

MINERAL INDUSTRY OF MICHIGAN, 1964



1966

ANNUAL STATISTICAL SUMMARY 3

Geological Survey

California State Division of Mines

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Geological Survey

. . . the State Geological Survey, shall make an annual report to the Governor, setting forth in detail the mineral statistics for the year; with the progress and development of . . . mining and smelting industries.

—Compiled Laws Mich. 1948 s.319.202

ANNUAL STATISTICAL SUMMARY 3

Mineral Industry of Michigan 1964

By

Donald F. Klyce

Industry Economist

Bureau of Mines, Minneapolis, Minnesota

Prepared in cooperation with

Bureau of Mines

United States Department of the Interior

1966



STATE OF MICHIGAN
 GEORGE ROMNEY, *Governor*

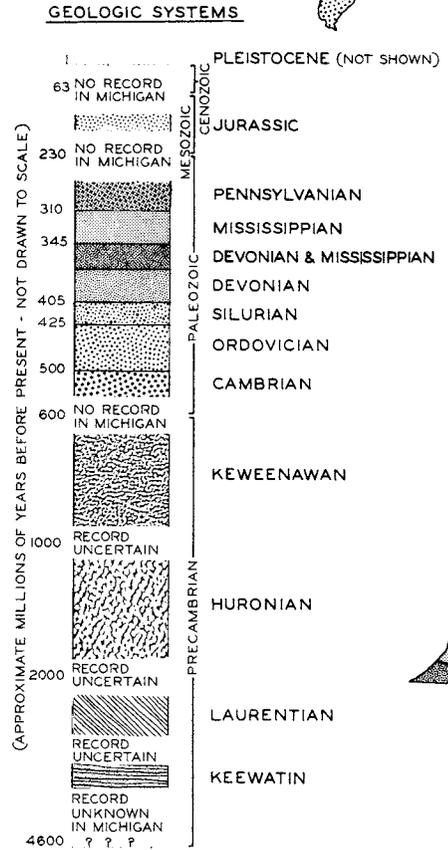
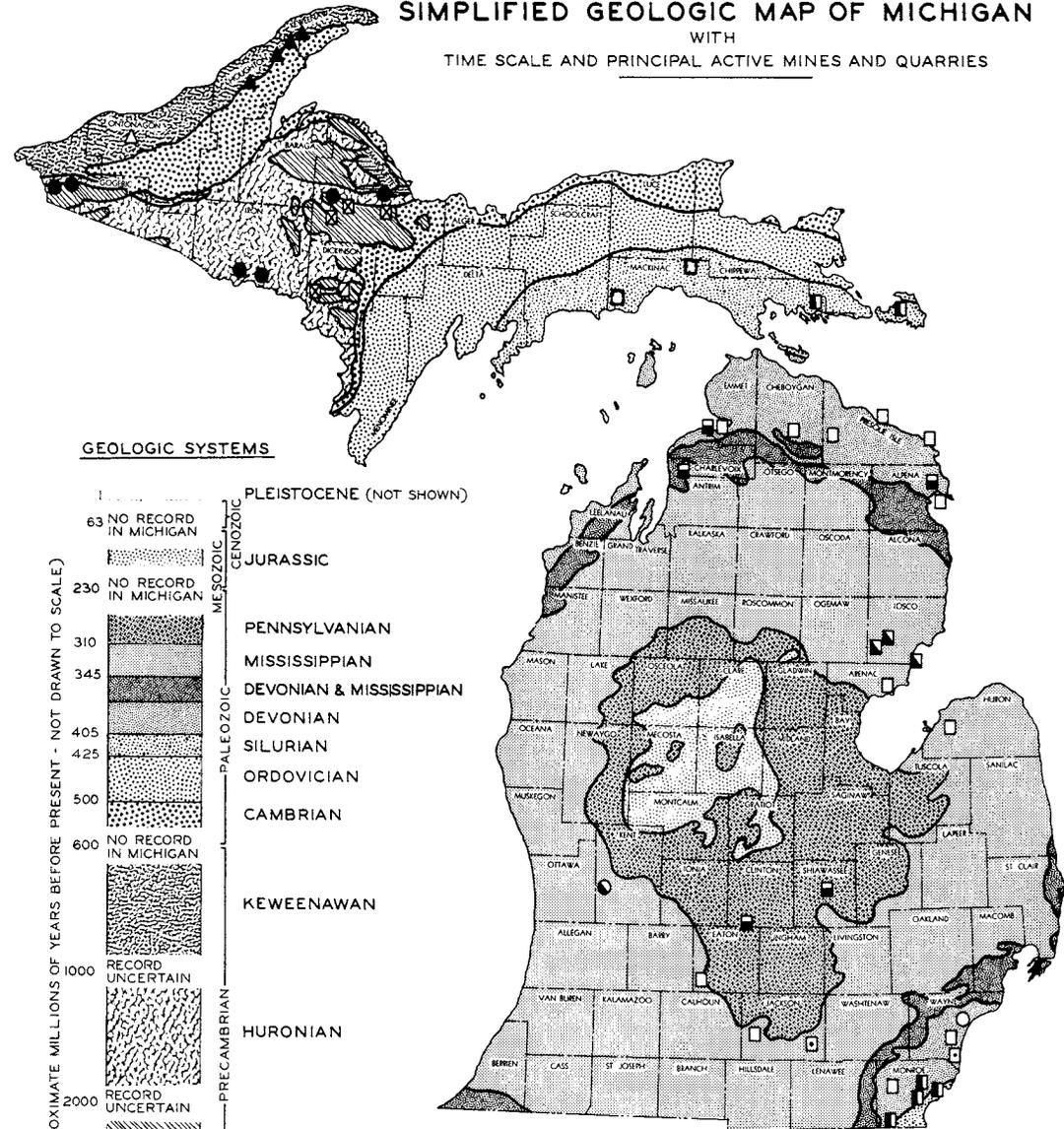
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SIMPLIFIED GEOLOGIC MAP OF MICHIGAN
 WITH
 TIME SCALE AND PRINCIPAL ACTIVE MINES AND QUARRIES



- | QUARRIES & OPEN PITS | | UNDERGROUND MINES | |
|----------------------|------------------------|-------------------|----------------|
| ☒ | IRON ORE BENEFICIATION | ▲ | NATIVE COPPER |
| □ | LIMESTONE | △ | COPPER SULFIDE |
| ▢ | DOLOMITE | ● | IRON ORE |
| ▣ | SHALE | ○ | SALT |
| ▤ | SANDSTONE | ◉ | GYPSUM |
| ▥ | GYPSUM | | |
| ▧ | MARBLE | | |

NOTE
 SEVERAL COPPER, IRON ORE, LIMESTONE, AND GYPSUM SYMBOLS REPRESENT MORE THAN ONE OPERATION
 MINERALS INDUSTRIES NOT SHOWN: SALT WELLS, SAND & GRAVEL, MARL, PEAT, OIL & GAS, NATURAL SALINES, AND CEMENT

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FOREWORD

Minerals rank among the most vital of all resources necessary to sustain an industrialized society. Precise knowledge of the amount and value of the minerals being produced and consumed is needed in both the public and private sectors of our economy. To insure the availability of adequate facts, government statutes prescribe the collecting and publishing of statistical information on these valued resources.

This report presents information on mineral operations in Michigan during 1964. Data is organized and presented as follows:

REVIEW BY COMMODITIES, commencing on page 3

REVIEW BY COUNTIES, commencing on page 11

This activity has been a statutory function of the State Geological Survey since 1911. Originally, the State Survey participated in a cooperative program with the U. S. Geological Survey. In 1925, however, Congress transferred the federal aspects of this work to the U. S. Bureau of Mines, with whom the state now maintains a cooperative agreement.

The present edition of this annual publication continues the revised style established last year. The U. S. Bureau of Mines provides unbound and untrimmed preprints of the *Michigan* chapter of its *1964 Minerals Yearbook*. The Michigan Department of Conservation prepares the cover and front and rear matter, and binds and distributes the finished booklet. Other publications of interest are listed inside the rear cover.

The excellent cooperative attitude of members of the minerals industry in Michigan made this report possible.

Harry O. Sorensen
John R. Byerlay
Mining & Economic Geology Section
Geological Survey Division
Department of Conservation

Lansing, Michigan
December, 1965

The Mineral Industry of Michigan

This chapter has been prepared under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the Michigan Department of Conservation, Geological Survey Division, State of Michigan, for collecting information on all minerals except fuels.

By Donald F. Klyce¹



MINERAL production in Michigan was valued at \$555 million, an alltime high. Increased output of all major minerals, except copper and petroleum, contributed to the record. Much of the increase was due to increased value of shipments of iron ore and cement. Producers of stone, salt, and chemicals also reported substantial gains in sales. Petroleum output declined for the third consecutive year. Iron ore was first in value, followed by cement, copper, sand and gravel, and petroleum. Nonmetals (construction materials and natural saline minerals) accounted for 55 percent of the State total, slightly less than in 1963. Metallic minerals increased to over 34 percent of the total value, while mineral fuels accounted for the remainder.

TABLE 1.—Mineral production in Michigan¹

Mineral	1963		1964	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:				
Portland.....thousand 376-pound barrels..	25, 016	\$76, 944	26, 745	\$84, 316
Masonry.....thousand 280-pound barrels..	1, 684	4, 519	1, 865	4, 954
Clays.....thousand short tons..	1, 958	2, 149	2, 385	2, 592
Copper (recoverable content of ores, etc.)...short tons..	75, 262	46, 361	69, 040	45, 014
Gypsum.....thousand short tons..	1, 315	4, 938	1, 421	5, 263
Iron ore (usable).....thousand long tons, gross weight..	19, 789	107, 201	13, 871	143, 979
Lime.....thousand short tons..	1, 371	18, 431	1, 430	19, 246
Magnesium compounds.....short tons..	266, 740	23, 062	306, 494	23, 385
Manganiferous ore (5 to 35 percent Mn) short tons, gross weight..	152, 957	W		
Natural gas.....million cubic feet..	32, 850	8, 902	31, 558	7, 984
Peat.....short tons..	251, 809	2, 413	269, 074	2, 412
Petroleum (crude).....thousand 42-gallon barrels..	15, 972	45, 520	15, 601	43, 839
Salt.....thousand short tons..	4, 244	33, 656	4, 345	35, 711
Sand and gravel.....do.....	50, 458	43, 433	51, 921	44, 405
Silver (recoverable content of ores, etc.)...troy ounces..	338, 997	434	349, 195	452
Stone.....thousand short tons..	30, 316	32, 065	34, 650	37, 002
Value of items that cannot be disclosed: Bromine, calcium chloride and calcium-magnesium chloride, gem stones, iodine, natural gas liquids, potassium salts, and values indicated by symbol W.....	xx	42, 001	xx	54, 941
Total.....	xx	† 492, 029	xx	555, 495

† Revised.

xx Not applicable.

W Withheld to avoid disclosing individual company confidential data.

¹ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

¹ Industry economist, Bureau of Mines, Minneapolis, Minn.

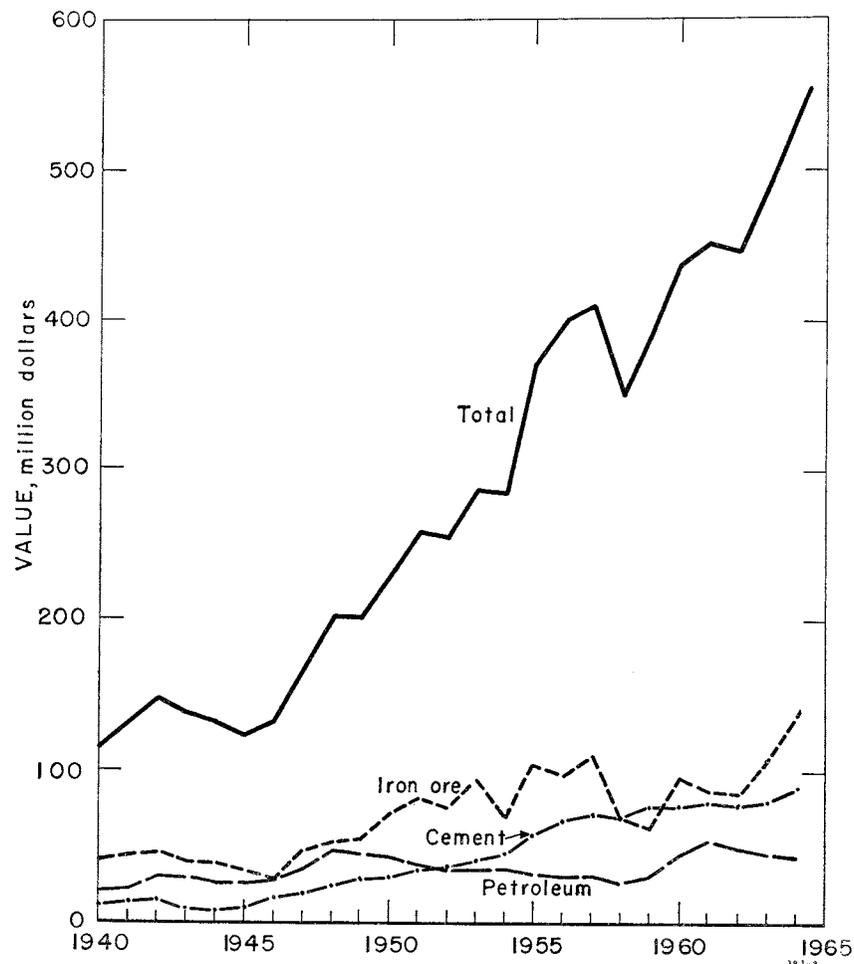


FIGURE 1.—Value of iron ore, petroleum, cement, and total value of mineral production in Michigan.

TABLE 2.—Value of mineral production in constant 1957-59 dollars
(Millions)

Year	Value	Year	Value
1953	\$323	1959	\$384
1954	306	1960	431
1955	385	1961	444
1956	396	1962	* 440
1957	412	1963	* 484
1958	352	1964	537

* Revised.

TABLE 3.—Employment and injury experience in the mineral industries

Year and industry	Men working daily	Man-days worked (thousands)	Man-hours worked (thousands)	Injuries		Injuries per million man-hours
				Fatal	Nonfatal	
1963:						
Metal	5,092	1,380	11,040	6	303	28
Nonmetal	4,298	1,439	11,549	1	158	14
Sand and gravel	2,654	544	4,570	1	59	13
Stone	2,988	864	6,987	1	40	6
Peat	276	45	434		3	7
Total	15,308	4,272	34,580	9	563	16
1964: ^p						
Metal	5,560	1,547	12,250	1	322	26
Nonmetal	4,355	1,447	11,244	1	45	4
Sand and gravel	2,750	560	4,654	2	81	18
Stone	3,815	1,174	9,351		46	5
Peat	291	54	495		12	24
Total	16,771	4,782	37,994	4	506	13

^p Preliminary.

REVIEW BY MINERAL COMMODITIES

NONMETALS

Cement.—Shipments of cement continued to increase and were 7 percent larger than in 1963. Average mill values per barrel were more stable than in previous years, and the decline that began in 1962 appears to have abated. The value of portland cement was \$3.15 in 1964 compared with \$3.08 in 1963; masonry cement was valued at \$2.66 in 1964 compared with \$2.68 in 1963. Portland cement was produced at nine plants in seven counties. At six of these plants masonry cement also was produced. Total capacity of the plants was 32.7 million barrels. Yearend stocks of portland cement at mills were nearly 2.6 million barrels, 57,000 barrels more than in 1963. About 54 percent of the cement shipped was used in the State. Principal out-of-State shipments were to Ohio, Illinois, Wisconsin, Indiana, and New York. Ready-mixed concrete companies purchased 56 percent of the cement produced, while the remainder went principally to contractors, concrete product manufacturers, and building material dealers.

TABLE 4.—Finished portland cement produced, shipped, and in stock
(Thousand 376-pound barrels and thousand dollars)

Year	Active plants	Production	Shipped from mills		Stocks at mills Dec. 31
			Quantity	Value	
1955-59 (average)	8	20,221	20,102	\$63,607	2,173
1960	9	20,971	21,187	73,082	3,023
1961	9	21,661	21,948	75,172	2,737
1962	9	23,070	22,682	73,267	3,354
1963	9	24,194	25,016	76,944	2,532
1964	9	26,802	26,745	84,316	2,589

Raw materials used in the manufacture of cement included 6.5 million tons of limestone and 2.2 million tons of clay or shale, as well as sand, gypsum, mill scale, slag, iron ore, grinding aids, and air-entraining compounds.

About 655 million kilowatt-hours of electrical energy was used. The wet process was used at eight of the nine plants. The other plant employed the dry process.

Clays.—Miscellaneous clay and shale was mined in 10 counties at 14 pits. About 86 percent of the output was used in cement manufacture. Manufacturers of heavy clay products (sewer pipe, draintile), pottery, and lightweight aggregate utilized the balance. The largest production came from operations in Alpena, Wayne, and Monroe Counties.

Gem Stones.—Small quantities of semiprecious stones, principally agates, thomsonite, and specimens of native copper and hematite, were collected by hobbyists. Most of the gem materials were found in the upper peninsula, chiefly on the beaches of Lake Superior. The material was used for handmade jewelry and for personal gem collections.

Gypsum.—Underground mines in Kent County and quarries in Iosco County were the source of gypsum. The tonnage produced was 8 percent larger than in 1963. The ore was milled and processed at plants in National City, Detroit, and Grand Rapids, as well as at plants in other States. Wallboard, exterior sheathing, lath, and plaster were manufactured. A substantial tonnage of uncalcined gypsum was sold as a cement retarder.

Lime.—The volume and value of lime produced was 4 percent larger than in 1963. Data for regenerated lime (produced by papermills, water purification plants, and acetylene processors) are excluded from the State total value of production. Wayne County led in lime production. Nearly three-quarters of the lime manufactured was used by producers. Nearly all (98 percent) of the lime was consumed within the State. Lime was used in chemical and metallurgical operations, water treatment, and paper and sugar manufacture. Most of the lime manufactured was quicklime. A small tonnage of hydrated lime was produced. The annual lime-burning capacity of the lime plants reporting exceeded 1.7 million tons. During the year construction was started on a 700,000-ton-per-year lime plant by Marblehead Lime Co. in Wayne County.

Natural Salines.—Bromine, calcium chloride, calcium-magnesium chloride, iodine, magnesium compounds, and potash were extracted from natural well brines at plants in Gratiot, Lapeer, Mason, Manistee, Midland, and Wayne Counties. The value of chemicals produced from natural salines, excluding salt, was about 6 percent higher than in 1963. During the year Wyandotte Chemicals Corp. began producing calcium chloride at its plant in Wayne County.

Perlite.—Perlite was expanded at plants in Iosco, Kent, and Wayne Counties from crude ore mined in New Mexico and Nevada. The material was used in plaster. Although the volume produced was slightly less than in 1963, a price increase resulted in a higher valuation for the 1964 output.

Salt.—Salt was recovered from natural well brines and artificial brines in Gratiot, Manistee, Midland, Muskegon, St. Clair, and Wayne Counties. One underground salt mine was operated in Detroit. Volume of output was 2 percent larger than in 1963, while value of

shipments was 6 percent higher. The principal uses were in chemical manufacture, meatpacking, ice removal, water softening, and animal feed. Purchase of salt for ice control again declined, but increased use in chemical manufacture, principally of chlorine and soda ash, more than made up for the loss.

Sand and Gravel.—Production of sand and gravel totaled nearly 52 million tons—the second highest in the Nation, and a record high for the State. A 20-percent increase in material for use in building offset a 3-percent decline in paving and road sand and gravel. The demand for industrial sand was 20 percent greater than in 1963. Sand and gravel was produced in all counties except Monroe. The Detroit area (Livingston, Macomb, Oakland, Washtenaw, and Wayne Counties), producing 18.7 million tons, accounted for 40 percent of the value and 36 percent of the State sand and gravel production. Production of more than 1 million tons was also reported from each of the following counties: Allegan, Ingham, Kalamazoo, Kent, Ottawa, and Tuscola.

Sand and gravel shipments were about 3 percent greater than in 1963. More than 92 percent of the sand and gravel was processed or treated. More than 48 million tons of sand and gravel was transported by truck, and the remainder was moved by rail or water. Production was reported by 358 commercial operations and 193 Government-and-contractor operations.

Leading producers of sand and gravel, in alphabetical order, included:

American Aggregates Corp.
Construction Aggregates Corp.
Grand Rapids Gravel Co.
Holloway Sand & Gravel Co., Inc.
Holly Sand & Gravel Division.
Michigan Silica Co.
The Nugent Sand Co., Inc.
Pickitt & Schreur, Inc.
Sargent Sand Co.
I. L. Whitehead Co.

Stone.—Limestone, sandstone, marl, and basalt were produced. Over 99 percent of the material was limestone, quarried in 14 counties by 19 commercial producers and 4 county highway agencies. Large quarries in Alpena, Chippewa, Emmet, Mackinac, Monroe, and Presque Isle Counties supplied most of the crushed stone. More than 27 million tons of stone was moved by water from company-operated ports on Lakes Huron and Michigan to steel mills, cement and lime plants, and other industrial consumers.

Limestone shipments were nearly 15 percent larger than in 1963 owing principally to greater demand for fluxstone, crushed stone for cement and lime, other industrial uses, and roadstone. Of the 34.5 million tons of crushed limestone produced, 13.0 million tons was used for flux, 12.2 million tons for cement and lime, 4.6 million tons for roadstone and aggregate, and the remainder for other industrial uses and agricultural purposes. The major producers of limestone, in alphabetical order, included:

Drummond Dolomite, Inc.
Dundee Cement Co.
The France Stone Co.

Huron Portland Cement Co.
Inland Lime & Stone Co.
Michigan Stone Co.
Penn-Dixie Cement Corp.
Presque Isle Corp.
United States Steel Corp.
The Wallace Stone Co.

TABLE 5.—Sand and gravel sold or used by producers, by classes of operations and uses

(Thousand short tons and thousand dollars)

Class of operation and use	1963		1964	
	Quantity	Value	Quantity	Value
Commercial operations:				
Sand:				
Building.....	4,827	\$3,444	5,754	\$4,169
Paving.....	5,049	4,535	5,135	4,274
Fill.....	3,092	1,383	3,204	1,412
Molding.....	2,178	3,896	2,819	5,085
Other ¹	721	1,707	694	1,620
Total.....	15,867	14,965	17,606	16,560
Gravel:				
Building.....	4,920	6,293	5,739	7,339
Paving.....	16,480	13,818	16,254	13,380
Railroad ballast.....	W	W	210	225
Fill.....	291	163	350	203
Other ²	438	423	418	457
Total.....	22,129	\$ 20,696	22,971	21,604
Total sand and gravel.....	37,996	\$ 35,662	40,577	38,164
Government-and-contractor operations:				
Sand:				
Building.....			107	48
Paving.....	1,965	1,014	1,659	744
Fill.....	1,497	516	1,215	394
Other.....	143	71	127	58
Total.....	3,605	1,601	3,108	1,244
Gravel:				
Building.....	66	30	196	76
Paving.....	8,257	5,947	7,641	4,764
Fill.....	355	121	347	141
Other.....	179	72	52	16
Total.....	8,857	6,170	8,236	4,997
Total sand and gravel.....	12,462	7,771	11,344	6,241
All operations:				
Sand.....	19,472	\$ 16,567	20,714	17,804
Gravel.....	30,986	\$ 26,867	31,207	26,601
Grand total.....	50,458	\$ 43,433	51,921	44,405

W Withheld to avoid disclosing individual company confidential data; included with "Other."
¹ Includes blast (1963), engine, glass, grinding and polishing, and other construction and industrial uses (1963-64), and railroad ballast and abrasive sands (1964).
² Includes railroad ballast (1963) and other miscellaneous gravel.
³ Data do not add to total shown because of rounding.

Marl was produced in 16 counties at 36 operations. The largest output was reported from Barry, Calhoun, Cass, and Kalamazoo Counties. Sandstone, used principally for building, was quarried and milled in Baraga and Jackson Counties. The National Park Service reported dredging a few hundred tons of basalt and sandstone at several locations on submerged park lands on Isle Royale for use as rubble and fill.

TABLE 6.—Dimension stone sold or used by producers, by kinds

Year	Basalt		Limestone		Sandstone		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1960.....			6,801	\$58,889	11,615	\$97,395	18,416	\$156,284
1961.....			27,516	119,950	7,045	54,057	34,561	174,007
1962.....			7,798	51,603	15,223	65,406	23,021	117,009
1963.....			4,938	60,371	8,937	62,348	13,875	122,719
1964.....	150	\$150	5,383	68,711	8,306	62,030	13,839	130,891

TABLE 7.—Crushed and broken stone sold or used by producers, by kinds and uses
(Thousand short tons and thousand dollars)

Kind and use	1963		1964	
	Quantity	Value	Quantity	Value
Basalt: Concrete aggregate and roadstone.....	15	\$15		
Limestone:				
Flux.....	11,194	12,785	12,969	\$14,792
Concrete aggregate and roadstone.....	3,860	4,616	4,593	5,464
Agriculture.....	484	888	679	1,147
Cement.....	8,157	6,455	9,273	7,610
Lime.....	2,387	2,128	2,956	2,709
Other ¹	4,029	4,987	4,048	5,065
Total.....	\$ 30,110	31,809	\$ 34,516	\$ 36,788
Marl: Agriculture.....	169	109	120	83
Sandstone:				
Riprap.....	(³)	(³)		
Concrete aggregate and roadstone.....	7	9		
Foundry.....	(³)	(³)		
Total.....	\$ 8	9		
Grand total.....	30,302	31,942	34,636	36,871

¹ Includes limestone for asphalt and miscellaneous filler, chemicals, dust for coal mines, mineral food poultry grit, railroad ballast, riprap, stone sand, and other uses (1963-64), and whitening or whitening substitutes (1964).

² Data do not add to total shown because of rounding.

³ Less than ½ unit.

Sulfur.—Byproduct sulfur was recovered from crude petroleum in Detroit by the Marathon Oil Co., using the Parsons process. Leonard Refineries, Inc., used the hydrofining process at Alma to recover sulfur.

Vermiculite.—Crude vermiculite, mined in southern and western States, was exfoliated at Dearborn by Zonolite Division, W. R. Grace & Co.

METALS

Metals accounted for 34 percent of the total value of mineral production, a 3 percent increase over that of 1963.

Copper.—Production of copper in terms of recoverable metal was 8 percent less than in 1963. The value of output decreased only 3 percent as the average weighted price increased to 32.6 cents per pound, compared with 30.8 cents in 1963. The price quoted by primary producers for delivered electrolytic copper at the beginning of 1964

was 31 cents per pound. The price advanced to 32 cents on March 17 and remained at 34 cents from September 23 until yearend. The price fluctuated around that point until the end of the year when it closed at 34.16 cents. Copper production was interrupted in August, September, and October by strikes at the Copper Range Co. and its subsidiary, White Pine Copper Co. The company mines, reclamation plant, mills, and smelter were shut down during the strike period.

Calumet & Hecla, Inc., operated seven mines, one reclamation plant, and one smelter in Houghton and Keweenaw Counties. Work began on construction of surface installation of the Kingston mine of Calumet & Hecla, Inc., in June. The Kingston was the first new native copper mine to be developed in Michigan in over 30 years.

TABLE 8.—Mine production of copper in 1964, by months, in terms of recoverable metal

Month	Short tons	Month	Short tons
January.....	6,510	August.....	6,265
February.....	6,080	September.....	1,130
March.....	6,385	October.....	3,560
April.....	6,675	November.....	6,255
May.....	6,350	December.....	6,480
June.....	6,555	Total.....	69,040
July.....	6,795		

TABLE 9.—Mine production of copper, in terms of recoverable metal

Year	Mines producing		Material treated		Copper	
	Lode	Tailing	Ore (short tons)	Tailing (short tons)	Short tons	Value
1955-59 (average).....	12	3	5,862,048	1,873,706	56,659	\$37,853,593
1960.....	9	3	5,600,290	2,192,818	56,385	36,199,170
1961.....	10	3	7,109,924	2,122,286	70,245	42,147,000
1962.....	9	3	7,555,357	1,812,530	74,099	45,644,984
1963.....	10	3	7,211,387	2,226,129	75,262	46,361,392
1964.....	9	3	6,717,862	2,174,478	69,040	45,014,050

Copper Range Co. operated the Champion mine and the Freda mill in Houghton County. The mill concentrated ore from the mine and tailings from the Redridge sands. White Pine Copper Co. operated a mine, mill, and smelter in Ontonagon County.

Iron Ore.—Iron ore shipments increased to nearly 13.9 million long tons from 10.8 million in 1963. Value of shipments increased 34 percent to \$144 million. Most of the gain was due to increased shipments of concentrates from low grade ores. Shipments of this material accounted for 47 percent of total iron-ore shipments, compared with 43 percent in 1963, and for 59 percent of the value of shipments in 1964. A total of 14 underground mines and 5 open-pit mines were active all or part of the year. Almost 73 percent of the crude ore mined came from open-pit operations, compared with 64 percent in 1963. Average iron content of usable ore produced was 57.93 percent natural. The average weighted mine value of Michigan iron ore, without respect to grade, was \$10.38 per long ton, compared with \$9.94 in 1963.

Michigan iron ore was shipped to producers of pig iron and steel,

except for a small quantity used in manufacturing iron oxide pigments. About 96 percent of the ore was shipped by rail to ore docks in Ashland, Wis., and in Escanaba and Marquette, Mich., then by water to lower Lake ports. The remainder was all-rail shipments to consuming districts. The lake shipping season for Michigan iron ores opened at Escanaba on April 3 and closed at the same port on December 18.

TABLE 10.—Crude iron ore¹ data, in 1964, by counties and ranges
(Thousand long tons)

County and range	Stocks of crude ore Jan. 1	Production		Shipments		Stocks of crude ore Dec. 31
		Underground	Open pit	Direct to consumers	To beneficiation plants	
County:						
Dickinson.....			3,448		3,448	
Gogebic.....	637	1,227		1,403		460
Iron.....	678	3,076		3,126		627
Marquette.....	2,375	1,816	13,086	1,224	14,534	1,520
Total.....	² 3,689	6,119	16,534	5,753	17,982	² 2,608
Range:						
Gogebic.....	637	1,227		1,403		460
Marquette.....	2,375	1,816	13,086	1,224	14,534	1,520
Menominee.....	678	3,076	3,448	3,126	3,448	627
Total.....	² 3,689	6,119	16,534	5,753	17,982	² 2,608

¹ Exclusive of iron ore containing 5 percent or more manganese.

² Data do not add to total shown because of rounding.

TABLE 11.—Usable iron ore shipped from mines, by ranges¹

Year	(Thousand long tons)			Total
	Marquette range	Menominee range (Michigan part)	Gogebic range (Michigan part)	
1955-59 (average).....	5,115	3,595	2,322	11,032
1960.....	4,881	4,018	1,892	10,792
1961.....	4,141	3,881	1,362	9,384
1962.....	4,470	3,462	1,480	9,422
1963.....	5,809	4,168	813	10,789
1964.....	7,909	4,560	1,403	13,871

¹ Exclusive of iron ore containing 5 percent or more manganese, natural.

TABLE 12.—Usable iron ore produced, by ranges¹

Year	(Thousand long tons)			Total
	Marquette range	Menominee range (Michigan part)	Gogebic range (Michigan part)	
1955-59 (average).....	4,960	3,599	2,343	10,903
1960.....	6,619	4,079	2,169	12,866
1961.....	3,265	4,097	1,062	8,364
1962.....	4,563	3,460	1,237	9,259
1963.....	5,706	3,729	902	10,336
1964.....	7,898	4,551	1,227	13,676
1854-1964.....	330,807	² 270,514	² 248,710	850,031

¹ Exclusive of iron ore containing 5 percent or more manganese, natural.

² Distribution by range partly estimated before 1966.

At yearend, estimated reserves of iron ores in Michigan totaled 81 million long tons,² not including about 1.8 billion tons of low-grade hematite ore.

According to a study by the Michigan Department of Conservation,³ the average mining cost per ton (delivered at Lake Erie ports) for underground mines was \$9.99 in 1964, compared with \$10.51 in 1963. Labor costs increased in 1964 to \$2.68 a ton from \$2.64, while taxes (excluding Federal income tax) dropped to \$0.49 from \$0.72 in 1963. Deferred costs also dropped significantly to \$0.56 from \$0.73. The following costs also were lower in 1964—general overhead, \$1.49 from \$1.55; transportation, \$3.05 from \$3.09. Federal income tax increased to \$0.26 per ton from \$0.24, while royalty costs increased to \$0.31 from \$0.29. Marketing cost remained at \$0.08 per ton. On the Gogebic Range delivered costs per ton averaged \$11.47 in 1964, compared with \$12.07 in 1963; on the Marquette Range costs dropped to \$11.49 from \$11.82; and on the Menominee Range costs also dropped to \$8.64 from \$9.09.

Pig Iron and Steel.—Pig iron and steel were manufactured in the Detroit area. Pig iron shipments and value were 13 percent higher than in 1963. Basic, bessemer, foundry, and low-phosphorus grades were produced. According to the American Iron & Steel Institute, Michigan steel production was more than 9.4 million tons, about 12 percent greater than in 1963.

Silver.—Silver was recovered from copper ore mined at the White Pine mine. Concentrates from a silver-recovery circuit in the White Pine mill were smelted separately for delivery to electrolytic refineries where the silver was recovered. Silver contained in fire refined copper is not recovered but is marketed as a constituent of lake copper.

MINERAL FUELS

Natural Gas and Natural Gas Products.—Slightly more than half of the State gas production came from oil well gas; the remainder from gasfields. St. Clair County had the largest gas production, nearly 39 percent of the State total. About 31 percent of the output came from the Albion-Pulaski-Scipio-Trend fields in Calhoun, Hillsdale, and Jackson Counties. Other major gas-producing areas were in Macomb, Missaukee, and Roscommon Counties. Nearly 94 percent of the gas came from these wells, while fields in 20 counties yielded the remainder. Four new gasfields were opened in 1964, increasing the producible gasfields to 83. However, only 32 fields produced gas for commercial sale.

Production of natural gasoline and liquefied petroleum gases was nearly 22 percent greater than in 1963. The top fields supplying gas for processing were Albion-Scipio, Boyd, and Belle River Mills. The new Willow River plant, which was opened in December 1963, processes gas delivered via interstate pipeline from Southwestern States. Most of the gain in total production came from this plant.

Peat.—Peat shipments increased nearly 7 percent, reversing a decline reported in 1963. Michigan was the leading peat-producing

State with over 42 percent of the national output. Peat was produced in 15 counties with 90 percent coming from Lapeer, Lenawee, Oakland, and Sanilac Counties. Peat was marketed principally as a soil conditioner. None was sold for fuel.

Petroleum.—The decline in petroleum production continued with a loss of only 371,000 barrels in 1964, compared with 1.1 million barrels in 1963. The fields of the Albion-Pulaski-Scipio-Trend produced nearly 9.3 million barrels, about 60 percent of the State total and only 68,000 barrels less than in 1963. According to data published in the Annual Statistical Summary of Michigan's Oil and Gas Fields, 1964, by the Geological Survey, Michigan Department of Conservation, no significant oil reserves were found or developed that would offset the decline in State output.

Undeveloped acreage under lease decreased to 1.4 million acres from 1.8 million acres in 1963.

Activity in geophysical exploration was about the same as in 1963. Most geophysical work was done in the eastern and northern part of the State. Five gravimeter crews worked a total of 38 crew-months and 6 seismograph parties worked a total of 7 crew-months. New oilfield discoveries in 1964 increased the number of active fields to 184. Four new pools were added to older fields. Seven pools or fields were abandoned and one pool converted to gas storage and secondary recovery. A total of 506 wells (exploratory and development) were completed in 1964, compared with 591 in 1963.

The ratio of discoveries to exploratory tests increased to 1:19 in 1964 from 1:13 in 1963. Twelve discoveries were made in 1964 of which eight wells were in the Devonian geologic system, three in the Mississippian, and one in the Silurian.

Petroleum was produced in 43 counties in 1964, all in the lower peninsula. Twelve refineries had a nominal crude-oil refining capacity of 184,000 barrels per day.

Fluid injection was used in producing about 3.6 million barrels of petroleum and 1.5 billion cubic feet of gas. More than 45 million barrels of fluid, mostly brines, were injected into producing formations through 327 wells. From the same fields, more than 45 million barrels of fluid, nearly all brine, was produced.

REVIEW BY COUNTIES

Mineral production was reported from all counties in Michigan. The value of output increased in 46 counties and decreased in 37 counties. More than \$1 million in minerals was produced in each of 43 counties. Marquette County led in value of production.

Allegan.—About 1 million tons of sand and gravel was produced by several commercial operators and the county road commission. Owing to decreased demand for road materials, output was reduced by about half a million tons. Four pits yielded marl for agricultural use. Natural gas production fell to 438 million cubic feet, 29 percent less than in 1963, while petroleum output declined to 250,000 barrels from 262,000 in the previous year. Small quantities of reed-sedge and moss peat were dug from bogs near Middleville and Wayland. It was sold in bulk for soil improvement and for packing plants, shrubs, etc.

² Geological Survey Division, Michigan Department of Conservation. General Statistics Covering Costs and Production of Michigan Iron Mines. June 1965, 15 pp.

³ Work cited in footnote 2.

TABLE 13.—Value of mineral production in Michigan, by counties¹

County	1963	1964	Minerals produced in 1964 in order of value
Alcona.....	\$158,935	\$178,000	Sand and gravel.
Alger.....	54,253	69,000	Do.
Allegan.....	1,860,432	² 1,347,433	Petroleum, sand and gravel, peat, stone, natural gas.
Alpena.....	W	W	Cement, stone, clays, sand and gravel.
Antrim.....	204,664	216,986	Clay, sand and gravel.
Arenac.....	1,315,214	1,247,038	Petroleum, stone, sand and gravel.
Baraga.....	242,320	44,850	Sand and gravel, stone.
Barry.....	406,172	443,214	Sand and gravel, petroleum, stone.
Bay.....	7,585,143	8,359,197	Cement, petroleum, lime, sand and gravel.
Benzie.....	139,901	13,000	Sand and gravel.
Berrien.....	567,968	1,072,741	Sand and gravel, stone.
Branch.....	94,622	102,920	Do.
Calhoun.....	8,081,390	² 6,782,895	Petroleum, sand and gravel, stone, natural gas.
Cass.....	370,244	270,749	Sand and gravel, petroleum, stone.
Charlevoix.....	23,469	42,000	Sand and gravel.
Cheboygan.....	246,165	202,189	Sand and gravel, stone.
Chippewa.....	4,236,858	3,324,830	Stone, sand and gravel.
Clare.....	1,579,679	² 1,736,725	Petroleum, sand and gravel, natural gas.
Clinton.....	269,239	319,604	Sand and gravel, clays.
Crawford.....	417,593	² 264,145	Petroleum, sand and gravel, natural gas.
Delta.....	195,834	170,146	Sand and gravel, stone.
Dickinson.....	12,252,971	17,808,288	Iron ore, sand and gravel, stone.
Eaton.....	548,814	505,861	Stone, sand and gravel, clays, peat.
Emmet.....	9,810,176	8,968,440	Cement, stone, sand and gravel.
Genesee.....	746,675	709,376	Sand and gravel, petroleum.
Gladwin.....	1,248,025	1,315,528	Petroleum, sand and gravel.
Gogebic.....	6,696,225	11,680,042	Iron ore, sand and gravel.
Grand Traverse.....	84,226	106,000	Sand and gravel.
Griott.....	W	W	Salines, salt, sand and gravel, petroleum, natural gas.
Hillsdale.....	12,773,619	² 14,741,652	Petroleum, sand and gravel, stone, natural gas.
Houghton ³	47,586,022	45,959,019	Copper, sand and gravel.
Huron.....	1,046,163	978,621	Stone, sand and gravel, lime, petroleum.
Ingham.....	1,005,097	972,096	Sand and gravel, peat.
Ionia.....	217,362	382,000	Sand and gravel.
Iosco.....	4,349,206	4,822,188	Gypsum, sand and gravel.
Iron.....	24,451,943	23,514,489	Iron ore, sand and gravel.
Isabella.....	1,467,209	² 1,742,337	Petroleum, sand and gravel, stone, natural gas.
Jackson.....	6,999,256	² 5,844,547	Do.
Kalamazoo.....	1,184,488	1,250,698	Sand and gravel, stone, peat.
Kalkaska.....	68,245	72,043	Petroleum, sand and gravel.
Kent.....	3,945,931	² 3,686,003	Sand and gravel, gypsum, petroleum, peat, natural gas.
Keweenaw.....	(⁴)	(⁴)	Copper, sand and gravel, stone.
Lake.....	56,098	110,968	Sand and gravel, petroleum.
Lapeer.....	1,287,262	1,682,723	Peat, salines, sand and gravel, petroleum.
Leelanau.....	100,828	51,000	Sand and gravel.
Lenawee.....	1,154,032	1,418,847	Cement, sand and gravel, peat, clays, petroleum.
Livingston.....	2,901,954	² 2,736,000	Sand and gravel, natural gas.
Luce.....	50,220	40,000	Sand and gravel.
Mackinac.....	W	W	Stone, sand and gravel.
Macomb.....	2,657,366	² 2,028,025	Sand and gravel, petroleum, natural gas.
Manistee.....	16,507,558	18,909,056	Salines, salt, sand and gravel.
Marquette.....	W	W	Iron ore, sand and gravel.
Mason.....	W	W	Salines, lime, sand and gravel, petroleum, natural gas.
Mecosta.....	190,627	² 248,123	Sand and gravel, petroleum, peat, stone, natural gas.
Menominee.....	673,832	781,177	Lime, sand and gravel.
Midland.....	W	W	Salines, salt, petroleum, sand and gravel, natural gas.
Missaukee.....	1,466,781	² 1,265,072	Petroleum, sand and gravel, natural gas.
Monroe.....	W	W	Cement, stone, clays, petroleum, peat.
Montcalm.....	1,119,196	² 1,077,159	Petroleum, sand and gravel, natural gas.
Montmorency.....	97,888	76,211	Sand and gravel, petroleum.
Muskegon.....	2,077,078	² 1,915,869	Salt, sand and gravel, petroleum, natural gas.
Newaygo.....	227,599	² 170,608	Sand and gravel, petroleum, stone, natural gas.
Oakland.....	6,839,509	² 7,393,223	Sand and gravel, peat, petroleum, natural gas.
Oceana.....	1,236,000	855,040	Petroleum, sand and gravel.
Ogemaw.....	1,091,672	² 1,035,098	Petroleum, sand and gravel, natural gas.
Ontonagon.....	(⁴)	(⁴)	Copper, silver, sand and gravel.
Osceola.....	985,614	² 887,699	Petroleum, sand and gravel, stone, natural gas.
Oscoda.....	53,148	28,055	Sand and gravel, petroleum.
Otsego.....	29,714	² 52,000	Sand and gravel, natural gas.
Ottawa.....	2,567,226	² 2,627,931	Sand and gravel, petroleum, stone, natural gas.
Presque Isle.....	W	W	Stone, sand and gravel.
Roscommon.....	667,528	² 714,813	Petroleum, sand and gravel, natural gas.
Saginaw.....	452,054	480,329	Clays, petroleum, lime, sand and gravel.
St. Clair.....	16,486,562	² 16,183,055	Salt, cement, petroleum, sand and gravel, clays, peat, natural gas.

See footnotes at end of table.

TABLE 13.—Value of mineral production in Michigan, by counties¹—Continued

County	1963	1964	Minerals produced in 1964 in order of value
St. Joseph.....	W	\$211,300	Sand and gravel, stone, peat.
Sanilac.....	\$966,130	1,148,822	Peat, sand and gravel, lime.
Schoolcraft.....	95,981	71,000	Sand and gravel.
Shiawassee.....	369,228	671,032	Sand and gravel, clays, peat.
Tuscola.....	2,003,801	2,209,389	Sand and gravel, petroleum, lime, peat.
Van Buren.....	355,564	323,459	Sand and gravel, petroleum, stone.
Washtenaw.....	1,332,645	² 938,456	Sand and gravel, petroleum, natural gas.
Wayne.....	41,805,111	² 47,394,260	Lime, cement, salt, sand and gravel, clays, stone, petroleum, salines, natural gas.
Wexford.....	59,275	114,000	Sand and gravel.
Undistributed ⁴	¹ 219,532,171	268,377,411	
Total.....	¹ 492,029,000	555,495,000	

¹ Revised.

W Withheld to avoid disclosing individual company confidential data.

² Values for natural gas and natural gas liquids are not available on a county basis, but are included with "Undistributed."³ Excludes value of natural gas.⁴ Includes value of mineral production in Keweenaw and Ontonagon Counties.⁵ Value of mineral production is included in that of Houghton County.⁶ Includes values for natural gas, natural gas liquids, gem stones, and some petroleum (1963), and some sand and gravel that cannot be assigned to specific counties, and values indicated by symbol W.

Alpena.—Huron Portland Cement Co., subsidiary of National Gypsum Co., produced portland and masonry cements at the world's largest cement plant at Alpena. During the year, ground was broken for construction of a second 460-foot kiln to be operational by mid-1965. Cement clinker production was to be increased by 2 million barrels per year. This was one phase of an expansion plan that will increase the Alpena plant capacity to 24 million barrels per year by 1975. Clay and limestone for use at the cement plant were produced in the Alpena area. About half a million tons of sand and gravel for building and road use were produced in the county.

Antrim.—Shale was mined for use in manufacturing cement at the Petoskey plant of Penn-Dixie Cement Corp. The county road commission produced gravel for road use.

Arenac.—Nearly 331,000 barrels of petroleum was recovered from nine fields, with the Deep River, Sterling, and Clayton fields producing the major portion. Sand and gravel for building, paving, and fill, and crushed limestone for highway use were produced in the county.

Baraga.—Sandstone for use in building construction was quarried and milled at Arnheim by Superior Natural Redstone Quarry. The county road commission produced sand and gravel for road use.

Barry.—About half a million tons of sand and gravel was mined from pits throughout the county. Marl for agricultural use was obtained from pits near Caledonia and Nashville. A small quantity of petroleum was recovered from the Hope and Johnstown fields.

Bay.—Aetna Portland Cement Co. produced portland and masonry cements at Bay City. The Monitor Sugar Division of the Robert Gage Coal Co. produced lime for use in sugar refining. About 352,000 barrels of petroleum was recovered from six fields, with Kawawlin and Essexville fields contributing the major portion. Bay Refining, Division Dow Chemical Co., refined crude oil at Bay City. The State highway department contracted for production of road gravel.

Berrien.—Industrial sand (engine and molding) was mined near Bridgman and Sawyer. Sand and gravel for building, paving, and fill was obtained from pits throughout the county. Nearly 1 million tons of material was produced. Marl was dug from two pits near Three Oaks.

Branch.—Sand and gravel, used principally for building, paving, and fill, was produced at plants principally in the vicinities of Coldwater and Union City. Marl for agricultural use was dug from pits near Fremont and Kinderhook and dipped from a lake near Colon.

Calhoun.—Although petroleum production dropped nearly half a million barrels, the county maintained its second place in output, with production of 2.3 million barrels. About 3.9 billion cubic feet of natural gas was produced, slightly less than in 1963. About 635,000 tons of sand and gravel for building, road construction, and fill was produced, about triple the amount reported in 1963. Marl was obtained from pits near Burlington and Union City and sold for agricultural use.

Cass.—The Jefferson field yielded about 9,000 barrels of petroleum, a decrease from 15,000 barrels in 1963. Marl was obtained from five pits and sold for agricultural use. Sand and gravel was produced from fixed plants in the Dowagiac and Niles areas and at portable plants at several sites in the county.

Cheboygan.—Limestone was quarried and crushed at two plants near Afton. It was sold for flux, roadstone, and agricultural use. Approximately 220,000 tons of sand and gravel was produced in the county, mostly with portable plants. Much of it was used for road construction and maintenance.

Chippewa.—Fluxstone, roadstone, and agricultural limestone were produced from a large quarry and crushing plant on Drummond Island. Sand and gravel production dropped sharply from that of 1963 as demand for road materials declined.

Clare.—Petroleum production of 614,000 barrels was reported from 12 fields. A major portion came from the Hamilton field. Gas production of nearly 193 million cubic feet was about the same as in 1963. A small quantity of road gravel was produced.

Clinton.—Clay, used in the manufacture of vitrified sewer pipe, was mined near Grand Ledge. About 361,000 tons of sand and gravel was produced for fill, paving, and building purposes. Harmon Sand & Gravel Co. of St. Johns and Floyd Lindsey, Maple Rapids, reported production for the first time in 1964.

Crawford.—Beaver Creek field yielded about 85,000 barrels of oil and 440 million cubic feet of natural gas. The State highway department and county road commission produced or contracted for gravel for fill and road construction and maintenance.

Delta.—Bichler Bros. of Escanaba quarried and crushed limestone for concrete aggregate and roadstone, and produced sand and gravel for building and road use. A large quantity of road materials, mostly gravel, was produced at other plants at several sites in the county.

Dickinson.—The Hanna Mining Co. operated the Groveland open-pit iron mine, concentrator, and pelletizing plant near Randville. The company installed a scavenger circuit to treat a portion of the tailings material.

Superior Rock Products Co. operated a quarry near Randville and produced limestone for use as terrazzo and ornamental concrete. Felch Quarry Co. operated a limestone quarry near Felch and produced material for roofing granules and other uses. Sand and gravel was produced for building and road use.

Eaton.—Clay was mined near Grand Ledge and used in the manufacture of vitrified sewer pipe. Cheney Limestone Co. quarried limestone at Bellevue and produced rubble, roadstone, and agricultural limestone. Reed-sedge peat was dug from a bog near Charlotte and sold for soil improvement. About 324,000 tons of sand and gravel was obtained from pits throughout the county. Much of the material was used for road construction and maintenance.

Emmet.—Penn-Dixie Cement Corp. produced portland and masonry cements at Petoskey. The company began an extensive modernization and expansion program during 1964 that included construction of a 525-foot kiln and raw mill to replace four existing kilns and raw mills, filtering tanks, and waste heat system. Plant capacity will be increased to 3 million barrels annually when construction is completed in 1965. Limestone was quarried near the plant for use in manufacturing cement. Gravel for road use was mined in the county.

Genesee.—About 926,000 tons of sand and gravel was produced in the county at six fixed plants and at four portable plants. The material was used for building and road construction and fill. The Otisville field yielded a small quantity of petroleum.

Gladwin.—Nearly half a million barrels of petroleum was produced from 13 fields, with the Grout and North Buckeye fields having the largest output. A small amount of sand and gravel was produced near Gladwin.

Gogebic.—Pickands Mather & Co. produced direct-shipping iron ore from two underground mines, Geneva and Peterson, the only active iron mines remaining on the Gogebic Range. Output was substantially greater than in 1963. Sand and gravel production totaled 280,000 tons and was used mainly for building and road construction.

Gratiot.—Michigan Chemical Corp. produced bromine, calcium-magnesium chloride, magnesium compounds, and salt from natural well brines at St. Louis. During the year construction was started on a \$2 million plant to produce granular calcium chloride. Initial capacity of 40,000 tons per year was planned with operations to start in the spring of 1965. The plant will furnish the basis for expansion of other brine chemical products of the company, but the principal market for the output was expected to be calcium chloride for ice control on highways. Leonard Refineries, Inc., operated a crude oil refinery at Alma. The company also recovered byproduct sulfur using the hydrofining process. About 67,000 barrels of petroleum was produced from the Summer field. A small quantity of natural gas was recovered from the North Star field. Production of 412,000 tons of sand and gravel was reported by five operators.

Hillsdale.—The county continued to lead the State in petroleum output with more than 5 million barrels reported, 800,000 barrels more than in 1963. Nearly 4 billion cubic feet of natural gas was produced. During the year 82 wells were completed in the county; 54 were dry holes and 28 were oil wells.

Marl for agricultural use was produced near Hillsdale. About 535,000 tons of sand and gravel was produced, mostly for building and road construction and maintenance.

Houghton.—Copper was produced by Calumet & Hecla, Inc., Copper Range Co., and Quincy Mining Co. Calumet & Hecla operated the Centennial No. 2, Centennial No. 3, Osceola No. 13, and Kingston mines. At the Kingston mine, construction on the surface installation neared completion at yearend, and underground development was expected to be completed by the middle of 1965. The company also operated a smelter near Hubbell and the Tamarack Reclamation plant. Copper Range Co. operated the Champion mine and Freda mill, which treated the Champion ore as well as tailings from the Redridge sands.

Quincy Mining Co. operated a reclamation plant at Hubbell and a smelter at Hancock. The company had taken action through the Quincy Mine Hoist Association to preserve the buildings and equipment connected with the No. 2 shaft, sunk in 1857. The project, to be completed and open to the public by June 1966, included the hoist, an observation floor on the No. 2 shaft house, and a scenic railroad using the rolling stock of the old narrow gage Quincy & Torch Lake Railroad.

The Limestone Mountain Co. quarry was idle in 1964. Sand and gravel for building and paving was produced in the county.

Huron.—Hydrated lime for use in sugar refining was produced by the Michigan Sugar Co. at Sebewaing. The Wallace Stone Co. (Division J. P. Burroughs & Son, Inc.) quarried and processed limestone at Bay Port. The material was used for rubble, riprap, roadstone, railroad ballast, and agricultural limestone.

Sand and gravel used mostly for building and paving was produced at several sites. A small quantity of petroleum was recovered from the Dwight and Grant fields.

Ingham.—More than 1.1 million tons of sand and gravel was produced, principally in the Holt, Lansing, and Mason areas. It was used mostly for road construction and maintenance, building, and fill. The Lansing Board of Water & Light recovered lime from calcium carbonate precipitated in the water purification process. A small quantity of reed-sedge peat was produced from a bog near Lansing by Winn's Peat Corp.

Iosco.—National Gypsum Co. quarried gypsum at Tawas City and processed crude ore at a plant at National City. At the same plant crude perlite, mined in New Mexico, was expanded for use in building plaster. United States Gypsum Co. operated a gypsum quarry at Alabaster. The material was used in manufacturing wallboard and other building products in plants at Detroit and Grand Rapids. Michigan Gypsum Co. operated a quarry near Whittemore. The crude material was sold as a cement retarder.

Road material was produced with a portable plant from a gravel pit near Greenbush.

Iron.—The Hanna Mining Co. mined and shipped iron ore from the Wauseca, Hiawatha, and Homer underground mines. On November 20, mining ceased at Shaft No. 1 of the Hiawatha mine owing to depletion of ore. Inland Steel Co. operated the Bristol and Sherwood mines.

Over half a million tons of sand and gravel was produced at several locations. The sand was produced by The Hanna Mining Co. for filling stopes at their mines in the county. The gravel was used for road construction.

Isabella.—Petroleum output declined to 362,000 barrels from 402,000 in 1963. Production was reported from 11 fields. The Wise field yielded a small quantity of natural gas. Leonard Refineries, Inc., refined crude oil at Mount Pleasant.

Nearly 1 million tons of sand and gravel was mined from pits at several sites. It was used for fill, building, and paving. Gatehouse Brothers produced marl from a site near Weidman.

Jackson.—Petroleum output declined for the third year to about 1.9 million barrels from 2.3 million in 1963. Natural gas production of 2 billion cubic feet was nearly as great as in the previous year.

About 680,000 tons of sand and gravel was produced, mostly for building and paving purposes. Limestone was quarried and crushed near Parma for concrete aggregate, roadstone, and agricultural use. Marl was dug from a pit near Horton. Sandstone for use mostly as building stone, flagging, and rubble was quarried and milled at three sites near Napoleon.

Kalamazoo.—Reed-sedge peat was dug from bogs near Kalamazoo and Scotts and sold for general soil improvement. Marl, for agricultural use, was obtained from pits in the Climax and Vicksburg areas. Nearly 1.3 million tons of sand and gravel was produced principally for use in road construction and maintenance.

Kalkaska.—Petroleum was recovered from the Beaver Creek and Excelsior fields. No natural gas production was reported during 1964. The county road commission mined sand and gravel for its own use.

Kent.—Gypsum was produced from underground mines by Bestwall Gypsum Co. and Grand Rapids Gypsum Co. The crude material was processed at company-owned plants and used in manufacturing wallboard, plaster, and other building products.

Perlite, mined in Nevada, was expanded at the Bestwall plant and used in plaster. Nearly 2.7 million tons of sand and gravel was produced, mostly in the Grand Rapids area. Peat was dug from bogs and sold for soil improvement and horticultural use. Petroleum and natural gas were recovered with the Walker field yielding the major portion.

Keweenaw.—Sand and gravel was produced by the county road commission for its own use. The National Park Service dredged basalt and sandstone at Isle Royale for use at Isle Royale National Park, which is located in the county.

Copper produced by Calumet & Hecla, Inc., from the No. 4 Ahmeek Peninsula, Allouez No. 3, and Seneca mines is included with Houghton County.

Lapeer.—Calcium-magnesium chloride was extracted from well brines at Mayville by Wilkinson Chemical Corp. Several peat bogs, near Imlay City, yielded reed-sedge peat for soil improvement and horticultural use. Production of 341,000 tons of sand and gravel was reported; most was for road use. About 35,000 barrels of petroleum was recovered from the Rich field.

Lenawee.—Portland cement was manufactured at Cement City by Peninsular Portland Cement Division of General Portland Cement Co.

Comfort Brick & Tile Co. manufactured draintile from clay mined near Tecumseh. Reed-sedge peat was dug from bogs near Adrian and Tecumseh.

About half a million tons of sand and gravel was produced at several sites in the county. Principal use was for road construction and repair. The Macon Creek and Medina fields yielded a small quantity of petroleum.

Mackinac.—Inland Lime & Stone Co., Division of Inland Steel Co., operated the Port Inland quarry. On July 30, the company shipped its 100th million ton of high calcium limestone from its Upper Peninsula operation. United States Steel Corp. operated the Cedarville limestone quarry. Both companies maintain large processing plants, as well as port facilities for shipping the material by water transport to industrial consumers. Road materials, mostly gravel, were mined at several sites in the county. Output was only one-third of the 1963 shipments.

Macomb.—Sand and gravel production totaled 2.8 million tons, compared with 3.5 million in 1963. The decline reflects decreased demand for building and road materials in the northeastern portion of the Detroit metropolitan area. Natural gas output tripled to 5.3 billion cubic feet from 1.7 billion in 1963. Production came from the Lenox and Ray fields. A small quantity of petroleum was recovered.

Manistee.—Bromine, calcium-magnesium chloride, and magnesium compounds were extracted from natural well brines of the Filer formation. Salt was recovered from artificial brines. In the Manistee area plants were operated by Great Lakes Chemical Corp., Manistee Salt Works, Michigan Chemical Corp., Morton Chemical Co., Morton Salt Co., and Standard Lime & Cement Co. Packaging Corp. of America produced regenerated lime for its own consumption by calcining calcium carbonate sludge in a rotary kiln.

Nearly half a million tons of sand and gravel was produced. The gravel was used mostly for road construction and maintenance, while the sand was sold for industrial purposes.

Marquette.—The county maintains first position in the State in value of minerals produced. Iron ore mines were operated by Cleveland-Cliffs Iron Co., Jones & Laughlin Steel Corp., and North Range Mining Co. Cleveland-Cliffs' \$50-million Empire mine complex, near Negaunee, had its first full year of operation. The annual rated capacity is 1.2 million tons of pellets with iron content in excess of 63 percent. The Empire beneficiating plant is the first in the United States to use full autogenous mills, grinding 90 percent of the magnetic ore to 500 mesh. Flotation was used to upgrade the concentrate. The single-line grate kiln pelletizing system is the largest in the world. County iron ore shipments were up 36 percent. The output of underground mines was up 20 percent and open-pit mines 46 percent. Sand and gravel production totaled 658,000 tons and was used for building and road construction, railroad ballast, and fill.

Mason.—Chemicals (bromine, calcium chloride, calcium-magnesium chloride, and magnesium compounds) were extracted from well brines

in the Ludington area by the Dow Chemical Co. Harbison-Walker Refractories Co. produced refractory magnesia from purchased magnesium hydroxide. Industrial sand (molding, grinding, polishing, and engine) as well as road gravel were produced.

The Dow Chemical Co. produced quicklime at Ludington. About 230,000 barrels of petroleum was produced from six fields. About 13 million cubic feet of natural gas was produced from the Logan field.

Mecosta.—Reed-sedge peat was dug from a bog near Lakeview and marl from pits near Mecosta. Both were sold for soil enrichment and improvement. Sand and gravel was mined throughout the county, mostly with portable equipment. Principal uses were for building and road construction. About 26,000 barrels of oil and 129 million cubic feet of natural gas were recovered from fields in the county.

Menominee.—Limestone Products Division of North Western-Hanna Fuel Co. produced quicklime and hydrated lime at Menominee. The lime was used in the manufacturing or processing of a wide range of industrial and chemical products. Nearly half a million tons of sand and gravel was produced, mostly for road construction and maintenance.

Midland.—Bromine, calcium chloride, calcium-magnesium chloride, iodine, magnesium compounds, and potash were recovered from natural well brines at Midland by The Dow Chemical Co. The company also recovered salt from artificial brines. Kaiser Aluminum & Chemical Corp. produced refractory magnesia from purchased magnesium hydroxide. Molding sand and sand and gravel for building and paving were produced near Midland. About 260,000 barrels of petroleum and 8 million cubic feet of natural gas were produced in the county.

Missaukee.—About 449,000 barrels of petroleum and 1.2 billion cubic feet of natural gas were recovered, principally from the McBain, East Norwich, Enterprise, Falmouth, and Forward fields. A small quantity of road gravel was produced for the State highway department.

Monroe.—Portland and masonry cements were produced by Dundee Cement Co. Raw materials (clay and limestone) were mined at the plant site. Clay for art pottery was mined near South Rockwood by F. W. Ritter Sons Co. Limestone for flux, roadstone, ballast, and agricultural use was quarried and crushed at Maybee, Monroe, and Ottawa Lake.

Humus and reed-sedge peat was dug from bogs near Ida and Petersburg and used for soil improvement. About 8,000 barrels of petroleum was produced, mostly from the Deerfield field.

Montcalm.—About 285,000 barrels of petroleum and 89 million cubic feet of natural gas were produced from a dozen fields. Largest output was reported from the Edmore and Reynolds fields. Sand and gravel output more than doubled to 569,000 tons because of increased demand for road use. Crude oil was refined by Crystal Refining Co. at Carson City.

Muskegon.—At Montague, Hooker Chemical Corp. recovered salt from artificial brines, and Union Carbide Corp. produced hydrated lime as a byproduct at their acetylene producing operation. The hy-

drated lime was sold for construction, agricultural, and industrial uses. About 631,000 tons of sand and gravel was produced. In addition to sand and gravel for building and road construction, a considerable tonnage of industrial sand was produced.

About 10,000 barrels of petroleum and 9 million cubic feet of natural gas were produced from several small fields. Crude oil was refined at Muskegon by Marathon Oil Co. and Naph-Sol Refining Co.

Newaygo.—Natural gas production at the Ensley field dropped to 51 million cubic feet from 119 million in 1963. About 21,000 barrels of petroleum was recovered from six fields. A pit near Grant yielded marl for agricultural use. Approximately 214,000 tons of sand and gravel was produced throughout the county, mostly with portable plants. Output was chiefly for building and road construction.

Oakland.—More than 8.1 million tons of sand and gravel was produced, the largest output of any county in the State. The material was used principally for building and road construction in the Detroit metropolitan area.

Humus and moss peat was dug from bogs in the Clarkston, New Hudson, and Novi areas. It was sold for soil improvement. The Northville field (Oakland County portion) yielded small quantities of petroleum and natural gas.

Oceana.—About 170,000 barrels of petroleum was produced from nine fields with the largest output reported from the Eldridge and Pentwater fields. Over 700,000 tons of sand and gravel was produced, mostly for road construction and maintenance.

Ogemaw.—Petroleum (336,000 barrels) and natural gas (645 million cubic feet) were produced. Nearly all production came from the Rose City and West Branch fields. Osceola Refining Co. refined crude oil at West Branch. About 237,000 tons of sand and gravel was produced.

Ontonagon.—White Pine Copper Co. (subsidiary of Copper Range Co.) operated a mine, mill, and smelter at White Pine. Output of both copper and silver was reduced chiefly because of a 7-week labor strike. In May a fire in the White Pine mine stopped production for 10 days. Exploratory drilling during 1964 indicated 60 million tons of additional reserves. Development of the longwall mining program continued. One longwall panel has been in operation for nearly a year on an experimental basis and is heavily instrumented to provide data on the behavior of rock under conditions created by the method. A second panel is planned for 1965.

About 398,000 tons of sand and gravel was produced in the county and used for road construction and maintenance.

Osceola.—Petroleum output totaled 265,000 barrels, and 219 million cubic feet of natural gas was produced from nine fields. Marl was dug from a pit near Tustin. About 224,000 tons of sand and gravel was produced from pits near Evart and Hersey.

Ottawa.—Nearly 2.1 million tons of sand and gravel was produced. Although most of the material was used for building, paving, and fill, some industrial sand was included. A small amount of marl was obtained from pits in the Hudsonville and Jenison areas.

About 267,000 barrels of petroleum was produced at five fields with the Dennison and Walker fields accounting for most of the output. Natural gas output totaled 170 million cubic feet.

Presque Isle.—Crushed limestone was produced at Rogers City by United States Steel Corp., and at Alpena by Presque Isle Corp. The material was shipped by water to steel mills, cement plants, and other industrial consumers. Large quantities were also sold for concrete aggregate, roadstone, and agricultural purposes. At Onaway, a small quantity of dimension limestone was milled mainly for building use by Onaway Stone Co.

More than half a million tons of sand and gravel was produced, mostly for road material.

Roscommon.—Nearly 1 billion cubic feet of natural gas and 193,000 barrels of petroleum were recovered. Most of the production came from the Headquarters and St. Helen fields. About 349,000 tons of sand and gravel was produced, nearly all with portable plants.

Saginaw.—Aetna Portland Cement Co. mined clay near Saginaw for use in manufacturing cement. Michigan Sugar Co. produced hydrated lime for use in sugar refining. Petroleum totalling 32,000 barrels was produced from five fields. Paving sand and gravel was produced for the State highway department.

St. Clair.—Peerless Cement Co., Division of American Cement Corp., produced portland and masonry cements at Port Huron. Clay was mined at the Smith Creek pit for use at the plant. Salt was recovered from artificial brines by Diamond Crystal Salt Co. at St. Clair and by Morton Salt Co. at Marysville. Reed-sedge peat was obtained from a bog near Capac. About 403,000 tons of sand and gravel was produced for building and paving use. Nearly 883,000 barrels of petroleum and 12.3 billion cubic feet of natural gas were recovered from 12 fields. The county natural gas output was the largest in the State.

St. Joseph.—Reed-sedge peat was dug from a bog near Three Rivers and sold for soil improvement. In the same area and at Nottawa, marl was obtained from pits and sold for agricultural use. Sand and gravel for building and road use was produced at several sites in the Three Rivers and White Pigeon areas.

Sanilac.—Peat was produced at Minden City and Sandusky. It was sold both in bulk and in packaged form for soil improvement and as a potting material. Michigan Sugar Co. produced hydrated lime at Crosswell for use in sugar refining. About 673,000 tons of sand and gravel was produced, much of it for road material.

Shiawassee.—Clay was mined at Corunna for use in manufacturing vitrified sewer pipe. Reed-sedge peat was obtained from a bog near Ovid. About 720,000 tons of sand and gravel was produced; this was double the amount reported in 1963.

Tuscola.—Michigan Sugar Co. produced hydrated lime at Caro for sugar refining. Moss peat was dug at Kingston and sold for soil improvement. Nearly 1.9 million tons of sand and gravel was produced. Although much of the material was sold for building and road construction, a substantial quantity of molding sand was reported. More than 82,000 barrels of petroleum was recovered from four fields.

Van Buren.—Industrial sand (molding and engine) was produced at Covert and South Haven, while road gravel was produced with portable plants at sites throughout the county.

A pit near Paw Paw yielded marl for agricultural use. About 24,000 barrels of petroleum was recovered at four fields.

Washtenaw.—About 921,000 tons of sand and gravel was produced, compared with 1.5 million in 1963, reflecting a lessened demand for road construction materials.

About 31,000 barrels of petroleum and 216 million cubic feet of natural gas were produced from the Northville field.

Wayne.—The county ranked third in value of mineral production, and the total was \$5.6 million greater than in 1963. Sand and gravel output totaled over 4.3 million tons, nearly twice the production reported in 1963. Material for road construction and maintenance accounted for much of the increase.

Salt was mined at Detroit by International Salt Co., Inc., and recovered from artificial brines at Wyandotte by Pennsalt Chemicals Corp. and Wyandotte Chemicals Corp.

Portland and masonry cements were produced at two plants in Detroit by Peerless Cement Co., Division of American Cement Corp. The company mined clay for cement at Allen Park. Wyandotte Chemicals Corp. produced portland cement at Wyandotte. Clay was mined at Livonia and used in producing lightweight aggregates. Draintile was manufactured from clay mined at Flat Rock.

Quicklime was produced in Detroit by Solvay Process Division of Allied Chemical Corp. and at Wyandotte by Wyandotte Chemicals Corp. Marblehead Lime Co. started construction in the River Rouge area of a lime plant with a designed annual capacity of 700,000 tons.

Calcium chloride was produced for company use and for sale by Wyandotte Chemicals Corp. Limestone was produced by the Michigan Foundation Quarry Co., Inc., for concrete aggregate and roadstone.

United States Gypsum Co. operated a calcining and board plant in Detroit. The company also expanded perlite at the Detroit plant. Zonolite Division, W. R. Grace & Co., exfoliated vermiculite at a plant in Dearborn. Marathon Oil Co. recovered byproduct sulfur from crude oil, using the Parsons process, at its Detroit refinery. A crude oil refinery was also operated by Socony-Mobile Oil Co. at Trenton. According to data published by the Michigan Geological Survey,⁴ the crude oil refinery of Petroleum Specialities, Inc., at Flat Rock was inactive. The Wayne County portion of the Northville field yielded 16,000 barrels of petroleum and 376 million cubic feet of natural gas.

⁴Geological Survey Division, Michigan Department of Conservation. Annual Statistical Summary 2, Michigan's Oil and Gas Fields, 1964. 1965, 17 pp.

PLATES

Photographs of several mineral operations
taken during 1965



Photo 1—Lightweight aggregate has been produced since 1952 at this Livonia plant of Light Weight Aggregate Corporation. Production goes largely into concrete masonry.



Photo 4—Sargent Sand Company sandstone quarry at Flat Rock, now producing foundry sand. Formerly operated by Huron River Quarry Company for producing limestone.

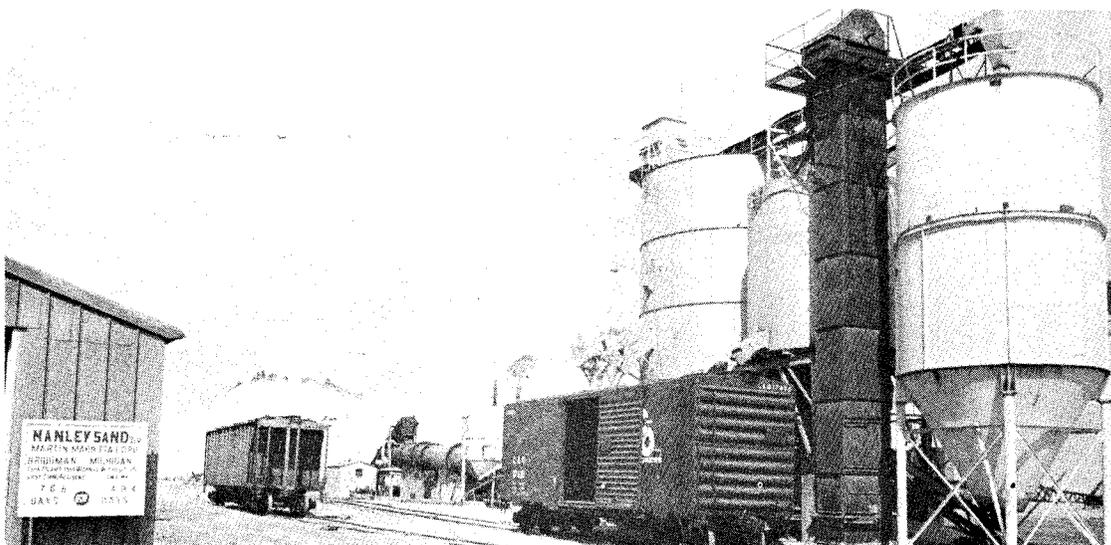


Photo 2—Sand plant of Manley Sand Division near Bridgman. Lake Michigan dunes are a vital source of molding sand for the steel industry.



Photo 5—Marl operation of Laverne Brizendine at Cook Lake near Dowagiac. Marl produced in Michigan goes entirely for agricultural use on lime deficient soils.



Photo 3—Gravel plant of Pickitt & Schreur at Allegan is one of about 20 heavy-media beneficiation plants in Michigan.

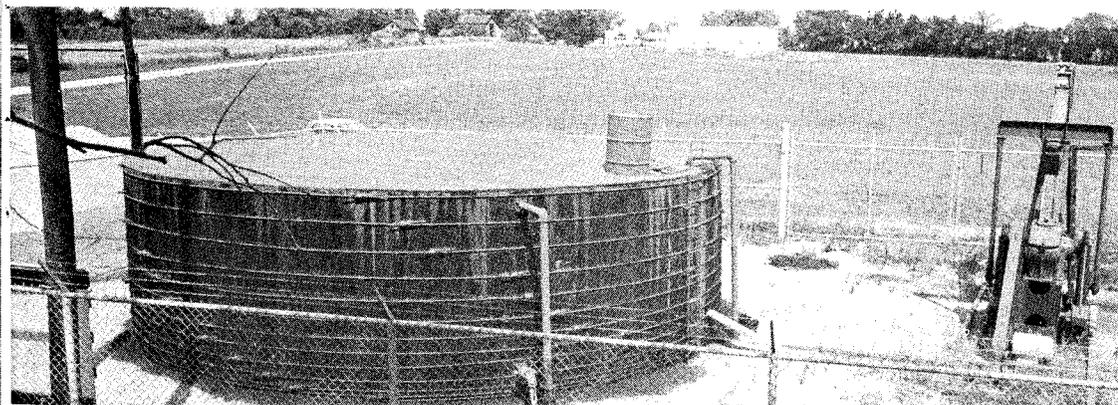


Photo 6—Natural brine well and storage tank at Vermontville. This brine is recovered from limestone at a depth of 2100 feet, and is used for dust- and ice-control on roads in Eaton County.

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