-27	2.21	1.96	81.81	45.84	14.02	6.70	
731	27-33	8.16	0.72	75.99	42.58	15.13	7.23	
732	33-35	7.24	0.99	82.72	46.35	9.06	4.33	
733	35-40	2.63	0.66	92.54	92.54	4.17	1.99	Base of Dundee.
734	40-42	9.50	0.22	87.79	49.20	2.49	1.19	
735	42-45	2.89	1.57	79.99	44.82	15.45	7.39	
736	45-48	4.95	0.06	87.08	48.80	7.91	3.78	Anderdon.
737	48-53	1.50	6.50	68.38	38.32	23.64	11.30	
738	53-55	0.96	5.01	70.54	39.53	23.49	11.23	Differences mainly alumina, iron, and organic matter.
739	55-58	0.54	3.76	59.99	33.63	35.70	17.07	
740	38-62	0.49	2.21	64.72	36.27	32.57	15.58	
741	62-65	0.29	4.01	62.36	34.94	33.34	19.94	
742	65-70	0.68	2.87	59.45	28.51	37.00	17.19	Flat Rock (?)
743	70-78	0.22	2.54	54.27	30.41	43.04	.....	
744	78-80	1.05	1.92	59.15	33.15	37.88	18.12	
745	80-83	0.31	0.56	58.09	32.55	40.04	19.15	

A large amount of stone has been removed. Most of the thinly drift covered area has been quarried and the overburden—locally is becoming very heavy.

The high calcium stone is used largely in the manufacture of soda ash and related products. It is also used for sugar and paper manufacture, flux, and agricultural purposes. The more magnesian and impure stone is used for concrete, road making, and railroad ballast.

Summary. The Dundee limestone at Sibley quarry is the only exposure of high calcium limestone in Wayne county. The areas of Upper Monroe dolomite under thin drift are small and of little commercial importance at present.

Analyses[1] *of Michigan limestones by counties.*

ALGER

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
19	Near Chatham, Alger Co.	Calciferous sandstone.	Hand specimen.....	Mich. Agri. Coll. Exp. Station.
20	Mud Lake 3 mi. S. of Autrain River falls.	Sandy dolomite.....	Hand specimen.....	*Rominger.....
21	Falls of Autrain	Sandy dolomite.....	Hand specimen.....	*Rominger.....
22	Coaling Sta. No. 3 of Munising Furnace, Grand Island Bay,	Slightly sandy dolomite. Top strata on hills.	Hand specimen.....	*Rominger.....
23	Near Munising Furnace, Gd. Island Bay,	Dolomite with some sand. Top of ravine near furnace.	Hand specimen.....	*Rominger.....

*Vol. I, Pt. III, p. 78, Mich. Geol. Surv.

ALPENA

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
24	Rockport quarry, Great Lakes Stone & Lime Co.,	Rockport limestone. Quarry beds from top to bottom. Dark bituminous limestone filled with white masses of coral, stromatopora, etc.	Composite of hand specimens.	R. C. Banks, Univ. of Mich. Lab., 1915.
25	Same as above.	Representative sample of entire quarry.	Same as above.....	Diamond Alkali Co...
26	Same as above.	Same as above.....	Same as above.....	Geo. F. Harris, Mich. Limestone & Chemical Co.
27	Same as above.	Near floor of quarry..	Same as above.....	Same as above.....
28	Same as above.	Near top of bluff.....	Same as above.....	Same as above.....
29	Same as above.	Carbonaceous matter in seams and around fossils.	Same as above.....	Same as above.....
30	Michigan Alkali Co. quarry, sec. 13, T. 31 N., R. 8 E.	Upper beds Nos. 1 and 2 S. E. side of quarry. Hard buff crystalline limestone 8 ft. thick.	Composite of hand specimens taken at top and bottom of beds.	R. C. Banks, Lab. Univ. of Mich. 1915.
31	Same as above.	Bed No. 3. Hard grayish buff crystalline limestone with bituminous streaks; 9 ft. thick,	Composite of hand specimens 1 ft. apart.	Same as above.....
32	Same as above.	Bed No. 5. Dark gray crystalline limestone with bituminous streaks; 4 ft. thick.	Same as above.....	Same as above.....

[1]Figures in italics calculated from original analyses.

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
35.00	5.00		32.00	*17.93*	22.00	*10.52*	.....	Water and organic matter 6 per cent.
†23.00	0.70		42.00	*23.54*	34.00	*16.26*	.....	Residue siliceous, finer comminuted dust.
†15.00	2.00		47.00	*26.34*	36.00	*17.22*	.....	Residue of quartz sand.
†3.70	4.00		53.00	*29.70*	39.00	*18.66*	.....	Residue of quartz sand.
†6.00	5.00		49.00	*27.46*	40.00	*19.13*	.....	Residue of quartz sand.

†Insoluble in HCl.

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
0.19	‡0.77		97.25	*54.50*	1.84	*0.88*	.....	Samples collected by R. A. Smith, Mich. Geol. Surv., 1914.
1.18	1.05		94.75	*53.10*	1.55	*0.74*	.....	Collected by Mr. Marsters.
1.51	1.08		93.50	52.36	3.90	1.86	Org + H_2O 1.47	Collected by Mr. Marsters.
0.54	1.07		95.73	53.61	2.65	1.27	.....	
0.86	1.51		95.50	53.48	2.12	1.01	.....	Collected by Mr. Hollister. Volatile matter 20.50 per cent. Combustible matter 22.80 per cent
.....	.....	.....	.....	.....	.....	.....	.....	
0.41	*0.90		90.43	*50.68*	8.31	*3.97*	.....	Samples taken by R. A. Smith, Mich. Geol. Surv., 1914.
1.13	*0.75		94.54	*52.98*	2.61	*1.25*	.....	Same as above.
4.03	*1.78		92.38	*51.77*	1.80	*.86*	.....	Same as above.

*R_2O_3=Iron, alumina, etc.

Analysis[1] *of Michigan limestones by counties.*—Con.

ALPENA COUNTY.—*Con.*

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.	Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.		Remarks.
33	Same as No. 30.	Bed No. 7. Light buff crystalline limestone 3 ft. thick.	Same as above.....	Same as above.....	1.46	*0.75		95.58	*53.56*	2.11	*1.01*	.....	.....	Same as above.
34	Same as above.	Beds Nos. 9 and 10. Grayish buff to buff crystalline limestone 8 ft. thick. Lowest beds in upper quarry.	Same as above.....	Same as above.....	2.09	*0.66		94.78	*53.12*	2.45	*1.17*	.....	.....	Same as above.
35	Same as above.	Lower quarry beds, Nos. 11 to 14 inc. Dark massive, crystalline & fossiliferous limestones, 28 ft. thick.	Composite of hand specimens.	Same as above.....	1.05	*1.02		96.40	*54.03*	1.52	*.73*	.....	.....	Same as above.
36	Same as above.	Different beds in quarry.	Hand specimen.....	H. H Hindshaw.....	0.61	0.28		93.15	*52.20*	3.72	*1.77*	$CaSO_4$ None		
37	Same as above.		Hand specimen.....	H. H. Hindshaw.....	7.05	2.97		84.95	*47.61*	1.82	*.87*	0.09	.....	Sample taken by H. H. Hindshaw.
38	Same as above.		Hand specimen.....	H. H. Hindshaw.....	3.63	1.07		90.96	*50.98*	2.09	*1.00*	0.07	.....	Same as above.
39	Same as above.		Hand specimen.....	H. H. Hindshaw.....	6.51	1.50		87.79	*49.20*	2.38	*1.14*	0.07	.....	Same as above.
40	Same as above.		Hand specimen.....	H. H. Hindshaw.....	0.91	0.32		97.59	*54.69*	1.42	*.68*	trace	.....	Same as above.
41	Same as above.		Hand specimen.....	H. H. Hindshaw.....	0.48	0.30		97.14	*54.44*	2.10	*1.00*	trace	.....	Same as above.
42	El Cajon Ptld. Cem. Co., quarry, El Cajon Beach, sec. 10, T. 32 N. R. 9 E.	Long Lake beds. Shaly fossiliferous (brachiopods) limestones. 3 beds, 6 ft. section in quarry.	3 hand specimens.....	R. C. Banks, Lab., Univ. of Mich., 1915.	32.85	6.27		59.00	*33.06*	1.92	*.92*	.....	.....	Samples by R. A. Smith, Mich. Geol. Survey, 1914.
43	Alpena Portland Cement Co. quarries, Alpena.	Compact limestone from quarry opposite cement plant.	Hand specimen.....	*F. Brady, Illinois Steel Co.	0.70	0.30	0.76	96.90	*54.30*	1.30	*0.62*	S. 0.022	P_2O_5. 0.020	Samples collected by A. W. Grabau, 1901.
44	Same as above.	Fragment of Favosites with cavities filled by infiltration.	Hand specimen.....	Same as above.....	0.38	0.19	0.21	98.69	*55.30*	0.52	*0.24*	0.009	0.004	
45	Same as above.	Quarry beds.....	Hand specimen.....	*S. H. Ludlow, Alpena Ptld. Cem. Co.	0.32	0.55		98.23	*55.05*	0.98	*0.47*	.....	.....	
46	Same as above.		Hand specimen.....	Same as above.....		0.73		95.16	*53.33*	3.91	*1.87*	.....	.....	SiO_2 included in Fe_2O_3—Al_2O_3.
47	Same as above.	Bluish coralline limestone with a flinty texture.	Same as above.....	Same as above.....		0.34		98.62	*55.27*	1.04	*0.50*	.....	.....	
48	Same as above.	"Sugar stone".....	Hand specimen.....	Same as above.....	.....	.....	.....	98.32	*55.10*	.....	.....	.....	.....	
49	Same as above.	Reef of coral limestone.	Hand specimen.....	Same as above.....	0.21	.....	0.33	99.33	*55.67*	0.21	*0.10*	.....	.....	Large blast of limestone. A later blast analyzed 99.63 $CaCO_3$.
50	Same as above.	Lower part of Alpena limestone. Sample from well of cement company, depth 32 ft.	Hand specimen.....	Same as above.....	0.40	1.00		97.16	*55.45*	1.06	*0.50*	.....	.....	
51	From Alpena quarries.	Traverse limestone, quarry product as shipped to Alma Sugar Co.	Composite sample from car lots.	†A. N. Clark, Alma Sugar Co., 1902.		1.30		97.60	*54.70*	1.09	*0.52*	.....	.....	SiO_2 included in Fe_2O_3—Al_2O_3.
52	Alpena Ptld. Cement Co.	Alpena limestone, quarry beds and beds penetrated in a well near plant.		‡W. H. Sherzer.....	0.33 to 1.77	0.13 to 1.21		89.10 to 98.37	*49.93* to *55.13*	0.92 to 8.67	*0.44* to *4.14*	.....	.....	Range in composition of quarry beds.

[1]Figures in italics calculated from original analyses.

*R_2O_3=iron, alumina, etc.

Analyses of Michigan limestones by counties.*—Con.

ALPENA COUNTY.—*Con.*

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.	Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.		Remarks.
54	Alpena Ptld. Cement Co., quarries, sec. 18, T. 31 N., R. 9 E.	Top shell; removed in stripping; 1 to 2 ft. thick.	Hand specimen.....	*F. M. Haldeman, 1900.	0.36	0.13		95.91	*53.75*	3.63	*1.74*	.....	.....	All samples show traces of sulphates and phosphates.
55	Quarry C. Alpena limestone series.	Top strata 2 ft. thick. (Below top shell).	Hand specimen.....	Same as above.....	1.77	0.35		89.10	*49.93*	8.67	*4.15*	.....	.....	
56		2nd strata, 2 ft. thick.	Hand specimen.....	Same as above.....	0.33	0.18		98.37	*55.13*	0.92	*0.44*	.....	.....	
57		3rd strata, 4 ft. thick.	Hand specimen.....	Same as above.....	0.38	0.19		98.03	*54.94*	1.36	*0.65*	.....	.....	
58		4th strata, 2 ft. thick.	Hand specimen.....	Same as above.....	1.38	1.21		96.35	*54.00*	0.94	*0.45*	.....	.....	
59		1st strata, 2 ft. thick.	Hand specimen.....	Same as above.....	1.64	0.27		96.50	*54.08*	1.26	*0.60*	.....	.....	
60	Quarry F. Alpena limestone series.	2nd strata, 1 ft. thick.	Hand specimen.....	Same as above.....	1.46	0.54		96.92	*54.32*	0.98	*0.47*	.....	.....	
61		3rd strata, 2 ft. thick.	Hand specimen.....	Same as above.....	0.42	0.18		98.14	*55.00*	0.98	*0.47*	.....	.....	
62		4th strata, floor of quarry.	Hand specimen.....	Same as above.....	0.68	0.26		98.03	*54.94*	1.05	*0.50*	.....	.....	
63	Richard Collins quarry N. E. of Alpena.	Alpena limestone series. Fragmental semi-porous limestone consisting of ground up organic remains.	Hand specimen.....	*F. M. Brady, Illinois Steel Co.	0.42	0.19	0.45	98.04	*54.94*	0.88	*.42*	S. 0.014	.....	Samples collected by A. W. Grabau, 1901.
64	Richard Collins quarry, sec. 12, T. 31 N., R. 8 E.	Quarry beds, fossiliferous limestone without distinct bedding.	Composite of hand specimens.	R. C. Banks, Lab. Univ. of Mich.	1.07	‡0.77		96.84	*54.27*	1.09	*0.52*	.....	.....	Samples collected by R. A. Smith.
65	Same as above.	Limestone dipping away from coral reef. Upper layer rather blue and shaly.		*A. N. clark.....	{	Insoluble 1.10	}	95.40	*53.46*	1.76	*0.84*	.....	.....	Samples collected by A. C. Lane.
66	Owen Fox quarry, across road from Collins quarry, Alpena.	Alpena limestone series. Unweathered and unfilled Acervularia, very porous.	Hand specimen.....	*F. M. Brady, Illinois Steel Co.	0.24	0.16	0.26	98.88	*55.42*	0.45	*0.21*	S. 0.006	.....	
67	Same as above.	Lower quarry beds. Compact light crystalline limestone.	Hand specimen.....	Same as above.....	0.32	0.29	0.33	94.83	*53.15*	4.20	*2.01*	0.020	.....	
68	Same as above.	Upper quarry beds. Dark crystalline limestone.	Hand specimen.....	Same as above.....	1.18	0.31	1.79	95.29	*53.40*	1.33	*0.64*	0.089	.....	
69	Same as above.	Fragment of unaltered Stromatopora.	Hand specimen.....	Same as above.....	0.24	0.16	0.32	98.84	*55.39*	0.43	*0.20*	0.007	.....	
70	Near Lake Huron, north of Alpena.	D-1		†A. N. Clark, Alma Sugar Co.	2.80	0.40		96.13	*53.87*	0.68	*0.32*	Undet.	.....	SiO_2=insol. matter in HCl.
70b	Same as above.	Traverse limestones E		Same as above.....	1.25	0.40		96.47	*54.06*	1.60	*0.76*	0.82	.....	
71	Same as above.	A		Same as above.....	8.60	1.40		88.86	*49.80*	0.38	*0.18*	0.76	.....	
72	Same as above.	D-2		Same as above.....	1.61	.....		94.77	*53.11*	1.28	*0.61*	2.34	.....	
73	Same as above.	B		Same as above.....	1.75	.....		97.70	*54.75*	0.60	*0.29*	.....	.....	
74	Same as above.	C		Same as above.....	0.40	.....		96.36	*54.00*	3.	*1.43*	0.24	.....	
75	Isaacson property, N. E. of Alpena Ptld. Cem. Co. quarry.	Two ft. below surface.		*S. H. Ludlow, Alpena Ptld. Cem. Co.	0.79	1.06		96.75	*54.22*	0.35	*0.17*	.....	.....	
76	M. J. Griffin quarry, 1 mi. N. W. of Bolton, S. ¼ sec. 5, T. 32 N., R. 7 E.	Quarry beds very crinoidal at top but shaly, bituminous, and crystalline near bottom.	Composite sample of hand specimens.	R. C. Banks, Lab. Univ. of Mich.	1.11	‡1.21		95.02	*53.25*	2.27	*1.08*	.....	.....	Sample taken by R. A. Smith, Mich. Geol. Surv., 1914.

*A. W. Grabau, Stratigraphy of the Traverse Group, Ann. Rept. 1901, Mich. Geol. Surv., pp. 179-183.

†A. C. Lane, Ann. Rept. 1902, Mich. Geol. Surv., p. 173.

‡R_2O_3=Alumina, iron, etc.

Analyses of Michigan

ALPENA

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
77	Same as No. 76.	Railroad cut, at surface.	Lime as burned.....	*E. J. Schneider.....
78	Same as above.			*E. J. Schneider.....
79	Same as above.	1st quarry on suface of subterranean passage.	Lime as burned.....	*E. J. Schneider.....
80	Same as above.			*E. J. Schneider.....
81	Same as above.	1st quarry, top layer 5 ft. from surface.	Lime as burned.....	*E. J. Schneider.....
82	Same as above.			*E. J. Schneider.....
83	Same as above.	1st quarry, top layer 8 ft. from surface.	Lime as burned.....	*E. J. Schneider.....
84	Same as above.			*E. J. Schneider.....
85	Same as above.	New quarry, top layer from surface.	Lime as burned.....	*E. J. Schneider.....
86	Same as above.			*E. J. Schneider.....
87	Same as above.	Top layer ¼ mile from new (?) quarry.	Lime as burned.....	*E. J. Schneider.....
88	Same as above.			*E. J. Schneider.....
89	2 mi. N. of Alpena, S. W. cor. sec. 5, T. 31 N., R. 8 E.	Rock outcrops on road side. Highly fossiliferous (crinoid stems and brachiopods) limestone.	Hand specimens, from surface.	*F. M. Brady, Illinios Steel Co.
90	3½ mi. N. of Alpena, S. E. ¼ sec. 27, T. 31 N., R. 8 E.	Compact gray limestone overlying Stropheodonta shales. Long Lake beds.	Hand specimen.....	Same as above.....
91	Alpena (exact location not given).	Specimen from Alpena limestone.	Hand specimen.....	*W. M. Curtis.....
92	R. Collins quarry, N. E. of Alpena.	Quarry beds.....		*S. H. Ludlow, Alpena Ptld. Cem. Co.
93 to 138	(See text).			

ARENAC

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
140	Omsted quarry, SE. ¼ sec. 17, T. 19 N., R. 6 E.	Gray dolomite, 4 to 5 feet thick.		†W. M. Gregory.....
141	Jas. McDonnell (formerly Thos. Burt) quarry, 3 mi. NE of Omer. SE¼ SE¼ sec. 1, T. 19 N., R. 5 E.	Quarry beds. White crystalline to dense grained limestone, stained with iron and organic matter. 3 ft. thick.	Composite of several hand specimens.	R. C. Banks, Lab. Univ. of Mich.
142	Same as above.	Top stratum.....		†Dow Chem. Co.....

*A. W. Grabau, Stratigraphy of the Traverse group, Ann. Rept. 1901, Mich. Geol. Surv., pp. 179-183.
†Lane, Limestone; Ann. Rept. 1903, Mich. Geol. Surv., p. 173.

limestones by counties.—Con.

COUNTY.—*Con.*

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.		Remarks.
1.81	1.54		.....	93.44	.....	2.99	.....	.....	
1.2	0.9		94.4	*52.90*	3.5	*1.6*	.....	.....	Calculated as limestone.
0.16	1.32		.....	95.89	.....	0.53	.....	.....	
0.2	0.8		95.5	*53.52*	0.6	*0.2*	.....	.....	Calculated as limestone.
1.67	1.42		.....	96.96	.....	0.49	.....	.....	
1.0	0.8		97.6	*54.70*	0.6	*0.2*	.....	.....	Calculated as limestone.
1.39	2.56		.....	94.48	.....	0.14	.....	.....	
0.8	1.5		97.5	*54.64*	0.2	*0.09*	.....	.....	Calculated as limestone.
2.85	1.10		.....	93.51	.....	1.69	.....	.....	
1.54	0.63		95.7	*53.63*	2.13	*1.02*	.....	.....	Calculated as limestone.
1.39	1.49		.....	95.53	.....	1.81	.....	.....	
1.8	0.9		97.9	*54.87*	3.20	*1.53*	.....	.....	Calculated as limestone.
4.62	0.45	1.15	92.38	*51.77*	1.36	*0.65*	Sul. 0.029	.....	Samples by A. W. Grabau.
4.54	0.50	1.36	91.82	*51.46*	1.67	*0.80*	0.084	.....	
1.318	0.536	1.159	95.231	*53.37*	0.946	*0.45*	Sul. traces.	.....	Water, 0.3%; organic matter, 1.51%; chlorine, slight traces; alkalies, traces.
0.62	0.33	0.60	97.39	*54.58*	1.09	*.52*	.....	.....	

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
3.94	0.38	0.76	53.50	.....	41.33	.....	.....	
4.78	‡1.52		92.53	51.86	1.00	.478	.....	Samples by R. A. Smith, Mich. Geol. Surv., 1914.
1.92	0.23	0.25	95.00	53.24	1.94	.928	.....	

‡R_2O_3=iron, alumina, etc.
NOTE: Numbers in italics calculated from original analyses.

Analyses of Michigan

ARENAC

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
143	M. J. Griffin quarry near W¼ post sec. 1, T. 19 N., R. 5 E., ¾ mi. NW of McDonnell quarry.	Gray to buff limestone. Much chert in nodules and irregular masses.	Hand specimen from clearest stone.	Dow Chem. Co.....
144	Apparently from SE¼ sec. 34 and SW¼ sec. 35, T. 20 N., R. 5 E.	Light gray to white fossiliferous limestone. Small exposure. Thickness unknown.		W. M. Gregory.....
145	Harmon & Crowell quarry, SE¼ sec. 13 or NE¼ sec. 24, T. 20 N., R. 7 E.	Top stratum, 1½ ft. thick.	Hand specimen.....	Crane & Co., Chicago Ill.

CHARLEVOIX

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
146	Charlevoix Rock Products Co., main quarry, SE¼ SE¼ sec. 28, T. 34 N., R. 8 W.	Quarry beds Nos. 1-3. Bed No. 1 light buff friable "sandy" looking limestone. Bed. No. 2 earthy, and No. 3 banded buff to dark gray. Section 20 ft.	Composite of hand specimens.	R. C. Banks, Lab. Univ. of Mich.
147	Charlevoix quarries, probably secs 28 & 29, T. 34 N., R. 8 W.	Traverse limestone...		Omega Ptld. Cem. Co., Jonesville.
148	Same as above.	Traverse limestone...		
149	Charlevoix Rock Products Co. quarry No. 2, SW¼ SE¼ sec. 28, T. 34 N., R. 8 W.	Top bed or No. 1. Yellow, friable earthy and very fossiliferous limestone, 3 ft. thick.	Hand specimen.....	R. C. Banks, Lab. Univ. of Mich., 1915
150	Same as above.	Bed No. 3. Hard, gray, crystalline limestone, 4 ft. thick.	Composite of hand specimens.	Same as above.....
151	Wolverine Lime Co., Charlevoix. Quarry in S½ SE¼ sec 29, T. 34 N., R. 8 W.	Small quarry 7 ft. deep, gray crystalline limestone similar to bed 3 in quarry No. 2 of Charlevoix Rock Products Co.		Same as above.....

limestones by counties.—Con.

COUNTY.—*Con.*

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
0.90	0.24	0.44	96.60	54.14	1.78	.851	.....	
5.90	0.12	0.36	92.30	51.72	1.32	.631	.....	
3.24	1.74		93.57	52.45	1.68	.803	.....	

‡R_2O_3=iron, alumina, etc.

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium Carbonate. $MgCO_3$.	Magnesium Oxide. MgO.	Miscellaneous.		Remarks.
0.29	0.51		97.46	*54.62*	1.44	*0.69*	.....	.....	
0.18	0.22		98.76	*55.35*	0.71	*0.34*	SO_3 none	....	Analysis furnished by Andrew Dougherty.
0.66	0.44		97.47	*54.62*	1.32	*0.63*	SO_3 none	....	Same as above.
.....	.....		89.56	*50.19*	.....	.....	.....	.....	Stone much weathered.
1.21	1.40		95.94	*53.77*	1.24	....	phos. 0.026	....	
0.82	0.40	0.45	97.05	*54.39*	1.05	.....	Sul. 0.039	Mn. 0.00	

NOTE: Numbers in italics calculated from original analyses.

Analyses of Michigan limestones by counties.

CHARLEVOIX COUNTY.—*Con.*

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.	Silica. SiO_2.	Iron Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.		Remarks.
												S.	Mn.	
152	Same as above.													
153	Wolverine Lime Co., Charlevoix, secs. 29 and 32, T. 34 N., R. 8 W.	Traverse limestones. Some or all of samples probably from quarry noted above.	Probably hand specimens.	D. H. Stacks, 1912.	0.64	0.80	0.77	96.85	*54.28*	0.74	.....	0.050	0.00	Analyses furnished by E. S. Stacks, Wolverine Lime Co.
					0.58	0.60	0.63	96.72	*54.20*	0.88	.....	0.073	0.00	
154	Same as above.													
155	Charlevoix quarries, probably secs. 28 and 29, T. 34 N., R. 8 W.	Traverse limestones...	.....	.....	1.52	0.55	0.72	96.54	*54.10*	0.82	.....	.038	0.00	
					5.20	2.60		88.97	*49.86*	2.59	*1.25*	0.00	.....	Analysis furnished by Andrew Dougherty.
156	Same as above.	Traverse limestones...	.....	R. E. Doolittle.....										
157	Same as above.	Traverse limestones...	.....	R. E. Doolittle, 1903..	5.20	3.12		90.93	50.92	0.87	*.42*	.....	.....	Same as above.
158	Same as above.	Traverse limestones...	.....	R. E. Doolittle, 1903..	5.04	3.14		88.64	49.64	2.06	*.98*	.....	.....	Same as above.
159	Same as above.	Traverse limestones...	.....	R. E. Doolittle, 1903..	5.10	2.48		91.42	51.20	0.92	*.44*	.....	.....	Same as above.
160	Norwood, low bluff on lake shore 1 mi. N., NE¼ sec. 34, T. 33 N., R. 9 W.	Upper Traverse series. Gray drusy dolomite finely crystalline....	Hand specimen.....	*Rominger.....	5.58	2.68		90.75	50.82	1.56	*.75*	.....	.....	Same as above.
161	Norwood, old quarry 1½ mi. N-NE. near NW. cor. NE. ¼ sec. 26, T. 33 N., R. 9 W	Light gray lithographic to dense grained limestone with many small crystals of calcite. Thickness exposed 5 ft.	Composite of hand specimens.	R. C. Banks, Lab. Univ. of Mich., 1915	Insol. 0.4	2.80		56.00	*31.38*	39.00	*18.66*	.....	.....	
162	Northern Lime Co., Bayshore or "Standard" quarry, S½ S½ sec. 6, T. 34 N., R. 6 W.	W. end of quarry bed. White to light gray limestone at top; beds 3, 4, and 5; soft yellow "sugary" limestones. Section about 15 ft. Bed No. 2 worthless—not sampled.	Same as above.....	Same as above.....	1.28	0.75		96.70	*54.19*	1.19	*.57*	.....	.....	Sample by R. A. Smith, Mich. Geol. Surv.
163	Bayshore Lime Co., Bayshore quarry. (Now Northern Lime Co., "Standard" plant).	High calcium beds, lower part of quarry.	.....	W. G. Banks, 1902...	0.16	0.55		79.16	*44.36*	20.03	*9.58*	.....	.....	
164	Northern Lime Co., Bayshore or "Standard" quarry.	Lime as burned from quarry.	Lump lime.....	Ashland Steel & Iron Co., 1902.	3.37	2.57		*91.77*	51.43	*1.04*	0.50	SO_3 0.60	.....	Diff. 0.38 per cent.
165	Same as above.	Same as above.....	Lump lime.....	Elk Rapids Portland Cement Co.	Insol. 0.77	0.77		.....	78.86	.....	15.54	CO_2+H_2O 4.06	.....	
(166-173, see text).														
174	Bayshore, 1 mi. E on lake shore. (3 mi. E Khagashewing Point.—Rominger.	Dark lithographic limestones at and just above lake level. 2 beds, upper 6-8 ft. thick.	Hand specimens.....	*Rominger.....		1.12		.....	73.45	.....	19.09	6.60	.....	
175	Northern Lime Co. "Superior" plant 2 mi. W. of Bayshore, S½ sec. 2, T. 35 N., R. 7 W.	Quarry beds Nos. 1-5; E. end. Yellowish white to yellow earthy limestones, laminated bituminous bed at bottom. Section 25 ft.	Composite of hand specimens.	R. C. Banks, Lab. Univ. of Mich., 1915	Insol. 1.00	.....		98.00	*54.92*	1.00	*0.48*	.....	.....	Approximate average analysis.
176	Khagashewing Point, old quarry.	Apparently the brownish sugary dolomites just below the light yellowish white earthy limestone seen in the Superior quarry of No. Lime Co.	Hand specimen.....	*Rominger.....	0.44	0.36		89.39	*50.10*	9.80	*4.69*	.....	.....	Samples by R. A. Smith, Mich. Geol. Surv.
					Insol. 0.50	1.50		58.00	*32.50*	38.00	*18.18*	.....	.....	

*Vol. III, Pt. I, pp. 58-60, Mich. Geol. Surv., 1869-1873.

NOTE: Numbers in italics calculated from original analyses.

Analyses of Michigan limestones by counties.

CHEBOYGAN COUNTY.

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.	Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
177	Campbell Stone Co., Afton quarry. Sec. 36, T. 35 N., R. 2 W.	Top bed, light gray dense grained to crystalline limestone, 0-5 ft. thick. (cup corals).	Hand specimen.....	R. C. Banks, Lab. Univ. of Mich., 1915	0.54	0.45		97.32	*54.54*	1.08	*0.52*	.....	Samples by R. A. Smith, Mich. Geol. Surv.
178	Same as above.	Bed No. 2 from top. Black bituminous coralline (cup corals) limestone, 6 ft. thick.	Hand specimen.....	Same as above.....	0.63	0.62		92.60	*51.90*	2.56	*1.22*	Org. 2.61	Same as above.
179	Same as above.	Bed No. 3. "Paper stone" bed. Light gray crystalline limestone, 4 ft. thick.....	Composite of hand specimen.	Same as above.....	0.24	1.44		96.97	*54.34*	0.12	*0.05*	.....	Same as above.
180	Same as above.	Beds Nos. 5 & 6. Both beds very bituminous and laminated. No. 5, 2½ ft. thick; No. 6, 5½ ft. thick.	Same as above.....	Same as above.....	0.28	0.37		98.04	*54.94*	1.07	*0.51*	.....	Same as above.
181	Same as above.	Beds 8, 9 and 10—lower 12 ft. of quarry	Same as above.....	Same as above.....	1.75	0.64		95.75	*53.66*	1.24	*0.59*	.....	Same as above.
182	Same as above.	Light colored stone...	Hand specimen.....	C. R. Lindfors, Mich. Sugar Co., 1907.									
183	Same as above.	Black bituminous limestone, (Bed No. 2?).	Hand specimen.....	Same as above.....	1.00	0.14		97.68	*54.74*	1.05	*0.50*	Org. 0.05	Insol. SiO_2, 0.96%; sol. SiO_2, 0.04%; moisture 0.05%.
					1.09	0.24		97.33	*54.54*	1.11	*0.53*	0.19	Insol. SiO_2, 1.06%; sol. SiO_2, 0.03%; moisture 0.04%.
184	Campbell Stone Co., Afton. NW¼ NE. ¼ sec. 36, T. 35 N., R. 2 W	Drill core 4 to 42 ft. Present quarry section. 4 ft. of surface.	Drill core, average analyses (made every 2 ft.).	Campbell Stone Co. 1907.	2.10	0.34		96.52	*54.09*	0.90	*.43*	0.08	$CaCO_3$ varied from 95% to 97.40%. Analyses every 2 ft.
185	Same as above.	Drill core 42 to 100 ft.	Same as above.....	Same as above.....	3. to 5.00	.....	.....	.....	.....	6. to 9.00	2.87 to 4.30	.....	
186	Campbell Stone Co., Afton. SW ¼ SE ¼ sec. 19, T. 35 N., R. 1 W.	Drill core 2 to 30 ft., 6 in.	Same as above.....	Same as above.....	3.40	0.38		94.20	*52.79*	1.80	*.86*	.....	Similar analyses for cores from SW¼ NE¼ sec. 25, T. 35 N., R. 2 W., also from NW¼ SW¼ sec. 13, T. 34 N., R. 2 W., and NW¼ SW¼ of same section.
186a	Black Lake quarry, 6 mi. N. of Onaway sec. 12, T. 35 N., R. 1 E.	Light gray fine grained limestone with calcite crystals.	Hand specimens.....	R. C. Banks, Lab Univ. of Mich., 1915	0.39	0.52		96.84	*54.27*	2.03	*.97*	.....	Samples by R. A. Smith, Mich. Geol. Surv., 1914.
187	Marion Stone Co., Afton, N E¼ sec. 7, T. 34 N., R. 1 W.	Quarry beds 1 to 5, and No. 7. Gray dense grained to crystalline limestone, fossiliferous in places. Section 21 ft.	Composite of hand specimens.	Same as above.....	0.80	0.55		96.88	*54.29*	1.24	*.59*	.....	Same as above.
188	W. G. Durrell property. Private claim 334.	Dundee limestone. Buff to gray bituminous limestone.	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		94.63	53.03	2.90	*1.39*	.....	
189	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		69.40	38.89	27.91	*13.35*	.....	
190	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		96.24	53.93	2.60	*1.24*	.....	
191	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		92.16	51.65	7.00	*3.35*	.....	
192	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.49	54.63	0.20	*.09*	.....	
193	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.69	54.74	0.72	*.34*	.....	
194	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		80.05	44.86	19.48	*9.32*	.....	Analyses of samples from exposures on Mill Creek, numbered in order from mouth of creek up stream for about 1200 ft.
195	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		98.83	55.38	0.87	*.42*	.....	
196	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		94.59	*53.01*	3.30	*1.58*	.....	
197	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		96.04	*53.82*	0.68	*.32*	.....	
198	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.10	*54.42*	0.80	*.38*	.....	
199	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		96.96	*54.34*	1.28	*.61*	.....	
200	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		96.18	*53.90*	1.75	*.84*	.....	
201	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		92.19	*51.66*	0.24	*.11*	.....	
202	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		94.94	*53.21*	0.80	*.38*	.....	
203	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		93.44	*52.37*	1.21	*.58*	.....	
204	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		94.91	*53.19*	3.66	*1.75*	.....	
205	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		94.08	*52.72*	1.50	*.72*	.....	
206	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.70	*54.75*	1.45	*.69*	.....	
207	Same as above.	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		96.25	*53.94*	1.65	*.79*	.....	

NOTE: Numbers in italics calculated from original analyses.

Analyses[1] of Michigan limestones by counties.

CHEBOYGAN COUNTY.—*Con.*

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.	Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $CaCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
208	Same as 207..	Same as No. 207.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.44	*54.61*	0.39	*.18*	.....	
209	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.14	*54.44*	0.90	*.43*	.....	
209a	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.64	*54.72*	0.96	*.46*	.....	
210	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.63	*54.71*	0.17	*.08*	.....	
211	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		98.21	*55.04*	0.36	*.17*	.....	
211a	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		98.43	*55.16*	0.99	*.47*	.....	
211b	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.63	*54.71*	0.26	*.12*	.....	
211c	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		96.05	*53.83*	0.12	*.05*	.....	
211d	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		99.07	*55.52*	0.13	*.06*	.....	
211e	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		97.09	*54.41*	0.90	*.43*	.....	
211f	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		96.43	*54.04*	2.70	*1.29*	.....	
211g	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		98.11	*54.98*	2.40	*1.15*	.....	
211h	Same as above	Same as above.....	Hand specimens.....	Prof. Stebbins.....	.....	Undet.		99.79	*55.92*	trace	.....	.....	
211i	Same as above	Same as above.....	Hand specimens.....	W. N. Thayer, Emery Inst. Cincinnati, O.	.....	‡0.87		99.13	*55.55*	none	.....	.....	
211j	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.47		98.53	*55.22*	trace	.....	.....	
211k	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	0.78		99.22	*55.60*	none	.....	.....	Same as No. 207.
211l	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.45		98.55	*55.23*	trace	.....	.....	
211m	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.36		98.64	*55.28*	trace	.....	.....	
211n	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	0.25		99.75	*55.90*	none	.....	.....	
211o	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.47		98.53	*55.22*	trace	.....	.....	
211p	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.54		98.46	*55.18*	trace	.....	.....	
211q	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	0.41		99.59	*55.81*	none	.....	.....	
211r	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	2.16		97.84	*54.83*	trace	.....	.....	
211s	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	0.79		99.21	*55.60*	none	.....	.....	
211t	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.44		98.56	*55.23*	trace	.....	.....	
211u	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.23		98.17	*55.02*	trace	.....	.....	
211v	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.88		98.12	*54.99*	trace	.....	.....	
211w	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	0.88		99.12	*55.55*	none	.....	.....	
211x	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.71		98.29	*55.08*	trace	.....	.....	
211y	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.13		98.87	*55.41*	none	.....	.....	
211z	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	2.08		97.92	*54.88*	trace	.....	.....	
211aa	Same as above	Same as above.....	Hand specimens.....	Same as above.....	.....	1.82		98.18	*55.02*	trace	.....	.....	
212	W. G. Durrell quarry near mouth of Mill Cr. Private claim No. 334.	Sample taken at 18 in. from top of quarry.	Hand specimens.....	Lab. Kelley Island Lime & Transportation Co., Cleveland, Ohio.	0.16	Undet.		82.62	46.30	16.97	*8.11*	.....	
213	Same as above	At 3 ft.....	Hand specimens.....	Same as above.....	0.24	Undet.		98.83	55.38	0.69	*.33*	.....	
214	Same as above	At. 7 ft.....	Hand specimens.....	Same as above.....	0.16	Undet.		98.28	55.08	1.36	*.65*	.....	
215	Same as above	At 10 ft.....	Hand specimens.....	Same as above.....	0.12	Undet.		98.83	55.38	1.01	*.48*	.....	
216	Same as above	Buff to gray and very dark bituminous limestone. Face 26 ft. 6 in. At 12 ft.	Hand specimens.....	Same as above.....	0.08	Undet.		97.84	54.83	1.92	*.92*	.....	Samples collected by F. A. Jones, Mgr. Operations, Kelley Island Lime & Trans. Co., 1915.
217	Same as above	At 16 ft.....	Hand specimens.....	Same as above.....	0.44	Undet.		93.43	52.36	5.98	*2.86*	.....	
218	Same as above	At 18 ft.....	Hand specimens.....	Same as above.....	0.16	Undet.		98.77	55.36	1.03	*.49*	.....	
219	Same as above	At 20 ft.....	Hand specimens.....	Same as above.....	0.20	Undet.		98.60	55.25	1.08	*.52*	.....	
220	Same as above	At 22 ft.....	Hand specimens.....	Same as above.....	0.20	Undet.		98.55	55.23	1.17	*.56*	.....	
221	Same as above	At 26 ft.....	Hand specimens.....	Same as above.....	0.32	Undet.		98.83	55.38	1.27	*.61*	.....	
222	Same as above	At 26 ft.....	Hand specimens.....	Same as above.....	0.12	Undet.		98.33	55.10	1.27	*.61*	.....	
223	Same as above	Average.....	Hand specimens.....	Same as above.....	0.20	Undet.		96.62	54.14	3.02	*1.44*	.....	
224	Same as above	Average 3-26 ft.....	.....	.....	0.204	Undet.		98.028	54.93	1.678	*.80*	.....	
226	Same as above	Grayish buff crystalline bituminous limestone, E. bank of Mill Creek 250 ft. from highway; 22 ft. section.	Composite of samples taken 6 in. apart from 22 ft. ledge.	R. C. Banks, Lab. Univ. of Mich.	1.67	*0.73		95.29	53.34	2.11	*1.00*	.....	Samples collected by Mich. Geol. Survey.
227	Same as above.	Same as above.....	Same as above.....	G. F. Harris, Mich. Limestone & Chemical Co., Rogers.	1.10	0.20		96.52	54.05	2.00	0.96	.....	Same as above.
228	Same as above.	Basal magnesian beds of the Dundee. Soft light to dark buff "sugary" limestone, bituminous. Test hole 6 ft. deep.	Composite of several hand specimens.	A. R. Todd and W. B. Scovill, Dept. State Dairy and Food.	1.97	*0.90		75.80	42.48	†21.33	*10.20*	.....	Samples taken in 1915 by L. W. Durrell and C. B. Fleming.

[1]NOTE: Numbers in italics are calculated from original analyses.

*R_2O_3=iron, alumina, etc.
†Magnesium carbonate by difference, not weighed.
‡Includes silica, iron, and alumina.

Analyses[1] *of Michigan limestones by counties.*

CHIPPEWA COUNTY.

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
229	West Neebish Rapids, St. Marys River.	Hard crystalline dolomite with some sand.	Probably hand specimens.	.....
230	NE. cor. of Encampment d'Ours Island.	Light colored brittle fossiliferous limestone; top beds.	Composite of 2 hand specimens.	*C. Rominger.
231	NE. cor. St. Joseph Island	Blue thin bedded nodular limestones with shale partings; middle strata.	Same as above.....	*C. Rominger.....
232	Same as above.	Bluish or greenish very sandy limestone with shale streaks. Lowest exposed beds at water's edge.	Same as above.....	*C. Rominger.....
233	Sulphur Island.	Sandy dolomite, top stratum on island.	Same as above.....	*C. Rominger.....
234	Marblehead quarry, Drummond Island, sec. 31, T. 42 N., R. 7 E.	6 ft. bed at top of quarry, 36 ft. above Lake Huron. Dark gray very crystalline dolomite.	Rock specimen.....	*C. Rominger.....
235	Same as above.	9 ft. bed below the 6 ft. bed. Yellowish white earthy fracturing dolomite.	Rock specimen.....	*C. Rominger.....
236	Same as above.	Lower beds of quarry; crystalline dolomite.	Rock specimen.....	*C. Rominger.....
236a	Drummond Island, exact location not given.	Niagara dolomite, siliceous and argillaceous.	.....	W. G. Miller, Geol. Surv. Can.
237	Marblehead, Drummond Island. Outcrop short distance N. of quarry.	Ash colored acervularia limestone 3 ft. thick near lake level.	Rock specimen.....	*C. Rominger.....
238	Same as above.	5 ft. drak gray bituminous nodular limestone, 30 ft. below acervularia bed.	Rock specimen.....	*C. Rominger.....
238a	Same as above.	Lowest beds in the Marblehead section.	Rock specimen.....	*C. Rominger.....
239	W. side Sitgreaves bay, Drummond Island.	Loose slabs just above the Hudson River group.	Rock specimen.....	*C. Rominger.....
240	Ludlow Seaman quarry, Drummond Island.	Upper 19 ft. of quarry. Hard finely crystalline dolomite.	4 pieces, 1 from each bed.	L. C. Nodell and C. K. Wirth, Univ. of Mich., 1914.
240a	Quarry Pt., W. side Drummond Island.	Quarry stone, laminated beds.	Rock specimen.....	*C. Rominger.....
240b	Same as above.	Sole bed of above quarry, more crystalline than the laminated beds.	Rock specimen.....	*C. Rominger.....
241	Lime Island, old quarry just north of Pittsburg Coal Co., St. Mary's River.	Hard buff to white finely crystalline dolomite beds, 10 to 28 ft. above river level.	Composite sample, 4 rock specimens.	L. C. Nodell and C. K. Wirth, Univ. of Mich., 1914.

[1]Figures in italics calculated from original analyses.
*Vol. I, Pt. III, pp. 48 and 78.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
†6.00	2.00		52.00	*29.14*	40.00	*19.13*	.....	Residue of quartz sand.
†8.00	1.00		89.00	*49.87*	2.00	*.95*	.....	Insoluble residue, quartzose.
†13.00	1.50		82.00	*45.95*	3.00	*1.43*	.....	Insoluble residue, argillaceous.
†4.06	1.60		47.30	*26.51*	2.50	*1.19*	.....	Residue chiefly of coarse quartz sand.
†12.00	3.00		47.00	*26.34*	38.00	*18.18*	.....	Residue of quartz sand.
†3.00	2.00		62.00	*34.75*	33.00	*15.78*	.....	Cloudy bituminous residue with some quartz granules.
†2.00	‡4.00		54.00	*30.26*	39.00	*18.65*	.....	Bituminous and siliceous residue.
†7.00	2.00		58.00	*32.50*	32.00	*15.31*	.....	Residue silicio-argillaceous.
4.33	4.14		51.18	*28.68*	39.38	*18.84*	.....	Iron and alumina exceptionally high, probably from lower Lockport.
†2.00	2.00		95.00	*53.24*	1.00	*.48*	.....	
†2.00	1.00		94.00	*52.68*	2.00	*.96*	.....	Residue bituminous with some quartz granules.
†9.00	2.00		52.00	*29.14*	35.00	*16.74*	.....	Silicio-argillaceous residue.
†6.00	3.00		52.00	*29.14*	38.00	*18.18*	.....	Siliceous residue.
1.71	**0.67		*55.47*	31.09	*45.78*	21.90	.....	Block stone quarried for construction purposes.
†1.00	1.00		60.00	*33.62*	32.00	*15.30*	.....	Same as above.
†1.00	1.00		59.00	*33.06*	38.00	*18.17*	.....	Siliceous residue.
1.25	**0.76		*36.40*	31.61	*44.55*	21.31	.....	Stone formerly burned for lime.

**R_2O_3=alumina, iron, etc.
†Insoluble in HCl.
‡Chiefly alumina.

Analyses of Michigan

CHIPPEWA

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
242	Point Detour, S t. Marys River.	Engadine dolomite. Light gray crystalline dolomite.	Rock specimen.....	*C. Rominger.....
243	Outcrop on logging railroad, sec. 8, T. 42 N., R. 2 E.	Engadine dolomite. Blue coarsely crystalline dolomite.	Rock specimen.....	L. C. Nodell and C. K. Wirth, Univ. of Mich., 1914.
244	¾ mi. S. of Haff P. O. (Dick) sec. 29, T. 44 N., R. 5 W., on Trout Lake-Ozark road.	Engadine dolomite, lower 20 ft. bed. Bluish coarsely crystalline dolomite, 2 ft. from top of bed.	Rock specimen.....	Same as above.....
245	Same as above.	Engadine dolomite, upper 30 ft. bed. Bluish gray coarsely crystalline dolomite, 20 ft. from bottom of bed.	Rock specimen.....	Same as above.....
246	H a ff P. O. (Dick), sec. 20, T. 44 N., R. 5 W., N. side of high bluff. Property of L. O. Poquin.	Engadine (?) dolomite or fossiliferous beds beneath.	Several rock specimens.	Dr. A. H. White, Mich. Univ. Lab.

DELTA

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
247	John Bichler q u a r r y, Groos P. O., 4 mi. N. of Escanaba.	B l u i s h argillaceous limestone. Top 11 ft.	Composite of 3 hand specimens.	L. C. Nodell and C. K. Wirth, Lab. Univ. of Mich., 1914.
248	Same as above.	Bluish argillaceous and fossiliferous limestone. Lower beds in quarry.	Composite of 2 hand specimens.	Same as above.....
249	East bank Escanaba River 1 mi. above mouth.	Bluish argillaceous and siliceous dolomite, highest strata exposed along river.	.....	*C. Rominger.....
250	Escanaba River 1½ mi. above mouth.	Wedge-shaped siliceous limestones next below the top strata.	.....	*C. Rominger.....
250a	White Fish River.	Trenton limestone.	.....	*C. Rominger.

*Vol. I, Pt. III, pp. 48 and 78.
†Insol. in HCl.

limestones by counties.

COUNTY.—*Con.*

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
†1.00	traces.		56.00	*31.38*	43.00	*20.57*	.....	
0.39	**0.22.....		56.24	31.52	43.06	22.60	.....	Typical specimen.
0.47	**0.23.....		55.94	31.35	42.77	20.46	.....	Bed very uniform in general character from top to bottom
0.32	**0.33.....		56.31	31.56	43.23	20.68	.....	Same as above.
0.80	0.32	0.71	52.97	29.76	44.22	21.16	.....	Sample dried at 105°-107°. Sample furnished by L. O. Poquin.

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
4.73	**2.71		*73.80*	41.36	*17.70*	8.51	.....	Sample collected by Mich. Geol. Surv.
4.85	**2.55		*79.92*	44.79	*13.25*	6.34	.....	Same as above.
†5.50	3.00		52.00	*29.14*	38.50	*18.42*	.....	Insoluble residue, silicio-argillaceous.
†6.40	1.00		88.00	*49.32*	4.00	*1.91*	.....	Insoluble residue, siliceous.
7.00	2.50		51.00	.....	38.00	.....	.....	Quartzoze residue.

‡Chiefly alumina.
**R_2O_3=alumina, iron, etc.
Note.—Numbers in italics are calculated from original analyses.

Analyses of Michigan

DELTA

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
251	Lower Falls of Escanaba River, 6 mi. above mouth.	Fossiliferous, shaly, and sandy limestones below the wedge-shaped limestones.	.....	*C. Rominger.....
252	Old quarry on N. bank of Days River, NE. sec. sec. 3, T. 40 N., R. 22 W.	Buff gray crystalline limestone. 6-ft. exposure.	2 hand specimens.....	L. C. Nodell and C. K. Wirth, Lab. Univ. of Mich., 1914.
253	Road cut 1 mi. NW. Rapid River NE. cor. sec. 19, T. 41 N., R. 21 W.	Buff gray crystalline and fossiliferous limestone. 4 ft. exposure.	Hand specimen.....	Same as above.....
254	Burnt Bluff, sec. 24, T. 38 N., R. 19 W.	Thin bedded dolomites lower 60 ft. of bluff.	Hand specimen.....	*C. Rominger.....
255	to 281, see text.			

EATON

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
282	Burt Portland Cement Co. quarry, Bellevue.	Main quarry beds, white to light gray limestone 12 ft. thick, east side of quarry.	Hand specimen.....	R. C. Banks, Lab. Univ. of Mich.
283	Same as above.	White limestone, main quarry beds.	.....	C. H. Denman, Burt Ptld. Cem. Co.
284	Bellevue quarries.	Light colored limestone with smooth conchoidal fracture, 8-10 ft. thick.	.....	†C. Rominger.....
285	Burt Portland Cement Co. quarries, Bellevue.	White to light gray limestones. Anal. of matter sol. in HCl.	.....	H. R. Brown.....
286	Same as above.	White to light gray limestones. Anal. of gangne insol. in HCl.	.....	.....
287	Same as above.	Brown dolomite stratum near top of quarry beds; 1 foot thick.	.....	†C. Rominger.....
288	to 294, see text.			

*Vol. I, Pt. III, pp. 48 and 78, Mich. Geol. Surv.
†Vol. III, Pt. I, p. 113.

limestones by counties.

COUNTY.—*Con.*

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
‡20.80	2.40		55.8	*31.27*	21.00	*10.00*	.....	Insoluble residue of quartz sand and some clay.
6.81	†2.96		*82.49*	46.79	*4.24*	2.03	.....	Samples collected by Mich. Geol. Surv.
5.14	†2.51		*81.98*	45.95	*10.36*	4.96	.....	Same as above.
‡2.50	1.00		56.60	*31.72*	39.00	*18.65*	.....	

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $CaCO_3$.	Magnesium oxide. MgO.	Remarks.
2.56	R_2O_3 1.59		94.78	53.12	1.03	0.492	
1.30	0.99	0.66	95.98	53.79	2.04	0.975	Analysis furnished by the Burt Ptld. Cement Co.
Insol. 1.50	Hyd. 0.50		96.00	53.80	1.00	0.478	
Sol. 0.1208	0.2093 FeO 0.2916	0.1008	95.10	53.300	1.009	0.483	Manganese 0.0449; arsenic, trace; sulphuric anhydrite.
Insol. 1.984		0.369	37.47	0.21	.....	.....	Sulphur as pyrites 0.175; organic matter 0.1334; diff. 0.145.
Insol. 9.00	5.50		56.00	31.38	23.00	11.00	

†R_2O_3=iron, alumina, etc.
‡Insoluble in HCl.
NOTE:—Figures in italics calculated from original analysis.

Analyses of Michigan

EMMET

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
295	No. Lime Co., quarry C, (W. quarry) Petoskey. Formerly Mich. Lime Co. In bluffs along Little Traverse Bay	Top 15 feet.....	.....	E. D. Campbell, Lab. Univ. of Mich., 1901
296	Same as above.	Next 10 feet.....	.....	Same as above.....
297	Same as above.	Next 6 feet.....	.....	Same as above.....
298 to 302, see text.				
303	No. Lime Co., Petoskey, quarry C.	Gray earthy limestone with streaks of lithographic stone. Lower 22 ft. of main quarry.	Composite of hand specimens.	R. C. Banks, Lab. Univ. of Mich., 1915
304	No. Lime Co., Petoskey, Test pit next the office in quarry C.	Gray lithographic to dense grained earthy limestone. Lower beds with bituminous laminae. Sect. about 8 ft.	.....	Same as above.....
305	No. Lime Co., Petoskey, quarry B.	Beds Nos. 2, 3, 4, 7 and 8 from top.	.....	Same as above.....
306	Same as above.	Bed No. 6, high calcium bed. Densely crystalline to earthy limestone. Burned for chemical lime; 6 ft. thick.	.....	Same as above.....
307	Same as above.	Bed No. 1. Top coralline and stromatoporoid dolomitic limestone. Mass of fossils in matrix of buff friable "brown sugary" limestone; 15-20 ft. thick.	Hand specimens.....	Same as above.....
308	Petoskey, quarry uncertain.	Dark fine grained bituminous limestone with shale like appearance. Strong odor of petroleum when struck.	Hand specimens.....	A. N. Clark, Alma Sugar Co., 1902.
309	Same as above.	"Stratum 1".....	Keg of samples.....	Same as above.....
310	Same as above.	"Stratum 2".....	Keg of samples.....	Same as above.....
311	Antrim Lime Co., Petoskey. Western part of city.	Upper 12 ft. of quarry. White earthy limestone.	Composite of hand specimens.	R. C. Banks, Lab. Univ. of Mich., 1915
312	Same as above.	Lower 12 ft. of quarry; upper beds white and earthy; lower buff laminated earthy to druse grained.	Same as above.....	Same as above.....

limestones by counties.

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Miscellaneous.	Remarks.
0.29	0.04	1.79	56.51	*31.67*	42.65	*20.40*	....	
0.10	Aver. 0.01	0.83	71.42	*40.03*	27.89	*13.34*	....	Analyses furnished by No. Lime Co.
.....		0.60	92.23	*51.69*	6.00	*2.87*	....	
0.68		0.27	82.50	*46.24*	16.30	*7.80*	....	Samples by R. A. Smith, Mich. Geol. Surv.
0.26		0.32	96.36	*54.00*	2.58	*1.23*	....	Same as above.
0.22		0.23	86.14	*47.28*	13.11	*6.27*	....	Same as above.
0.26		0.28	94.78	*53.12*	4.18	*2.00*	....	Same as above.
0.09		0.46	62.86	*35.23*	36.41	*17.42*	....	Same as above.
Insol. 0.44		0.43	96.58	*54.13*	2.00	*.95*	....	Bed uncertain but probably from bituminous laminated beds in test pit in quarry C, Northern Lime Co., Petoskey.
Insol. 1.03		0.80	83.05	*46.54*	15.11	*7.23*	....	
Insol. 1.21		0.70	90.62	*50.79*	7.47	*3.57*	....	
0.18		0.29	97.40	*54.59*	2.15	*1.03*	....	Samples by R. A. Smith, Mich. Geol. Surv., 1914.
0.87		0.58	87.14	*48.84*	11.33	*5.42*	....	Same as above.

NOTE: Figures in italics calculated from original analyses.

Analyses of Michigan

EMMET

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
313	Petoskey Crushed Stone Co. Quarry 4 mi. W. of Petoskey, sec. 11, T. 34 N., R. 6 W.	Thick bedded hard tough crystalline beds at east end of quarry, used for road metal. Sect. about 35 ft., upper 12 ft. sampled.	Same as above.....	Same as above.....
314	W. E. Smith, et. al. property 4½ mi. W. of Petoskey. (Old quarry of Petoskey Stone & Lime Co.) NE¼ NE¼ sec. 9, T. 34 N., R. 6 W.	Top bed of quarry. Bed badly broken. Sect. exposed 3 to 4 ft.	Same as above.....	Same as above.....
315	Same as above.	Quarry beds Nos. 2, 3, 5, 7, 8, 9, 10, and 11, Sect. about 20 ft.	Same as above.....	Same as above.....
316	Same as above.	Lowest exposed beds at foot of trestle and below quarry floor. Beds Nos. 12 and 13 white earthy limestone. Thickness exposed 4 ft.	Same as above.....	Same as above.....
317	W. E. Smith, et. al., property 4½ mi. W. of Petoskey. Test pit on E end near S¼ post, sec. 3, T 34 N., R. 6 W.	Test pit beds. Gray lithographic limestone with fossils and calcite crystals. Bottom bed fossiliferous and crystalline. Section 5 ft.	Same as above.....	Same as above.....

HURON

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
318	Wallace Stone Co., Bayport quarries, N E¼ sec. 5, T. 16 N., R. 10 E.	2nd bed from top. Tough gray limestone 3 ft. thick. Formerly burned for hot lime.	.....	*Prof. Langley.....
319	Same as above.	Beds 3 and 4. Tough gray sandy magnesian limestones, each 3 ft. thick.	.....	*A. C. Benedict.....

*Vol. VII, Pt. II., pp. 214 and 216, Mich. Geol. Surv., 1900.

limestones by counties.

COUNTY.—*Con.*

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Remarks.
1 00	0.81		93.00	*52.12*	44.96	*2.37*	Same as above
0.75	0.63		83.90	*47.02*	14.38	*6.88*	Same as above.
0.71	0.41		93.96	*52.66*	4.65	*2.22*	Same as above.
2.50	1.74		80.88	*45.33*	14.84	*7.10*	Same as above.
1.77	1.20		94.68	*53.06*	2.02	*.96*	Same as above.

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Remarks.
3.330		1.334	91.538	51.29	0.944	.451	Stratum now quarried away.
20.85	FeS_2 0.15	2.04	61.52	34.48	14.50	6.93	Silica is free sand.

NOTE: Figures in italics calculated from original analyses.

Analyses of Michigan

JACKSON

Analysis No.	Location of quarry or deposit.	Name, thickness, and character of bed.	Kind of sample.	Analyst or authority.
320	Old quarries N E of Parma, probably in sec. 29, T. 2 S., R. 2 W.	Brown cellulose dolomite, argillaceous and ferruginous; upper stratum.	.....	*C. Rominger.....
321	One mi. NE of Parma in road on N side sec. 30, T. 2 S., R. 2 W.	.....	Hand sample.....	Mich. Ptld. Cem. Co., Chelsea, 1915.
322	Same as above.	.....	Hand sample.....	Same as above.....
323	Secs. 11 and 12, T. 3 S., R. 2 W., on main road from Jackson to Spring Arbor	.....	Hand sample.....	Same as above.....
324	In road between secs. 24 and 25, T. 3 S., R. 2 W.	.....	Hand sample.....	Same as above.....
325	Old Shoemaker farm 3 mi. S of Jackson, possibly in secs. 15 or 16, T. 3 S., R. 1 W.	Light colored limestone bed below 4 or 5 ft. of brown ferruginous cellulose dolomite.	.....	*C. Rominger.....
326	3 mi. S. of Jackson in railroad cut, Cincinnati & Northern Ry.	Light gray fine grained limestone, 4 to 6 ft. deep.	Hand sample.....	Same as above.....
327	Old quarry, Allen farm E½ SE¼ sec. 2, T. 2 S., R. 1 W.	Light gray fine grained limestone 4 to 5 ft. thick.	Crusher run sample..	Mich. Ptld. Cem. Co., Chelsea, 1915
328	Same as above.	Same as above.....	Crusher run sample..	Same as above.....
329	Old quarry, Allen farm, E½ SE¼ sec. 2, T. 2 S., R. 1 W.	Light gray fine grained limestone 4 to 6 ft. thick.	Hand sample.....	Same as above.....
330	Same as above.	Same as above.....	.....	.....
331	Old quarry on Haar farm, SE¼ SW¼ sec. 1, T. 2 S., R. 1 W.	Light gray fine grained limestone 8 to 10 ft. thick.	Hand sample.....	Mich. Ptld. Cem. Co., Chelsea, 1915.
332	Old quarry near center sec. 1, T. 2 S., R. 1 W.	Light gray fine grained limestone 4 to 6 ft.	Hand sample.....	Same as above.....
333	Old quarries about 3 mi. N of Jackson on N. side of Portage river sec. 1, T. 1 S., R. 1 E., and SW¼ sec. 6, T. 1 S., R. 2 E.	Light colored "smooth," compact, "brittle" limestone, 0-9 ft. thick.	.....	*C. Rominger.....
334	to 394, see text.			

*Vol. III, Pt. I, pp. 115, 116, 117, Mich. Geol. Surv., 1873-1876.

limestones by counties.

COUNTY.

Silica. SiO_2.	Iron. Fe_2O_3.	Alumina. Al_2O_3.	Calcium carbonate. $CaCO_3$.	Calcium oxide. CaO.	Magnesium carbonate. $MgCO_3$.	Magnesium oxide. MgO.	Remarks.
{ Insol. 2.90		18.40	63.70	35.70	11.4	5.45	
2.74		1.26	*94.32*	52.86	.....	trace	Analyses furnished by N. S. Potter, Jr., V. P. and Gen'l. Mgr. Mich. Ptld. Cem. Co., Chelsea, Mich.
14.08		2.56	*81.58*	45.72	.....	not det	
9.04		0.80	*85.89*	48.14	*1.71*	0.82	
4.22		1.68	*29.80*	29.80	*43.38*	20.75	
4.00		1.00	94.00	34.63	1.00	.478	Silica is quartz sand.
6.72		5.26	*71.16*	39.88	*16.43*	7.86	
2.80		0.78	.....	53.22	.....	0.00	
1.28		0.56	.....	54.70	.....	.....	
2.50		0.88	*96.96*	54.34	.....	*0.00*	Analysis furnished by N. S. Potter, Jr., V. P. and Gen'l. Mgr., Mich. Ptld. Cem. Co., Chelsea, Mich.
2.30		0.94	*96.53*	54.10	.....	*0.00*	
1.60		2.00	*90.75*	50.86	.77	0.37	
3.20		1.94	*93.21*	52.24	*1.90*	0.91	
{ Insol. 1.40		0.70	96.90	70.62	1.00	.478	

NOTE:—Figures in italics calculated from original analyses.