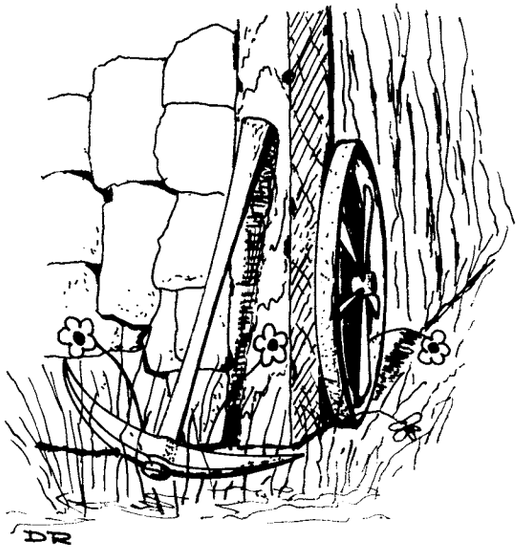
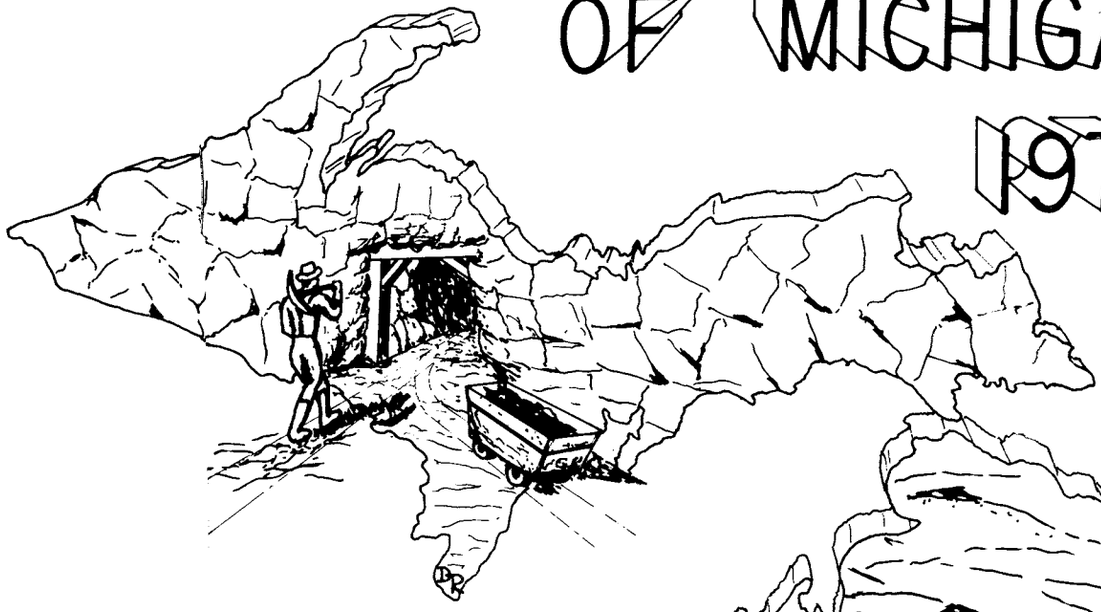


MINERAL INDUSTRY OF MICHIGAN 1976



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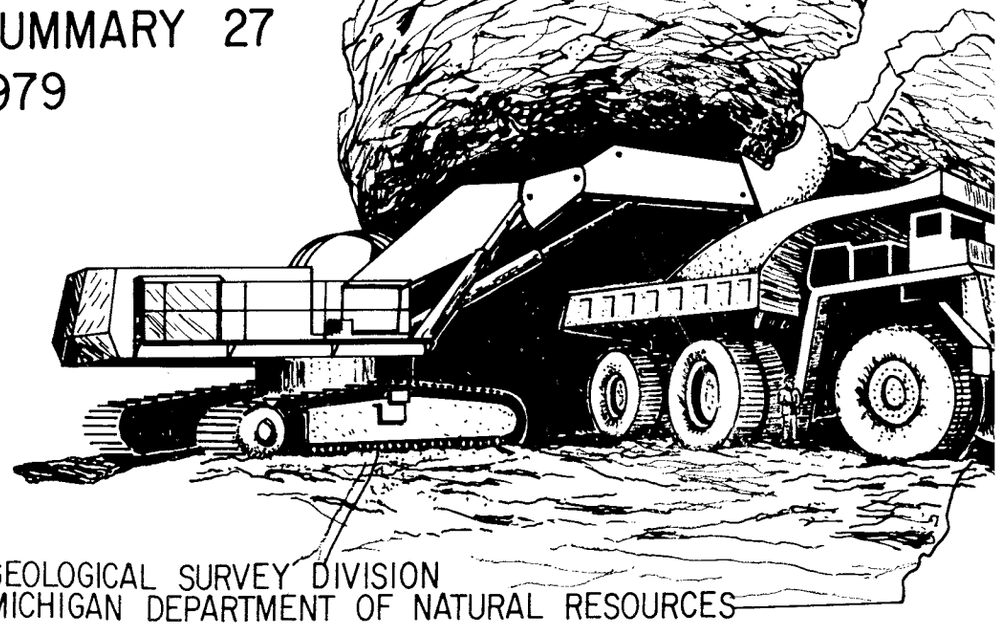

GEOLOGICAL SURVEY DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Published by authority of State of Michigan
Compiled Laws of 1970 section 321.6

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Michigan Department of Natural Resources
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Lansing, Michigan 48909

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Preprint from the 1976

BUREAU OF MINES MINERALS YEARBOOK

The Mineral Industry of Michigan

In cooperation with

Bureau of Mines

Geological Survey Division

Lansing, Michigan

PREFACE

The covers , illustrated by staff cartographer Donald E. Raymond , celebrate the 1976 Bicentennial Year by depicting some of the changes in mining methods. Hundreds of years ago prehistoric Indians mined native copper by hand from what is now the Keweenaw Peninsula. Today, modern machinery has increased the production and efficiency of the mining industry.

No doubt the local use of stone for building material and clay for brickmaking began as soon as settlers started to inhabit Michigan, long before statehood. The importance of minerals to the well-being of the people of Michigan was recognized by the first State legislature. When the legislature met in 1837 the Michigan Geological Survey was created as the first State agency with Dr. Douglass Houghton appointed State Geologist. The Survey investigated the occurrence of salt seeps and other mineral resources in the new State.

In 1976 the Michigan mineral industry was quite diversified, producing many different commodities found within the State. The processing of minerals also extended to many commodities shipped here from other locations. The end products of mineral-based materials is extremely varied.

"The Mineral Industry of Michigan - 1976" was written and published by the U.S. Bureau of Mines (U.S.B.M.) as a chapter in their 1976 "Minerals Yearbook". Through a memorandum of understanding between the U.S.B.M. and the Geological Survey Division of the Michigan Department of Natural Resources, this chapter is also offered as the Geological Survey Division's "Annual Statistical Summary 27".

A companion publication by the Geological Survey Division is the Annual Directory entitled "Michigan Mineral Producers". The directory contains the names, addresses and locations of metallic and nonmetallic mineral producer operations plus numerous maps, historical production and value charts, and associated geological information.

Copies of the Annual Statistical Summary cost twenty-five cents and single copies of the Directory and the current List of Available Geological Survey Division Publications, may be obtained free. These publications are available from Information Services Center, Michigan Department of Natural Resources, Box 30028, Lansing, Michigan 48909.

Statistics on Michigan's oil and gas production, drilling, exports and imports, and other pertinent data are published as "Annual Statistical Summary, Michigan's Oil and Gas Fields". This is compiled by the Subsurface and Petroleum Geology Unit of the Geological Survey Division. The information is for the preceding calendar year. "Annual Statistical Summary 28" is available for $2.00 plus State sales tax, from the Information Services Center.

Lansing, Michigan
March, 1979

Milton A. Gere, Jr.
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UNITED STATES DEPARTMENT OF THE INTERIOR • Cecil D. Andrus, Secretary
BUREAU OF MINES

This publication is a chapter from the current Bureau of Mines Minerals Yearbook, comprising *Volume I, Metals, Minerals,* and *Fuels; Volume II, Area Reports: Domestic; Volume III, Area Reports: International.* The separate volumes of the Yearbook are sold by the Superintendent of Documents, Washington, D.C. 20402.

The Mineral Industry of Michigan

This chapter has been prepared by the Bureau of Mines, U.S. Department of the Interior, and the Geological Survey Division of the Michigan Department of Natural Resources, under a memorandum of understanding for collecting information on all minerals except coal and liquid fuels.

By Edward C. Peterson [1] and Esther A. Middlewood [2]

Michigan's mineral industry continued to make significant gains in 1976, mainly because of record petroleum and natural gas production and higher prices for the minerals produced. For the fifth consecutive year, the value of Michigan's raw mineral output increased, establishing a record high of $1.54 billion, a 19.5% rise over that of 1975.

Nonmetallic mineral production rose after 5 consecutive years of decline, reflecting increased demands in the construction industry. These commodities contribute the major part of the State's total mineral value, accounting for $574 million, or 37.2% of the total. Nationally, Michigan continued to be a leading producer of bromine, calcium chloride, cement, gypsum, salt, and sand and gravel. Michigan is the sole producer of iodine in the United States.

Metals accounted for $503 million, or 32.6% of the total mineral value. Iron ore continued to be the single leading mineral commodity in terms of value. Shipments and values were significantly higher in 1976. Production and value of copper declined 41% and 36%, reflecting a slump in the copper industry which began in mid-1974 and prevailed throughout 1976.

Total output of mineral fuels (natural gas, natural gas liquids, peat, and petroleum) were valued at $466 million, an increase of 37% over 1975. Oil and gas production continued at record levels, accounting for 30% of the total mineral value in 1976. The State continued to be the largest domestic producer of peat. After 2 years of limited coal production, no output was reported in 1976.

Major developments in the mineral industry of Michigan during 1976 included: Plans announced by Cleveland-Cliffs Iron Co. (CCI) for a $750 million expansion of iron ore production capacity at the Tilden and Empire properties near Ishpeming; awarding a $13.6 million contract to The Dow Chemical Co. of Midland by the U.S. Energy Research and Development Administration (ERDA) to test the feasibility of extracting oil and gas from the Antrim Shale deposits that underlie most of lower Michigan; proposed acquisition of Copper Range Co., the parent company of White Pine Copper Co. and the State's major copper producer, by Louisiana Land & Exploration Co. (LL&E); and exploration for uranium deposits on 200,000 acres of Upper Peninsula land leased jointly by the Tennessee Valley Authority (TVA) and a subsidiary of International Nickel Co.

Each year the Geology Div., Department of Natural Resources (DNR), publishes a directory of mineral producers operating in the State. The current issue, the 10th Annual Directory issued, lists over 500 mineral operations that were active during 1976, exclusive of oil and gas. The names and addresses of producers and

[1] State Liaison Officer, Bureau of Mines, Lansing, Mich.
[2] Liaison program assistant, Bureau of Mines Liaison Office, Lansing, Mich.

Table 1.—Mineral production in Michigan [1]

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
Cement:				
Masonry ---thousand short tons	183	$6,429	218	$8,370
Portland ---do	4,573	131,324	4,931	145,381
Clays ---do	1,818	3,580	1,934	4,741
Copper (recoverable content of ores, etc.) short tons	73,690	94,618	43,707	60,840
Gem stones	NA	8	NA	10
Gypsum ---thousand short tons	1,224	5,936	1,837	9,842
Iron ore (usable), thousand long tons, gross weight	14,089	339,113	16,245	441,206
Lime ---thousand short tons	1,434	36,540	1,456	39,686
Natural gas ---million cubic feet	102,113	64,740	119,262	106,739
Natural gas liquids:				
Natural gasoline and cycle products thousand 42-gallon barrels	656	3,294	3,504	19,725
LP gases ---do	1,348	5,945	1,215	6,806
Peat ---thousand short tons	245	3,206	300	3,714
Petroleum (crude) ---thousand 42-gallon barrels	24,420	262,352	30,421	329,637
Salt ---thousand short tons	4,020	68,353	4,219	78,740
Sand and gravel ---do	47,051	73,397	47,403	78,455
Silver (recoverable content of ores, etc.) thousand troy ounces	632	2,795	311	1,352
Stone ---thousand short tons	39,946	73,800	41,485	82,381
Value of items that cannot be disclosed:				
Bromine, calcium chloride, iodine, and magnesium compounds	XX	116,223	XX	125,441
Total	XX	1,291,653	XX	1,543,516
Total 1967 constant dollars	XX	511,107	XX	p 554,894

p Preliminary. NA Not available. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 2.—Value of mineral production in Michigan, by county [1]

(Thousands)

County	1975	1976	Minerals produced in 1976 in order of value
Alcona	$124	$187	Sand and gravel.
Alger	77	207	Do.
Allegan	2,474	2,174	Petroleum, sand and gravel, stone, natural gas, peat.
Alpena	61,660	65,116	Cement, stone, clays, sand and gravel.
Antrim	W	W	Petroleum, natural gas, clays, sand and gravel.
Arenac	W	W	Petroleum, stone, sand and gravel.
Baraga	110	183	Sand and gravel.
Barry	W	W	Sand and gravel, petroleum, stone.
Bay	11,801	14,115	Cement, petroleum, sand and gravel, lime.
Benzie	33	W	Sand and gravel, petroleum.
Berrien	4,691	5,095	Sand and gravel, stone.
Branch	488	217	Do.
Calhoun	17,909	21,716	Petroleum, natural gas, sand and gravel, stone.
Cass	W	W	Sand and gravel, petroleum, stone.
Charlevoix	W	W	Cement, stone, sand and gravel.
Cheboygan	188	W	Stone, sand and gravel, petroleum.
Chippewa	W	W	Stone, sand and gravel.
Clare	3,930	W	Petroleum, sand and gravel, natural gas.
Clinton	W	W	Sand and gravel, clays.
Crawford	9,741	W	Petroleum, natural gas, sand and gravel.
Delta	W	W	Sand and gravel, stone.
Dickinson	W	W	Iron ore, sand and gravel, stone.
Eaton	4,969	8,239	Natural gas, petroleum, stone, sand and gravel, clays, peat.
Emmet	16,025	15,520	Cement, stone, clays, sand and gravel.
Genesee	W	W	Sand and gravel, petroleum.
Gladwin	W	W	Petroleum, sand and gravel.
Gogebic	249	158	Sand and gravel.
Grand Traverse	36,065	67,787	Petroleum, natural gas, sand and gravel.
Gratiot	11,030	11,097	Magnesium compounds, calcium chloride, salt, sand and gravel, petroleum, natural gas.
Hillsdale	20,410	19,448	Petroleum, natural gas, natural gas liquids, sand and gravel.
Houghton	1,375	2,959	Copper, sand and gravel, silver, stone.
Huron	W	W	Stone, lime, sand and gravel.
Ingham	30,872	31,913	Petroleum, natural gas, natural gas liquids, sand and gravel, peat.
Ionia	627	407	Sand and gravel.
Iosco	W	W	Gypsum, sand and gravel.
Iron	W	W	Iron ore, sand and gravel.
Isabella	W	W	Petroleum, sand and gravel.
Jackson	6,984	W	Petroleum, natural gas, sand and gravel, stone.
Kalamazoo	W	W	Sand and gravel, stone.
Kalkaska	64,541	80,471	Petroleum, natural gas, natural gas liquids, sand and gravel.
Kent	5,028	5,117	Sand and gravel, gypsum, petroleum, peat, natural gas.
Keweenaw	31	36	Sand and gravel.
Lake	W	W	Petroleum, sand and gravel.
Lapeer	2,832	3,654	Peat, petroleum, sand and gravel, calcium chloride, natural gas.
Leelanau	W	W	Sand and gravel.
Lenawee	W	1,021	Do.
Livingston	W	W	Sand and gravel, natural gas, petroleum.
Luce	W	W	Sand and gravel.
Mackinac	W	13,354	Stone, sand and gravel.
Macomb	W	W	Sand and gravel, natural gas, petroleum.
Manistee	61,375	126,365	Petroleum, magnesium compounds, salt, natural gas, bromine, sand and gravel.
Marquette	W	W	Iron ore, sand and gravel, stone.
Mason	57,984	68,882	Magnesium compounds, calcium chloride, lime, bromine, natural gas, petroleum, sand and gravel.
Mecosta	845	723	Petroleum, sand and gravel, natural gas, peat.
Menominee	174	76	Sand and gravel.
Midland	38,178	31,613	Bromine, calcium chloride, magnesium compounds, petroleum, salt, iodine.
Missaukee	7,558	7,496	Petroleum, natural gas, sand and gravel.
Monroe	23,538	33,099	Cement, stone, clays, sand and gravel, peat, petroleum.
Montcalm	W	W	Petroleum, sand and gravel.
Montmorency	4	W	Sand and gravel.
Muskegon	W	W	Sand and gravel, salt, petroleum.
Newaygo	W	W	Petroleum, sand and gravel.
Oakland	16,434	18,505	Sand and gravel, natural gas, petroleum, peat.
Oceana	W	W	Sand and gravel, petroleum.
Ogemaw	W	6,731	Petroleum, sand and gravel, natural gas.

See footnotes at end of table.

Table 2.—Value of mineral production in Michigan, by county [1]—Continued

(Thousands)

County	1975	1976	Minerals produced in 1976 in order of value
Ontonagon	W	$59,550	Copper, silver, sand and gravel.
Osceola	W	3,937	Petroleum, sand and gravel, natural gas liquids, natural gas.
Oscoda	W	W	Sand and gravel, petroleum.
Otsego	$68,324	78,812	Petroleum, natural gas, sand and gravel.
Ottawa	5,264	W	Sand and gravel, petroleum.
Presque Isle	30,144	W	Stone, sand and gravel.
Roscommon	4,115	4,443	Petroleum, natural gas, sand and gravel.
Saginaw	2,440	W	Sand and gravel, lime, petroleum.
St. Clair	40,988	47,507	Salt, petroleum, natural gas, sand and gravel.
St. Joseph	W	W	Sand and gravel, stone, peat.
Sanilac	W	W	Peat, sand and gravel, lime.
Schoolcraft	W	1,423	Stone, sand and gravel.
Shiawassee	951	W	Peat, sand and gravel, clays, petroleum.
Tuscola	W	2,268	Sand and gravel, petroleum, lime, natural gas.
Van Buren	W	W	Sand and gravel, petroleum.
Washtenaw	W	W	Do.
Wayne	77,175	88,716	Lime, cement, salt, sand and gravel, stone, clays, petroleum.
Wexford	3,167	W	Petroleum, natural gas, sand and gravel.
Undistributed [2]	538,727	593,169	
Total [3]	1,291,653	1,543,516	

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Value of petroleum and natural gas are based on an average price per barrel and cubic foot, respectively, for the State.

[2] Includes values for gem stones and some sand and gravel that cannot be assigned to specific counties, and values indicated by symbol W.

[3] Data may not add to totals shown because of independent rounding.

Table 3.—Indicators of Michigan business activity

	1975	1976 p	Change, percent
Employment and labor force, annual average:			
Total civilian labor force—thousands	3,922.0	3,997.0	+1.9
Unemployment—do	490.0	374.0	−23.7
Employment (nonagricultural):			
Mining—do	13.8	12.7	−8.0
Manufacturing—do	983.7	1,056.7	+7.4
Contract construction—do	106.3	105.3	−.9
Transportation and public utilities—do	143.5	144.6	+.8
Wholesale and retail trade—do	656.4	674.7	+2.8
Finance, insurance, real estate—do	134.0	136.9	+2.2
Services—do	515.3	539.3	+4.7
Government—do	583.1	594.0	+1.9
Total nonagricultural employment—do	3,136.1	[1] 3,264.3	+4.1
Personal income:			
Total—millions	$54,463	$61,485	+12.9
Per capita	$5,978	$6,754	+13.0
Construction activity:			
Number of private and public residential units authorized	36,980	45,895	+24.1
Value of nonresidential construction—millions	$605.8	$599.3	−1.1
Value of State road contract awards—do	$220.3	$280.0	+27.1
Shipments of portland and masonry cement to and within the State—thousand short tons	2,475	2,735	+10.5
Mineral production value:			
Total crude mineral value—millions	$1,291.7	$1,543.5	+19.5
Value per capita, resident population	$142	$170	+19.7
Value per square mile	$22,187	$26,514	+19.5

p Preliminary.

[1] Data do not add to total shown because of independent rounding.

Sources: U.S. Department of Commerce, U.S. Department of Labor, Highway and Heavy Construction Magazine, and U.S. Bureau of Mines.

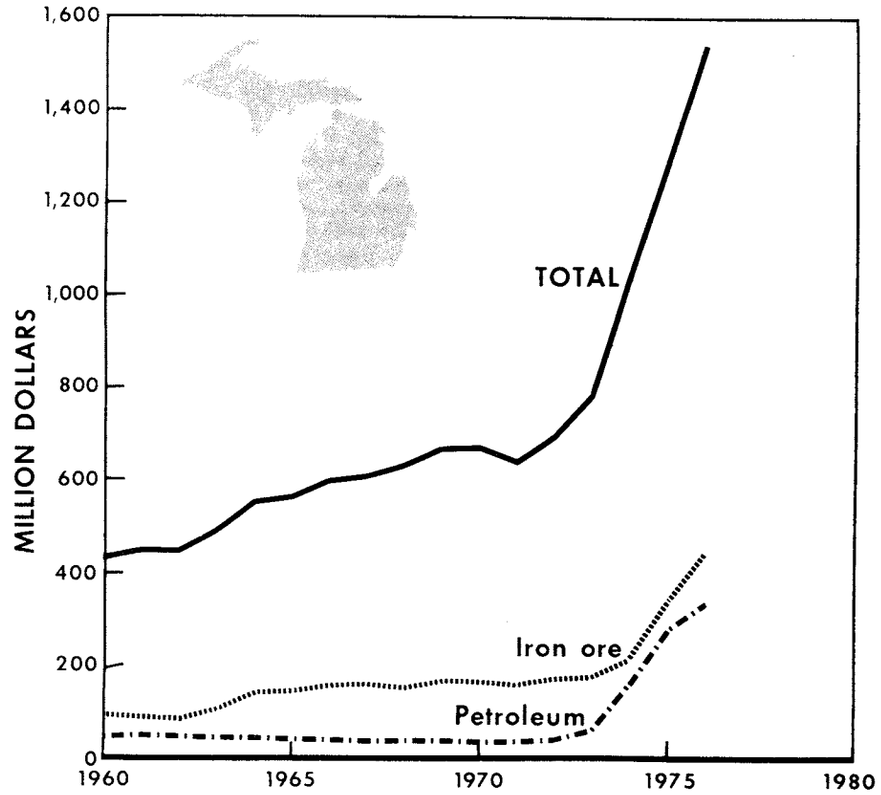

Figure 1.—Value of iron ore, petroleum, and total value of mineral production in Michigan.

processors are arranged alphabetically under the appropriate raw material or manufactured commodity. In addition, a listing of all producers by county is included, providing the location of the various operations whenever possible. Other data in the publication pertinent to Michigan's mineral industry include recent legislation, geologic information, and a listing of current State publications. The 1976 edition is unique in that it also contains a listing of the current DNR sand and gravel pits arranged by county. These pits are on lands under the jurisdiction of DNR and are mined according to a mine plan which includes the overall reclamation of the pit site upon completion of the removal operations.

Protection of workers involved in mining activities improved during 1976, with a reduction in injury rates reported. Inspections performed by the two Michigan field offices of the Mining Enforcement and Safety Administration (MESA) totaled 844. These inspections included health (dust, air, noise, and radiation) and all safety aspects of the mining industry. Under an agreement with the Michigan Department of Labor, all mine investigations are conducted by MESA inspectors, making them responsible for the health and safety of approximately 13,000 mine workers.

Legislation and Government Programs.—Active Federal Bureau of Mines contracts and grants to State universities

and private industry in Michigan totalled approximately $2.5 million in 1976. Many of these projects are continued from previous years, but about $63,000 of new contracts were issued during 1976, that involved mineral availability and mining technology.

In May 1976, the National Science Foundation awarded a $3,000 subcontract to Michigan Technological University to study institutional and economic factors of geothermal energy resources for the production of electrical energy.

On October 23, 1976, Michigan Technological University officials dedicated an experimental mine developed as a research and educational facility. University officials reached an agreement with owners of the Quincy Mining Co. over the long-term lease of a 1,800-foot section of an inactive underground copper mine in Ripley. The facility will be used as a laboratory for the education of students in mining engineering, research and development of improved mining methods, and as a site for the testing of prototype underground mining equipment.

Also in October, ERDA awarded a $13.6 million contract to The Dow Chemical Co. to develop technology that would permit tapping the Antrim Shale as a source of synthetic gas. For the past 20 years, Dow has been conducting a proprietary experimental program with Antrim Shale supported by an oil shale development consortium in Michigan.

The Governor announced the approval of 13 Michigan economic development grants totalling $1.08 million from the Upper Great Lakes Regional Commission in 1976. Among the new grants was $23,264 to Northwestern Michigan College at Traverse City for expanding a recently initiated petroleum technology training program in cooperation with Michigan's oil and gas industry.

Two major controversial issues generated interest in the Michigan Legislature during 1976; oil and gas drilling in the Pigeon River Country State Forest, and the disposal of nuclear wastes in Michigan. Numerous bills designed to protect the environment from these activities were either defeated or referred to legislative committees during the session. Included were H.B. 6141, which provided for an advisory opinion on drilling wells in Pigeon River; H.B. 6549, providing for State acquisition of all outstanding interests in Pigeon River; H.B. 6610, requiring certification of reliability before construction of nuclear waste disposal facilities; and S.B. 1551, regulating the disposal of high-level radioactive wastes.

Although not directly related to mining operations, two other bills might eventually have an effect on mineral production. House Bill 5989 prohibited the use of sodium chloride (salt) on roads, streets, or highways; while H.B. 6555 banned the sale of phosphate detergents. Neither bill was reported out of committee at the close of 1976. Michigan is the Nation's second leading producer of salt.

Legislation to repeal Public Act 264 of 1967, entitled "Mine Safety Act of 1967," was passed by the House of Representatives on November 22, 1976, and referred to the Senate for approval. At the close of 1976, the bill (H.B. 5580) remained in the Senate Committee on Labor. Therefore, the law remained on record but is not funded by the Legislature.

A bill, originally introduced in January 1975 as H.B. 4038 was a source of controversy for several months. The bill was designed to establish controls over the mining of Michigan's sand dunes. Representatives of the sand mining industry raised objections to the surveillance fee system proposed by DNR. Spokespersons for the sand mining and automotive industries also claimed the bill would adversely affect the automotive industry by reducing the supply of sand. Nearly all the foundries producing automobile parts use Lake Michigan sand as core molds. Local citizens supported the bill to protect a fragile environment that cannot be duplicated elsewhere. The bill spent almost 8 months in the Senate Conservation Committee, after passing the House by a margin of 97 to 6 in November 1975. Public Act 222 was signed into law on July 30, 1976, and takes effect on April 1, 1977.

A bill proposing the creation of a Michigan Port Authority was introduced in the State Legislature at the close of 1976. The bill would enable cities and counties to develop local port authorities and to receive managerial and financial assistance from State and Federal Governments. The last major port legislation in Michigan was adopted in 1925. The 1925 Act limits port development to the financing capabilities of the port city.

Exploration.—Potentially important deposits of rocks rich in the phosphate mineral apatite, a major raw material in fertilizer production, may occur in northern Michigan. Testing of rock samples found during fieldwork conducted by the U.S. Geologial Survey indicated the existence of such materials. Government scientists announced the discoveries, located about 40 miles northwest of Marquette. Geologic studies indicate the deposits are about 2 billion years old, and they appear to be among the oldest and richest sedimentary accumulations of phosphate known in the United States. A deposit of phosphate in the Upper Peninsula could be valuable as a small-scale industry producing fertilizers for midwest farmers.

Other exploration in Michigan during 1976 included the following activities:

CCI and Chevron Oil Co. formed a joint venture to investigate copper potential of the Kona Dolomite Formation in Marquette County, as well as to explore for uranium and other base metals.

Uranium exploration by the TVA continued on a 200,000-acre tract in the western part of the Upper Peninsula.

Continued oil and gas exploration was concentrated in the northern regions of the Lower Peninsula.

Transportation.—The Soo Line Railroad, operators of a 42-mile stretch of track linking Baraga, Calumet, Hancock, and Lake Linden, have petitioned the Interstate Commerce Commission for the right to abandon the line. The track serves an area hard-hit by copper mine closings and slowdowns in recent years. It has served the western Upper Peninsula's copper country since 1872, but Soo Line officials report it turned into a losing proposition as the copper mines closed.

Seven Great Lakes shipping companies joined the Maritime Administration in funding a $230,000 research project to open the northern waterways to year-round shipping. The project seeks to develop an improved bow design that will enable bulk-carrying vessels to transit the heavy ice that halts shipping operations in the winter. The ice-transiting bow research is part of a winter navigation demonstration program authorized by Congress in 1970 and aimed at extending the navigation season on the entire Great Lakes-St. Lawrence Seaway System. Shipping companies involved in the project include Pickands Mather & Co., Litton Great Lakes Corp., American Steamship Co., Hanna Mining Co., Cleveland-Cliffs Steamship Co., Oglebay Norton Co., and United States Steel Corp.

The State Highway Commission approved plans for a study of Michigan's 22 commercial harbors in May 1976. The $400,000 study will evaluate the role of harbors in the State's economy, predict their future, and suggest improvements in port facilities. The 18-month study is scheduled to begin in January 1977, and it will be conducted by the Department of State Highways and Transportation, Port Development Section. Michigan uses the Great Lakes for the transport of coal consumed by electric power companies, as well as the shipment of many mineral commodities (iron ore, sand and gravel, stone, etc.).

The air-bubbling system designed by CCI and installed at the Escanaba ore-loading facility in 1974 made a major contribution to keeping the loading pier and turning basin open to shipping in late 1976. Exceptionally severe ice conditions throughout the Great Lakes Seaway System created problems for winter navigation. Research and environmental studies associated with the Great Lakes Winter Navigation Program continued to be conducted by CCI and various Government agencies during the year.

The Lake Superior and Ishpeming Railroad began operation of a new facility at the Port of Marquette in 1976 to improve the handling of coal destined for the Presque Isle powerplant of the Upper Peninsula Generating Co. The new facility consists of an unloading hopper situated offshore in Presque Isle harbor just north of the city, a conveyor system, and a stockpile adjacent to the powerplant. Formerly, the coal was delivered to the Marquette Dock Co., near the city's downtown area, owned jointly by Pickands Mather & Co. and Spear & Sons, Inc. On an annual basis, the coal handled by the dock amounted to about 500,000 tons in 50-vessel cargoes. As a result of a major expansion in the iron ore operations of CCI, an increase was required in the capacity

of Upper Peninsula Generating, owned 80.96% by Cliffs Electric Co., a wholly owned subsidiary of CCI, and 19.05% by Upper Peninsula Power Co. of Houghton. To provide the expanded requirements of the Tilden and Empire mines, three additional units are under construction at Upper Peninsula Generating. These units, now under construction for service in 1979, added to the seven units currently operating will require 2 million short tons of coal annually. The existing seven units will continue to operate on eastern coal, with delivery coming from Sandusky and Toledo, Ohio. The other three units will use western low-sulfur coal.

On June 17, 1976, the official dedication of the first transshipment and storage terminal on the Great Lakes for low-sulfur coal originating in the Western United States took place in Superior, Wis. The new $35 million facility, owned by Midwest Energy Resources Co., a wholly owned subsidiary of Detroit Edison Co., is designed to handle coal produced by Decker Coal Co. at its open pit mine in southeastern Montana and transported to the head of the Lakes by Burlington Northern Railroad. At the Superior terminal, the coal is loaded into self-unloading vessels of the American Steamship Co. fleet for delivery to Detroit Edison's powerplant in St. Clair. The Wisconsin terminal is situated at about midpoint in the 1,700-mile distance between the Decker mine and the St. Clair plant. The facility represents a gateway for the transportation of fuel from West to East, a movement counter to previous routes from East to West. The new Belle River powerplant, located near the present St. Clair facility, is targeted for completion by Detroit Edison early in the 1980's. This plant is also scheduled to burn western coal to generate electricity for customers in southeastern Michigan.

Employment.—Michigan continued to suffer from high unemployment rates during 1976. According to statistics from the Michigan Employment Security Commission, unemployment for the State averaged 10% during the year, compared with 14% in 1975.

In January 1976, mining operations at the White Pine copper mine were cut back because of depressed copper prices. More than 2,000 employees were laid off, giving the White Pine area an unemployment rate of 21.9%. In addition, about 120 workers were indefinitely laid off in October when the Centennial mines in Calumet, operated by Homestake Copper Co., closed. According to Homestake officials, the mines will be kept up so that mining could resume if conditions improve in the industry. About 45 persons continued to be employed in Centennial's copper exploration program.

Assistance was available for some mine workers under the Trade Readjustment Assistance Act of 1974, that became effective April 3, 1975. White Pine Copper Co. and Jones & Laughlin Steel Corp., whose Warren steel plant closed during 1976, were certified for assistance. Reasons given for certification included sales and production of the firms have decreased substantially due to increased imports.[3]

[3] Michigan State Economic Record. Economic Assistance Under the Trade Act of 1974. V. 18, No. 5, September-October 1976, pp. 1–2, 10–12.

Table 4.—Michigan: Employment and injury statistics in the mineral industry

	Number of men	Man-hours worked	Number of injuries			Frequency injury rates per million man-hours[1]		
			Fatal	Non-disabling	Nonfatal disabling	Fatal injuries	Nonfatal disabling injuries	Non-disabling
1975 r								
Metal:								
Iron	4,371	8,997,941	--	344	20	--	38.23	2.22
Copper	2,886	5,535,217	1	130	64	0.18	23.49	11.56
Total or rate-metal	7,257	14,533,158	1	474	84	.07	32.62	5.78
Nonmetal:								
Sand and gravel	1,900	2,447,818	--	43	57	--	17.57	23.29
Stone	1,942	3,811,618	--	27	24	--	7.08	6.30
Other nonmetals[2]	697	1,327,729	--	6	56	--	3.77	42.18
Total or rate-nonmetal	4,539	7,587,165	--	75	137	--	10.30	18.80
Total, 1975	11,796	22,120,323	1	549	221	.05	24.82	9.90
1976								
Metal:								
Iron	4,464	9,105,481	2	333	4	.22	36.57	.44
Copper	1,633	3,074,823	--	63	31	--	20.49	10.08
Total or rate-metal	6,097	12,180,304	2	396	35	.16	32.51	2.87
Nonmetal:								
Sand and gravel	1,779	2,032,969	1	38	41	.49	18.69	20.17
Stone	3,106	6,244,519	--	99	13	--	15.85	2.07
Other nonmetals[2]	691	1,405,276	--	28	50	--	19.93	36.31
Total or rate-nonmetal	5,576	9,682,764	1	165	104	.10	17.04	10.74
Total, 1976	11,673	21,863,068	3	561	139	.14	25.66	6.36

r Revised.
[1] All injuries and all man-hours reported and in file will be tabulated, but when computing injury-frequency rates, only those injuries for which man-hours are reported and in file will be used.
[2] Includes clay, gypsum, peat, and salt.
Source: Mining Enforcement and Safety Administration, Health and Accident Analysis Center, Denver, Colo.

REVIEW BY MINERAL COMMODITIES

NONMETALS

Abrasives, Manufactured.—In March 1976, Detroit Abrasives Co., Inc., began transformation of metallic abrasives at its plant in Owosso. The plant, purchased from MWA Co. (known as Mid-West Abrasive Co. prior to 1968), has housed machinery for producing ceramic abrasives for general industrial use since the early 1950's. MWA closed down production early in 1975 and sold the plant to Detroit Abrasives in September. The new Owosso Div. of Detroit Abrasives reduces man-made aluminum oxide crude ore into various grades of fine-gain abrasive material for use in the manufacture of sandpaper and grinding wheels.

The addition of Detroit Abrasives brings the total number of companies producing metallic abrasives in Michigan up to four in 1976. Production and value during the year increased by 16% and 25%. Michigan rose to first place in the national standings.

Bromine.—Michigan ranked second in production and value of bromine in the United States during 1976. Output of elemental bromine decreased 33% in quantity and 33.5% in value compared with 1975 levels. Bromine was recovered from well brines in Michigan by the following companies:

Company	Plant location	County
The Dow Chemical Co.	Ludington --- Midland ----	Mason. Midland.
Michigan Chemical Co.	St. Louis ----	Gratiot.
Morton Chemical Co.	Manistee ----	Manistee.

In August, The Dow Chemical Co. announced it was phasing out production of ethylene dibromide. At the same time, the company released plans calling for quadrupled production of calcium bromide at its Midland plant by late 1977. Anticipated production includes 60 million pounds of calcium bromide solution and 12 million pounds of flake annually. Dow attributed rapidly increasing worldwide demand for calcium bromide solutions in the oil and gas drilling industry responsible for expansion plans.

Michigan Chemical Co. announced plans to discontinue operations at its St. Louis plant within 2 years because of the high cost of meeting pollution criteria. The company planned to move its bromine operations to its El Dorado, Ark., plant by September 1978. Michigan Chemical is trying to sell the St. Louis plant, which employs about 350 persons.

Under an agreement reached with State officials in September, Michigan Chemical will pay a $20,000 fine for polluting the Pine River with discharges from the St. Louis plant. The company is one of two firms which for more than 3 years have been involved in a controversy over an accidental mixing of PBB (polybrominated byphenyl) with animal feed in Michigan. Company officials have agreed to operate the plant until it is sold, as long as it can be operated on a profitable basis within the pollution control guidelines of the State of Michigan.

Calcium Chloride.—Michigan remained the leading U.S. producer of calcium chloride in 1976, with increases in both quantity and value of 9% and 13% respectively, over that of 1975. Calcium chloride is produced from brine in Gratiot, Lapeer, Mason, and Midland Counties by The Dow Chemical Co., Michigan Chemical Corp., and Wilkinson Chemical Corp.

Cement.—Production of portland cement in Michigan during 1976 registered a 10.4% gain. However a 3% decrease in masonry cement was recorded for the same period.

Imported clinker was processed by three cement companies: Martin Marietta Cement Co., Wyandotte Cement Inc., and Jefferson Marine Terminal (Div. of Edward C. Levy Co.).

Table 5.—Michigan: Portland cement salient statistics
(Short tons)

	1975	1976
Number of active plants	8	8
Production	4,634,247	5,117,999
Shipments from mills:		
Quantity	4,572,739	4,931,392
Value	$131,323,993	$145,381,014
Stocks at mills, Dec. 31	691,376	688,745

Table 6.—Michigan: Masonry cement salient statistics
(Short tons)

	1975	1976
Number of active plants	5	5
Production	220,129	213,491
Shipments from mills:		
Quantity	183,456	217,799
Value	$6,429,396	$8,369,742
Stocks at mills, Dec. 31	78,885	72,120

In a recent effort to improve overall efficiency, eliminate duplication of effort, and make possible better service to customers, National Gypsum Co., the parent of Huron Cement in Alpena, announced a consolidation program. In September 1976, the Allentown Cement Div. of Pennsylvania was combined with the Huron Cement Div. of Michigan to form a new cement division simply called Cement Div.—National Gypsum Co. Headquarters for the new division are located in Southfield.

Clays.—Clay and shale are mined by five companies in Michigan for use as an ingredient in the manufacture of cement. This use accounts for approximately 90% of the total clay production in 1976. Three other operators produce clay and shale for making drain tile, sewer pipe and flue linings, bricks, and pottery. Output of clay and shale in 1976 registered a 6% gain in quantity and a 32% rise in value when compared with 1975.

In September 1976, Janick Corp. of Toronto, Canada, parent of Canadian Brick, purchased the Michigan Brick operations in Corunna, Shiawassee County. The Canadian company announced plans to increase capacity at the facility by 21 million bricks per year, giving the plant an annual capacity of 69 million bricks.

Gypsum.—A federally guaranteed loan of $1.05 million was made to Grand Rapids Gypsum Co. in April 1976 for the development of a new second level at the Butterworth Street mine in Kent County. Construction of an incline to a new level beneath the present mine will result in increased long-term production. The expansion will result in increased employment of 20% to 30% in the next few years.

National Gypsum Co. celebrated the Golden Anniversary of its National City plant during 1976. The plant was built in 1926 and began production in 1927. Present employment at the three Iosco County facilities stands at 160 workers. Operations in Iosco County include the production facility at National City, now under partial modernization; the quarry in Grant Township; and Port Gypsum, ½ mile south of Tawas City limits on Lake Huron. Estimated reserves at the quarry, when calculated in 1954, were 75 million tons. The National City plant uses approximately 130,000 tons per year in the production of wallboard and cement rock used as a hardening retardant in setting cement.

National Gypsum is one of three gypsum companies in Iosco County. The others are United States Gypsum Co. at Alabaster, which employs an average of about 80 persons and Michigan Gypsum Co., which employs about 20 persons. United States Gypsum screens and ships raw materials at this location, but does no manufacturing in Iosco County.

Five companies mined 1.8 million tons of crude gypsum valued at $9.8 million during 1976 in Iosco and Kent Counties. Output and value rose significantly, registering 50% and 66% gains, reflecting the improvement in the construction industry. Michigan currently ranks first among the States in the production of crude gypsum.

Four companies calcined gypsum in Iosco, Kent, and Wayne Counties during 1976. Output and value increased 18.4% and 43.7% respectively, compared with 1975. Actual output registered 455,643 tons valued at $13.9 million in 1976. Calcined gypsum is used in the manufacture of plaster board, lath, and plaster.

Iodine.—The Dow Chemical Co. retained its title as sole U.S. producer of iodine during 1976, despite plans by another firm to begin production from brines in Oklahoma. Production showed a 33% decrease in 1976, with a 26% decrease in value compared with 1975.

Lime.—Michigan remained a leading producer of lime in 1976, placing fourth in the national ranking. Production amounted to 1.5 million tons, a 1.5% increase over 1975. Value of lime produced rose slightly to $39.7 million an 8.6% increase. Lime in Michigan is used primarily in the manufacture of alkalies, steel, and petrochemicals. Leading counties of production were Wayne and Mason.

Magnesium Compounds. — Michigan again took the lead in the production of magnesium compounds during 1976 accounting for 63.5% of the U.S. total. Production increased 16% and value rose 27% compared with 1975.

Remodeling and construction work continued at Martin Marietta's Refractories Div. plant located at Midland. Although production was originally scheduled to begin in the second half of 1976, the company needed additional time to comply with air pollution regulations related to burning coal as fuel. The new target date is April 1977. Raw materials for the operation will be supplied by the Midland facility of The Dow Chemical Co. Dow will process dolomitic lime supplied by railcar from Martin Marietta's plant and convert the lime to magnesium hydroxide. The magnesium hydroxide will then be moved by pipeline from Dow to Martin Marietta. The new facility includes pipelines, pumps, and storage tanks. It will produce an intermediate grade of magnesite used for specialty refractory applications.

Martin Marietta continued the major expansion program begun almost 7 years ago at its Manistee plant. The plant, previously known as Standard Lime and Refractories Co., is one of the Nation's largest manufacturers of basic specialty products, chemical magnesium oxide, and periclase. Calcined dolomitic lime and brine are the essential raw materials used by Martin Marietta to manufacture the products, and chemical purity of 98.5% magnesium oxide is achieved. Dolomitic lime is shipped to Manistee by rail from another facility at Woodville, Ohio. Brine, which is pumped from wells adjacent to the Manistee plant, is reacted with the lime to produce magnesium hydroxide, which is then calcined to convert it to magnesium oxide. Martin Marietta has also invested $12 million in its Eastlake periclase plant to increase capacity and to install expanded pollution control facilities. The complex at Manistee-Eastlake employs approximately 230 persons.

Perlite.—Crude perlite, mined in other States, was expanded by Harborlite Corp. and United States Gypsum Co. at plants located in Kalamazoo and Wayne Counties. Output of expanded perlite increased 15% in quantity and 46% in value over 1975. Expanded perlite is used for filter aid and plaster aggregate.

Salt.—Production of salt in Michigan during 1976 amounted to 4.2 million tons, an increase of 5% above 1975. Value of salt sold or used during the year rose slightly to $11.4 million or 17%, reflecting the effects of continued inflation.

At Manistee, Hardy Salt Co. was well into its plant rehabilitation project during 1976. The project is expected to cost over $1 million before completion. Manistee's other major salt producer, Morton Salt Co., was involved in a similar rehabilitation program. Both companies will receive a tax break under a State law encouraging industrial investment. Under the Michigan Plant Rehabilitation Law, industries are allowed to replace obsolete equipment, where an increase in employment is anticipated from the replacement, and to maintain existing tax valuations on the replaced portion of the plant for 12 years. Hardy and Morton indicated that a total increase of some 40 jobs is expected over the 12-year period. Salt is manufactured from brines at these locations.

Diamond Crystal Salt Co. continued work on its $2.5 million expansion and modernization program at its St. Clair brine operation during 1976. The project is scheduled for completion in 1977.

Rock salt is mined in only one location in Michigan. International Salt Co., Inc., removes salt from an underground mine at Detroit, Wayne County. The salt is obtained from a depth of approximately 1,150 feet beneath the surface of the city.

Sand and Gravel.—Nearly every county in the State of Michigan contributed to the total construction sand and gravel production registered in 1976. Output for the year amounted to 42.1 million tons, while value registered at $58.3 million.

A significant development for American Aggregates Corp. during the year was the announcement of plans to construct a new sand and gravel processing plant at Galesburg. (Kalamazoo County). Plans call for a production capacity of 700 tons per hour and completion is scheduled for November 1977.

Michigan again led the Nation in the production of industrial sand during 1976. The sand, most of which comes from dunes found along the Lake Michigan shoreline, is in demand by foundries and other automotive-related industries. Table 9 presents a comparison of industrial sand sold or used, by use category, for 1975–76.

Only 4% of the total sand and gravel produced is used at the pit site. The remaining 96% is shipped to consumers by truck (84%), railroad (6%), waterway (3%) and other (3%).

Table 7.—Michigan: Construction aggregate [1] and industrial sand sold or used, by major use category

(Thousand short tons and thousand dollars)

Use	1976	
	Quantity	Value [2]
Construction aggregate:		
Concrete aggregate (residential, nonresidential, highways, bridges, dams, waterworks, airports, etc.)	12,371	21,501
Concrete products (cement blocks, bricks, pipe, etc.)	5,462	8,600
Asphaltic concrete aggregates and other bituminous mixtures	7,153	11,450
Roadbases and coverings	10,933	11,676
Fill	4,850	3,611
Other uses	1,299	1,419
Total	[3] 42,067	58,257
Industrial sand	5,336	20,198
Total construction aggregate and industrial sand	47,403	78,455

[1] Includes processed and unprocessed sand and gravel.
[2] Values f.o.b. plant of blended processed sand and gravel used as construction aggregate. Unit value of construction aggregate is generally higher than the unit value of unblended processed sand or gravel.
[3] Data do not add to total shown because of independent rounding.

Table 8.—Michigan: Sand and gravel sold or used by producers, by county, in 1976

(Thousand short tons and thousand dollars)

County	Number of mines [1]	Quantity	Value
Alcona	4	167	187
Alger	4	147	207
Allegan	9	618	739
Alpena	2	W	W
Antrim	3	111	173
Arenac	1	33	10
Baraga	4	172	183
Barry	6	535	769
Bay	1	W	W
Benzie	1	32	32
Berrien	9	1,518	5,093
Branch	4	179	214
Calhoun	7	526	683
Cass	12	816	908
Charlevoix	4	135	141
Cheboygan	4	74	54
Chippewa	3	86	66
Clare	5	383	413
Clinton	12	1,041	1,460
Crawford	2	W	W
Delta	6	406	577
Dickinson	5	192	339
Eaton	10	659	806
Emmet	7	208	257
Genesee	3	148	298
Gladwin	2	W	W
Gogebic	6	161	158
Grand Traverse	5	175	444
Gratiot	9	383	364
Hillsdale	3	413	428
Houghton	6	252	276
Huron	4	102	142
Ingham	10	219	135
Ionia	7	303	407
Iosco	3	W	W

See footnotes at end of table.

Table 8.—Michigan: Sand and gravel sold or used by producers, by county, in 1976 —Continued

(Thousand short tons and thousand dollars)

County	Number of mines [1]	Quantity	Value
Iron	4	89	76
Isabella	4	607	593
Jackson	3	219	455
Kalamazoo	9	762	1,545
Kalkaska	1	5	5
Kent	17	1,682	3,531
Keweenaw	1	18	36
Lake	2	55	69
Lapeer	6	522	777
Leelanau	3	W	W
Lenawee	5	614	1,021
Livingston	17	2,558	3,046
Luce	2	W	W
Mackinac	7	218	185
Macomb	6	1,014	2,259
Manistee	3	125	82
Marquette	5	626	1,124
Mason	2	W	W
Mecosta	3	291	320
Menominee	4	67	76
Missaukee	3	94	80
Monroe	2	W	W
Montcalm	7	249	420
Montmorency	3	W	W
Muskegon	3	744	2,894
Newaygo	5	56	86
Oakland	26	10,969	17,168
Oceana	5	439	1,010
Ogemaw	5	510	535
Ontonagon	1	80	30
Osceola	3	475	644
Oscoda	2	W	W
Otsego	3	75	113
Ottawa	13	1,617	2,487
Presque Isle	2	W	W
Roscommon	1	W	24
Saginaw	4	936	2,322
St. Clair	2	W	W
St. Joseph	5	402	463
Sanilac	2	W	W
Schoolcraft	3	77	67
Shiawassee	8	300	390
Tuscola	10	922	1,516
Van Buren	5	216	223
Washtenaw	12	2,598	2,779
Wayne	4	1,612	6,181
Wexford	4	523	1,295
Undistributed [2]	2	4,850	6,567
Total [3]	432	47,403	78,455

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Reflects only mines that have reported in response to the annual canvass of operators.
[2] Includes data withheld and some sand and gravel that cannot be assigned to specific counties.
[3] Data may not add to totals shown because of independent rounding.

Table 9.—Michigan: Industrial sand sold or used by producers, by use

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Glass	W	W	595	3,352
Molding	2,104	7,102	2,150	8,735
Blast	W	W	3	16
Fire or furnace	W	W	W	W
Engine	207	451	305	581
Chemical	--	--	W	18
Foundry	W	W	702	2,522
Metallurgical	W	W	1,339	3,765
Other uses	2,061	5,545	241	1,209
Total [1]	4,372	13,099	5,336	20,198

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1] Data may not add to totals shown because of independent rounding.

Slag–Iron and Steel.—Michigan continued to be one of the Nation's leading producers of slag during 1976. Slag is categorized as a manufactured mineral, along with cement and lime, and is used by the construction industry. Edward C. Levy Co., located in Wayne County, processes all the slag from Ford Motor Co.'s Steel Div., Great Lakes Steel, and McLouth Steel.

Stone.—Five companies quarried dimension stone for rough construction, rubble, dressed construction stone, and other uses during 1976. Output increased 3% to 7,559 tons valued at $129,300. Crushed stone was produced by 38 companies at 45 quarries. Output increased 4% to 41.5 million tons valued at $82.2 million. Michigan ranked sixth in the Nation for the production of crushed stone. Tables 10–11 provide detailed information on the type of stone quarried and its use in 1976 compared with 1975 data.

Table 10.—Michigan: Stone sold or used by producers, by kind

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Dimension stone total [1]	7	138	8	129
Crushed and broken:				
Limestone	30,672	52,104	40,214	77,296
Dolomite	7,970	16,565		
Marl	85	153	66	156
Traprock	9	17	W	W
Other [2]	1,202	4,822	1,197	4,751
Total [3]	39,938	73,662	41,477	82,202
Grand total [3]	39,946	73,800	41,485	82,331

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes limestone, dolomite, and sandstone.
[2] Includes granite and sandstone, and kinds indicated by symbol W.
[3] Data may not add to totals shown because of independent rounding.

Table 11.—Michigan: Production of crushed stone [1] by use

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Flux stone	10,190	19,360	10,380	21,570
Lime manufacture [2]	11,050	18,680	11,120	20,700
Cement manufacture	7,334	12,250	8,272	14,900
Concrete aggregate	5,075	8,648	4,531	7,643
Macadam aggregate	1,214	2,520	1,934	4,275
Roadstone	1,430	2,151	1,223	1,844
Bituminous aggregate	754	1,258	954	1,864
Dense-graded roadbase stone	796	1,633	829	1,779
Agricultural limestone	516	1,022	510	1,142
Riprap and jetty stone	255	409	375	730
Railroad ballast	278	496	309	542
Surface treatment aggregate	120	290	119	280
Soil conditioning	85	153	66	156
Other uses [3]	842	4,787	858	4,775
Total [4]	39,940	73,660	41,480	82,200

[1] Includes limestone, marl, traprock, and sandstone.
[2] Includes stone used in chemical stone for alkali works and sugar refining.
[3] Includes stone used for glass, refractory stone, paper manufacture, mineral food, filter stone, terrazzo and exposed aggregate, and other uses.
[4] Data may not add to totals shown because of independent rounding.

Sulfur.—Byproduct sulfur was recovered from crude petroleum by TOTAL Leonard, Inc., at its Alma Refinery and by Marathon Oil Corp. in Detroit during 1976. Production remained the same in quantity and decreased 2.3% in value from 1975.

Shell Oil Co. announced plans in 1976 to construct a $6 million plant in Manistee County for the separation of sulfur from natural gas. The plant is expected to produce about 25 tons of sulfur per day, while "sweetening" natural gas from nine wells in the area.[4] The sulfur conversion plant is necessary to meet environmental requirements and will allow Shell to produce and sell the sulfur as a byproduct. Construction is scheduled to begin in mid-1977.

Vermiculite.—Michigan's sole producer of exfoliated vermiculite continued to be W. R. Grace & Co. Production at the Dearborn (Wayne County) plant fell 14% in 1976, while value rose 3% compared with 1975. The manufactured product was used both in the construction industry and in agriculture.

METALS

Copper.—Native copper ores of the Keweenaw Peninsula in Michigan contain elemental copper found in amygdaloidal volcanic flows and conglomerate beds. The district produced a considerable tonnage of copper in times past, but is now inactive. The area, however, is again being investigated for commercial production possibilities by a group including Homestake Copper Mining Co.

Strata-bound deposits are another important source of copper, possibly accounting for one-fourth of the world's resources. In the United States, the most important example of this type of deposit is the Precambrian Nonesuch shale in the Upper Peninsula of Michigan.[5] Here, the copper occurs primarily as chalcocite in siltstones, shales, and sandstones. Such deposits are the scene of White Pine's mining operations.

A slump in the copper industry, which began in mid-1974, prevailed throughout 1975–76. Mine production at White Pine's mine in Ontonagon County for 1976 was on a curtailed basis at production levels geared to market conditions. The company shut down mine, mill, and related operations for 4 weeks starting in mid-November 1976, with the smelter continuing normal operations to consume a stockpile of accumulated concentrates; poor demand and generally weak prices were the significant factors affecting operations.

[4] Manistee News-Advocate, Sept. 29, 1976.
[5] Engineering and Mining Journal. V. 177, No. 6, June 1976, p. 74.

Table 12.—Michigan: Mine production (recoverable) of silver and copper

		1974	1975	1976
Mines producing: Lode		1	2	2
Material sold or treated:				
Copper ore	thousand short tons	8,301	9,033	3,801
Production:				
Quantity:				
Silver	troy ounces	642,944	632,336	310,837
Copper	short tons	67,012	73,690	43,707
Value:				
Silver	thousands	$3,028	$2,795	$1,352
Copper	do	103,601	94,618	60,840
Total	do	106,629	97,413	62,192

On January 5, 1976, the output of the White Pine mine was reduced by approximately 75%, from a production rate of 25,000 tons of ore per day to about 6,300 tons per day. The curtailment of operations required the layoff of a substantial number of employees. Production levels were changed several times during the year to balance refined copper production with market demand and to control inventories of finished product. Mine production ranged between a low of 24.5% of design capacity in February and a high of 59.4% in November.

Renovation of the southwest shaft of the mine and construction of related surface facilities were completed during 1976. However, production from the facility was delayed by the curtailment of mine production. Hoisting of ore from development mining began on September 1, and by yearend, 54,000 tons of ore had been hoisted at an average grade of 33 pounds of copper per ton of ore.[6]

According to the 1976 Annual Report of the Copper Range Co., White Pine copper mine produced an average of 10,806 tons of copper ore per day at an average grade of 27.7 pounds of copper ore per ton. The average price received per pound was $0.69 compared with $0.58 in 1975.

Despite numerous variations in volume, White Pine's mill operated at a record recovery rate of 87.78% of the contained copper, the highest yearly average ever recorded at the mine. As an experiment during the year, the mill successfully processed the first of some 300,000 tons of smelter slag (waste) by blending controlled amounts of such slag with mine ore and running the mixture through the mill. The slag yielded approximately 625,000 pounds of additional copper. This experiment suggests an additional source from which copper can be recovered in the future.

At the end of 1976, proven extractable reserves at the White Pine mine were estimated to be approximately 90.3 million tons of copper sulphides and native copper ore with an average grade of 1.17% copper.[7] The estimate has been calculated using a 1% copper cutoff and includes only reserves to a depth of 2,200 feet, the present maximum depth at which mining has been carried on. In addition, the company estimates that a probable extractable ore reserve of approximately 122 million tons with an average grade of 1.11% copper exists at levels between 2,200 and 3,500 feet, at which the company believes mining operations can be successfully conducted.

Copper Range Co., parent of White Pine Copper Co., approached Amoco Minerals Co., as well as several other companies, about possible sale of all or part of the Copper Range operations. As a result, the LL&E and Copper Range Co. announced plans to enter into a letter of intent looking toward a definitive agreement for LL&E to acquire all of the outstanding common stock of Copper Range. Copper Range has been seeking to sell all or part of its assets since 1975 because of a cash shortage.

Employees of the White Pine Copper Co., laid off since January 4, 1976, were certified as eligible for the federally funded and sponsored Trade Readjustment Assistance program. The program provides cash benefits, job retraining, and relocation assistance to employees laid off

[6] Copper Range Annual Report, 1976, p. 7.
[7] Copper Range Annual Report, 1976, p. 8.

because of the impact of imports on production and employment within a firm. Regular unemployment benefits run out for most of the workers in January 1977.

CCI, serving as the managing partner in a joint venture with Chevron Oil Co., continued to explore the copper potential of the Kona Dolomite in Marquette County. The area under study is near the eastern end of the Marquette Synclinorium where CCI controls a large block of mineral lands. The new joint venture, established during the latter part of 1975, will build on information obtained from previous exploration.

Iron Ore.—Iron ore is produced at four open pits and two underground mines in Michigan. Producers are CCI at four locations in Marquette County, Inland Steel Co. in Iron County, and Hanna Mining Co. in Dickinson County.

Pellet output from CCI's Michigan operations during 1976 amounted to 14.5 million tons, an increase of 18% compared with the 1975 figure of 12.3 million tons.[8] The Tilden, Empire, and Republic mines reported record production during the year. Natural ore production from the Mather B mine, CCI's only operating underground mine, totaled 1.7 million tons, of which 1.4 million tons was delivered to the Pioneer pellet plant for pelletizing.

Shipments from the Sherwood underground mine, operated by Inland Steel Co., amounted to 305,950 gross tons of coarse and fine ore in 1976.[9] Output from this property is railed to the Port of Escanaba for transfer to vessels.

Iron ore shipments from Hanna Mining Co.'s Groveland mine amounted to 1.9 million tons in 1976, compared with 2 million tons in 1975.[10]

CCI confirmed plans during 1976 for expansion of both the Empire and Tilden mines, as well as related electric generating facilities in the Upper Peninsula. When completed in 1979, the expansions will represent an investment totalling approximately $750 million. The expansion program will increase annual iron ore pellet production by 2.8 million tons at Empire and 4 million gross tons at Tilden. In conjunction with the mine expansion programs, CCI is constructing three 80-Mw steam turbine generating units at Marquette. These units will furnish power for the expanded mine projects, plus additional power requirements for present mining operations.

Participants in the Empire mine are Inland Steel Co., McLouth Steel Corp., International Harvester Co., and CCI, which serves as manager of the operation. Current design capacity at Empire is 5.2 million tons per year. Production from the expanded facility is slated to begin about January 1, 1980. The expansion will add about 475 jobs at the mine, for a total workforce of about 1,500 workers.

The Tilden mine is a joint venture of the Algoma Steel Corp. Ltd., Jones & Laughlin Steel Corp., Sharon Steel Corp., the Steel Co. of Canada Ltd., Wheeling-Pittsburgh Steel Corp., and CCI, which manages the operation. Earlier in 1976, CCI stretched out preliminary work for expansion at Tilden to provide additional time for evaluating operations at the mine's existing concentrating and pelletizing plant, which was completed in 1974. The delay was attributed to difficulty in controlling moisture levels of iron ore concentrate in the filtering section of the plant. According to company officials, the problem has been successfully solved.

The installation of a new primary crusher in the pit vertical footwall, approximately 500 feet below the surface at CCI's Republic mine, was completed in 1976. A 3,600-foot conveyor tunnel through the footwall of rock to convey the ore from the primary crusher to the secondary crushing system on the surface is an integral part of the new system. The $14 million project is expected to minimize truck haulage requirements and result in greater efficiency and increased productivity.

CCI and Republic Steel entered into an agreement during 1976 for a research and development program working toward possible development of the Cascade iron formation in Marquette County. CCI is the principle owner of the property and will serve as manager of the project. Plans call for continued drilling and laboratory and pilot plant testing which could lead

[8] Cleveland-Cliffs Iron Co. Annual Report, 1976, p. 4.
[9] Skillings' Mining Review. V. 66, No. 5, Jan. 29, 1977, p. 13.
[10] Skillings' Mining Review. V. 66, No. 12, Mar. 19, 1977, p. 6.

to development of the iron ore reserve in the 1980's. Initial investigations indicate that Cascade has reserves for sustaining a 4-million-ton-per-year mine, similar to the present Tilden operation.[11]

Iron Oxide Pigments.—Increased shipments of crude iron oxide pigments in Michigan reflected the growing recovery of the automotive industry during 1976. CCI's operation in Marquette County reported increases of 44% and 42% in quantity and value. The primary use of the red iron oxide pigments is the manufacture of paint.

Production of finished iron oxide pigments began at the new BASF Wyandotte Corp. facility in Wyandotte, Wayne County, during 1976. The plant, owned by BASF Wyandotte, is controlled by its Colors and Chemicals Div. located in New Jersey. Production included both synthetic red and yellow iron oxide.

[11] Cleveland-Cliffs Iron Co. Annual Report, 1976, p. 6.

Table 13.—Michigan: Usable iron ore [1] produced (direct shipping and all forms of concentrates), by range

(Thousand long tons)

Year	Marquette range	Menominee range (Michigan part)	Gogebic range (Michigan part)	Total		
				Gross weight		Iron content (percent)
				Ore [2]	Iron content	
1854–1971	399,593	295,350	249,625	944,568	NA	NA
1972	9,131	2,533	--	11,664	7,332	62.86
1973	9,036	2,404	--	11,440	7,210	63.02
1974	8,920	2,419	--	11,339	7,153	63.08
1975	12,443	2,331	--	14,774	9,327	63.13
1976	14,663	2,318	--	16,980	10,759	63.36
Total	453,786	[3] 307,355	[3] 249,625	1,010,765	NA	NA

NA Not available.
[1] Exclusive after 1905 of iron ore containing 5% or more manganese.
[2] Data may not add to totals shown because of independent rounding.
[3] Distribution by range partly estimated before 1906.

Table 14.—Michigan: Iron ore shipped from mines

(Thousand long tons)

Year	Direct-shipping ore [1]	Concentrates and agglomerates, total	Total usable ore [2]	Proportion of beneficiated ore to total usable ore (percent)
1972	727	11,965	12,692	94.3
1973	463	11,927	12,389	96.3
1974	548	11,054	11,602	95.3
1975	288	13,801	14,089	98.0
1976	356	15,888	16,245	97.8

[1] Includes crushed, screened, and sized ore not further treated.
[2] Data may not add to totals shown because of independent rounding.

Iron and Steel Scrap.—A $3.2 million expansion project at the East Jordan Iron Works foundry in Charlevoix County was announced in February 1976. The expansion will increase the company's mold-making capacity and necessitate the hiring of an additional 50 workers. The plan was presented to the city council at a public hearing required as part of the company's application for an Industrial Facilities Exemption Certificate, giving the company a 12-year tax break on the expansion. The expansion will bring an automated mold line into the foundry, which will produce 600 molds per hour rather than the 100 under the present system. The expansion work was due to be completed in September 1977.

Campbell, Wyant, and Cannon (CWC) Foundry of Muskegon completed a $16 million modernization program involving its Henry Street plant. The modernization program provides the plant with new melting equipment, automatic molding facilities, a new core room, and new cleaning and finishing equipment. The renovation program involved complete modernization of the foundry. The improvement program was approved by the CWC parent company, Textron, Inc., to strengthen the plant's position in the foundry industry.

Learning to cope with persistent shortages of essential raw materials has been perhaps the biggest challenge facing American manufacturing firms in the past few years. Springport Steel Products Co.'s situation became so critical that the container firm has gone into partnership with another wire-using firm to build their own steel-making plant at Springport, in Jackson County. The new plant is being built jointly by Springport Steel and Tri-State Engineering and Manufacturing Co. of Washington, Pa. The plant is thought to be the first such cooperative effort by steel-using companies to meet material needs. The new plant melts scrap steel in four 3,000° electric induction furnaces and then rolls 6-inch-square billets, each 56 inches long, into 1,300-foot coils of 11/32-inch steel rod. When completed, the plant should employ about 60 workers on 3 shifts and will be able to produce 300,000 tons of rod per year. The company decided to begin work on its own rod foundry in November 1973, when it was able to buy a surplus rod rolling mill from Bethlehem Steel Corp. Springport Steel will use about one-seventh of the steel rod produced from the plant. The remainder will be used by Tri-State, which operates a container plant in Adrian.

Hoover-Ugine Co., a joint venture of Hoover Ball & Bearing Co. and a subsidiary of the French firm Pechiney Ugine Kuhlman, was closed on December 31, 1976, because of technical difficulties relating to production. The venture, a 50–50 partnership formed in 1973, has been manufacturing wire rod from scrap using a patented process. The process, initially developed in the United States through the facilities of Battelle Memorial Institute, involves the cleaning, shredding, and compacting of scrap steel and the heating—but not melting—of billets made from that material. The billets are then extruded into rod, which is wound into coils for shipment to customers. In the fall of 1973, Hoover executives anticipated that annual sales capacity of the plant would be about $22 million. The plant, located at Bridgeman, could not produce enough wire rods to break even and could not get enough uniform scrap metal to make the process work. Hoover-Ugine had employed 110 workers, of which 43 were laid off in September and another 60 were let go when the plant closed. The remaining workers are in management positions and will continue to explore possible alternative uses for the plant.

Officials of Huron Casting Inc., located in Huron County, finalized an $800,000 loan agreement in October 1976 for the construction of a new foundry at Pigeon. The firm, initially employing 35 workers, will produce steel castings for excavation and farm equipment. Melting, as well as the manufacture of patterns and molds, will take place at the foundry.

A $4 million general contract for the construction of a new foundry was awarded by officials of the Eaton Corp.'s Saginaw plant. Projected to be one of the most modern facilities of its type in the world (hardenable iron casting), the foundry will occupy land at the southeast corner of the present complex. A scheduled construction completion date of May 1977 was set, with full operation expected by late 1977. Called a Disamatic, or DISA, foundry for the type of automatic molding machines to be installed, the facility will provide about 40 new jobs. Besides the DISA molding machines, the foundry will be equipped with new melting furnaces, a new sand system, and pollution control devices.

Pig Iron and Steel.—Michigan's production of raw steel in 1976 amounted to 10.4 million net tons, a 14% increase over the 9.1 million tons recorded in 1975, according to the American Iron and Steel Institute. With a total of 7.7 million tons, Michigan placed fourth in the national ranking of pig iron consumption during 1976. Pig iron production in 1976 amounted to 7.4 million tons, compared with 7 million tons in 1975. Value of pig iron rose to $1.3 million, a 2.7% gain over the comparable 1975 figure.

After 2 years of site evaluation, North Star Steel Co., jointly owned by Cargill Inc. of Minneapolis, Minn., and Co-Steel International of Canada, selected Monroe as the location for its new minimill. The $50 million plant will eventually employ more than 1,000 workers. The electric furnace was in the planning stages at the close of 1976.

Ford Motor Co. opened two new electric steel furnaces in 1976 which will add 500 jobs at the firm's Rouge manufacturing complex. When in full operation, each furnace will run 24 hours per day and produce a 200-ton batch of molten steel every 4 hours. The two units can produce 750,000 ingot tons per year, adding 25% to Ford's current steel capacity of 3 million tons. The new furnaces complete a 12-year expansion and modernization program for Ford's Rouge steel operations. Ford is the only U.S. automaker to produce its own steel for motor vehicles.

McLouth Steel Corp. announced a reorganization of its stainless steel operation into a separate division in 1976, aiming at an annual production of 80,000 tons of stainless-sheet and -strip steel. The facility, located in Detroit, employs approximately 400 persons and is equipped with $25 million of technological improvements.

Jones and Laughlin Steel Corp. (J&L) announced the closing of its Warren plant at the end of 1976 because the company has quit producing stainless bar, rod, and wire products. According to company officials, prices for their products have been depressed for several years as the result of heavy imports. The closing affected about 550 salaried and hourly workers at the plant, which employed about 1,200 when operating at full capacity. J&L workers were certified eligible for assistance under the Trade Readjustment Assistance Act of 1974. The J&L plant was a major producer of stainless steel in Michigan.

Silver.—Production of silver at White Pine Copper Co.'s facility in Ontonagon County continued during 1976. Production dropped substantially, down 51%, while value fell by 52% below 1975. The decrease in production is directly related to the decrease in copper output at the White Pine facility.

Uranium.—TVA has joined International Nickel Co. (INCO) in a uranium exploration program covering 200,000 acres of northwestern Michigan. The acreage, which is centered in Baraga and Marquette Counties and extends into Iron County, was leased from Ford Motor Co. in 1975 for a period of 50 years. Under the pact, TVA has first rights to INCO's share of production in the event the property proves commercially feasible. Ford may participate in the exploration venture to the extent of a 10% interest and will earn a royalty up to 10% in any production operation. An estimated $500,000 will be spent on exploration work.

A report evaluating the uranium and thorium potential of the Upper Peninsula of Michigan and northern Wisconsin was prepared by Michigan Technological University under a grant from ERDA. The report contains a discussion of the background geology and the mode of occurrence of uranium and thorium in the Precambrian. The Michigan Technological study was part of the ERDA Grand Junction Office's ongoing national uranium resource evaluation program.

CCI and Chevron Oil Co. formed a joint venture in 1976 to explore for uranium and base metals in Michigan's Upper Peninsula.

MINERAL FUELS

Coal.—The State's sole producer of coal, Michigan Aggregate Corp., suspended operations at its small strip mine located in Ingham County. During its 2-year operation, the mine produced approximately 20,000 tons of coal, all of which was sold to a local utility company.

Early in 1976, Detroit Edison Co., a Michigan power company, finalized a 26-year contract with Decker Coal Co. of Montana for the supply of about 200 million tons of western coal. The tonnages required by Detroit Edison for use in two electric generating facilities are scheduled to increase steadily from 3.9 million short tons in the first 2 years (April 1976 to April 1978) to reach 7.6 million short tons during April 1980–81, and 8 million tons in the years thereafter.

In June 1976, Michigan Technological University completed a study of Michigan's coal reserves under a contract with the Federal Bureau of Mines. The increasing demand for energy products and the proximity of the Michigan coal basin to potential markets has revived interest in this region. The study is a compilation centered around the quality and quantity of Michigan's coal, with special emphasis given to those considerations which bear on the future development potential of this resource.[12]

Coke and Coal Chemicals.—Three companies operated oven-coke plants in Michigan in 1976. They are Allied Chemical Corp., Ford Motor Co., and Great Lakes Steel Corp. All transfer coke to integrated operations and affiliated companies. The majority of the coke was consumed by blast furnaces. Coal-chemical materials produced at these coke plants include crude coal tar, diamonium phosphate, sodium phenolate, and crude light oil.

In July 1976, Allied Chemical Corp. announced plans to spend $45 million to modernize its Semet-Solvay Div.'s coke oven plant along the Detroit River. Completion of the project is scheduled for the end of 1977.

Natural Gas.—Gas production, which began an upward surge in the mid-1950's, has continued to steadily climb. Production in 1976 amounted to 120,250,528 Mcf (thousand cubic feet) and is expected to other few years.[13] Average daily gas procontinue an upward trend for at least anduction in 1976 amounted to 329,429 Mcf, according to the Petroleum Geology Unit, Michigan Department of Natural Resources. Natural gas production and value follow in table 15.

Natural gas imports to Michigan markets and gas storage fields in 1976 by way of interstate pipelines amounted to 793,678,-469 Mcf, a slight decrease from the 840,-412,900 Mcf imported in 1975. These imports primarily come from Texas, Louisiana, Kansas, and Oklahoma gasfields.

[12] Kalliokoski, J. Magnitude and Quality of Michigan's Coal Reserves (Research Grant No. G0155165). BuMines Open File Rept. 102–76, 1976, 33 pp.; available for consultation at the Office of the Assistant Director—Fuels, Columbia Plaza, Washington, D.C.; the Eastern Field Operation Center, Pittsburgh, Pa.; Michigan Department of Natural Resources, Geological Survey Division, Lansing, Mich.; Michigan Technological University, Houghton, Mich.; The Hoyt Public Library, Saginaw, Mich.; and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.

[13] Michigan Manufacturer and Financial Record. V. 139, No. 5, May 1977, p. 16.

Table 15.—Michigan: Natural gas production and value, by county

County	1975		1976	
	Quantity (million cubic feet)	Value[1] (thousands)	Quantity (million cubic feet)	Value[1] (thousands)
Allegan	49.4	$31.3	24.5	$21.5
Antrim	1,394.8	884.3	1,060.5	931.1
Calhoun	5,024.2	3,185.3	4,932.5	4,330.7
Clare	112.6	71.4	79.2	69.5
Crawford	598.1	379.2	976.3	857.2
Eaton	2,950.0	1,870.3	3,956.8	3,474.1
Grand Traverse	19,842.9	12,580.3	33,484.3	29,399.2
Gratiot	2.3	1.5	2.6	2.3
Hillsdale	4,507.5	2,857.8	4,084.8	3,586.5
Ingham	3,991.0	2,530.3	4,048.0	3,554.1
Jackson	2,316.3	1,468.5	2,553.3	2,241.8
Kalkaska	36,313.2	23,022.6	29,522.1	25,920.4
Kent	6.1	3.9	3.8	3.3
Lapeer	33.6	21.3	22.0	19.3
Livingston	1,361.0	862.9	1,203.6	1,056.8
Macomb	324.3	205.6	235.1	206.4
Manistee	1,956.1	1,240.2	11,279.0	9,903.0
Mason	3,927.9	2,490.3	4,581.2	4,022.3
Mecosta	14.5	9.2	44.6	39.2
Missaukee	632.2	400.8	588.3	516.5
Oakland	1,327.0	841.3	916.8	805.0
Ogemaw	254.3	161.2	205.5	180.4
Osceola	56.1	35.6	153.9	135.1
Otsego	10,601.0	6,721.0	11,122.6	9,765.6
Ottawa	51.5	32.7	--	--
Roscommon	370.3	234.8	322.0	282.7
St. Clair	2,843.0	1,802.4	2,087.5	1,832.8
Tuscola	--	--	35.0	30.7
Wexford	1,817.0	1,152.0	2,721.3	2,389.3
Total[2]	102,678.2	65,098.0	120,250.1	105,579.6

[1] County values calculated by using State average value per Mcf: $0.634 for 1975 and $0.878 for 1976.

[2] Data may not add to totals shown because of independent rounding.

Source: Michigan Department of Natural Resources, Division of Geology, Petroleum Geology Unit.

Pipelines.—In mid-June 1976, gas began flowing to the Albion plant of the Malleable Iron Div. of Hayes-Albion Corp. The pipeline runs from the Albion plant to three gas wells in Eaton County. The private line runs for 32 miles and cost approximately $1.5 million. This project is unusual because Shell and Amoco, as producers, have negotiated a contract to sell the gas directly to the end user, Hayes-Albion Corp. The arrangement is not unique in Michigan's petroleum history, but it is a "first" for natural gas.

Consumers Power Co., a Jackson-based utility, has contracted with Mid-America Pipeliners, Inc., to construct approximately 1 mile of 12-inch pipeline to connect 12 wells at a gas storage field in St. Clair County. The pipeline, estimated at a cost of $160,000, is part of an overall project costing approximately $5.45 million. Consumers will be able to increase storage capacity in various parts of Michigan to up to 123.6 billion cubic feet by early 1977.

In October 1976, the Federal Power Commission authorized Great Lakes Gas Transmission Co. of Detroit to build a $2.5 million, 15-mile natural gas pipeline across the U.S.-Canadian border at St. Mary's River between Michigan and Ontario. The pipeline will be the second crossing of the river and would be adjacent to the existing pipeline.

On June 7, 1976, the Michigan Public Service Commission (MPSC) approved 22.6 miles of new gas pipelines for Michigan Consolidated Gas Co. in Kalkaska, Grand Traverse, and Manistee Counties. Michigan Consolidated's lines will transport sour gas to sweetening facilities in a three-county area. The design specifications of the proposed pipelines were reviewed by MPSC to insure public safety in transporting the toxic gas.

Storage.—The first underground gas storage project in Michigan was completed by the Michigan Consolidated Gas Co. at the depleted Austin gasfield in Mecosta County in 1941. By the end of

1976, Michigan had 37 underground storage reservoirs with a total working capacity of 529.3 billion cubic feet.[14] This accounts for over 15% of the Nation's total working storage capacity.

Gas storage made news in the winter of 1976–77, when fuel shortages throughout the midwest forced schools and factories to close. Michigan was spared many of these problems because gas stored in the underground reservoirs during the summer months was withdrawn when needed to meet the unusually high demand of a harsh winter.

Consumer Power Co. announced plans to expand its gas storage facilities by almost 10% with the award of a $160,000 pipeline contract to a Michigan firm in June of 1976. Pipeline work began in June and was completed in September, completing conversion of the Hessen storage field and connection of 12 wells in St. Clair County. The Hessen field will hold a working volume of 10 to 12 billion cubic feet of gas and can be expanded later. The gas will be supplied by the utility's major suppliers, mainly Panhandle Eastern Pipe Line Co., Trunkline Gas Co., and some Michigan sources.

Two additional gas storage reservoirs, the Marsac Creek and the Capac, are scheduled for conversion in 1977–78. Marsac Creek will be operated by Consumers Power Co. in St. Clair County and will have a working capacity of 3.3 billion cubic feet. Capac, with a working capacity of 30.0 billion cubic feet, will be operated by Michigan Wisconsin Pipeline Co.

Refineries.—Shell Oil Co. installed a stabilizer column and associated equipment at its Kalkaska gas plant during 1976. The new equipment is designed to prevent wax buildup in processing equipment. It will allow the plant to operate at design efficiency while processing gas well condensate with high wax content produced from the Niagaran Trend fields.

Consumers Power Co.'s Marysville synthetic gas reforming plant, one of the world's largest, produces some 20% of the utility's annual gas requirements. Marysville manufactures methane gas by reforming liquid hydrocarbons through a catalytic process originally developed by the British Gas Council. Supplies of the light hydrocarbon feedstocks are drawn from both Canadaian and Michigan suppliers. The Marysville gained some attention when it was being built between 1971–74 because of labor difficulties. During that period, the construction cost for the facility more than doubled the original estimates. The plant first began production of natural gas in July 1973, but actual completion of the facility did not occur until April 1974.

Because of its dependence on imported feedstocks and the increased construction costs at the Marysville plant, Consumers Power's natural gas rates are higher than any other utility in Michigan. During 1976, the State Attorney General's Office recommended closing the Marysville facility. Company officials, however, stated that the plant will remain in operation at least until 1980, when the present Canadian contract expires.

Natural Gas Liquids.—The amount of liquids produced from gas-condensate reservoirs associated with western and northern Michigan reef traps continued to increase in 1976. Gas plants operated by Shell Oil Co. and Amoco Production Co. in Kalkaska County strip natural gas liquids from the gas. The liquids are then sold to another company through the Shell pipeline that terminates at Marysville.

Akron Hydrocarbons continued construction of a processing plant in Quanicassee (Tuscola County) with a rated capacity of 10 million cubic feet of gas daily. Plant design work began late in 1975 and actual onsite construction began early in the summer of 1976. Full-scale startup for the plant occurred in December 1976, with an initial daily throughput of 3 to 4 million cubic feet. The plant is expected to be operated at rated capacity before the end of 1977. Dry natural gas from the facility will enter a new, recently completed Southeastern Michigan Gas Co. pipeline. Butane removed from the feedstock will be delivered to Niles, and propane and condensate will be taken by Wilson Propane. In addition to the Akron-Salina field production, the plant is capable of processing an additional 20,000 gallons daily of outside liquids. At rated capacity, the plant is expected to yield 45,000 gallons of liquids per day. Three original wells have been connected to the plant and two additional wells drilled early in 1976 await completion. Additional wells are programed for 1977.

[14] Oil and Gas News. V. 83, No. 19, May 13, 1977, p. 21.

Oil Shale.—On October 1, 1976, The Dow Chemical Co. of Midland was awarded a $13.6 million, 4-year grant from the ERDA to find a way to extract gas and oil from Michigan's Antrim Shale deposits. Antrim Shale is part of the Devonian Shale Formation that underlies many Eastern and Midwestern States, including 25,000 square miles of southern Michigan. The shale contains roughly 10 gallons of kerogen per ton, versus 25 to 40 gallons per ton in Colorado shale. For the past 20 years, Dow has been conducting a proprietary, experimental program with Antrim Shale supported by an oil shale development consortium in Michigan. Dow will contribute and utilize an 80-acre site near Croswell in which $877,000 has been invested. Current experiments involve drilling one initial well, then three additional observation wells. The total program calls for the drilling of eight wells, with extraction procedures on 40 acres to begin in the summer of 1977. To date, no long-term combustion of the Antrim Shale has been achieved. Although Dow estimates 2.5 trillion barrels of oil is trapped in the shale, company officials say commercial production from the formation still lies well in the future.

Peat.—Michigan remained the leading producer of peat in the United States during 1976, accounting for 31% of the U.S. total. Production, amounting to 300,103 tons, rose 22.5%; while value registered $3.7 million, a 15.8% gain. Although both production and value rose over 1975, the average value per ton dropped from $13.09 in 1975 to $12.38 in 1976. Most of Michigan's peat is used as a soil conditioner, with the remainder used as an ingredient for potting soils, mushroom beds, and packing flowers.

Petroleum.—Michigan wells in 1976 produced a total 30.4 million barrels of crude oil and petroleum liquids, giving the State its best production year on record. The new alltime highs are principally attributable to Niagaran reef development, especially in the northern Lower Peninsula area spanning the State from Ludington to Rogers City. The most heavily developed and now on-line counties, including Mason, Manistee, Wexford, Grand Traverse, Kalkaska, Antrim, Crawford, and Otsego, accounted for almost 64% of all liquid hydrocarbons produced in Michigan during 1976. Oil production increased 24.6% over 1975. During 1976, Otsego County led the State as an oil-producing area, averaging 17,400 barrels daily.

Table 16.—Michigan: Oil and gas well drilling completions, by county, in 1976

County	Proved field wells [1]			Exploratory wells			Total	
	Oil	Gas	Dry	Oil	Gas	Dry	Wells	Footage
Allegan	3	--	--	--	--	1	4	12,173
Antrim	--	--	--	--	--	2	2	9,076
Arenac	--	--	--	--	--	2	2	5,900
Barry	--	--	--	--	--	2	2	7,073
Bay	--	--	--	--	--	2	2	6,537
Benzie	--	--	1	--	--	1	2	11,938
Branch	--	--	--	--	--	1	1	3,610
Calhoun	6	2	9	2	4	12	35	119,177
Cass	3	--	1	--	--	--	4	2,800
Cheboygan	--	--	--	--	--	5	5	18,042
Clare	1	--	1	--	--	1	3	14,313
Crawford	1	--	2	2	1	1	7	49,576
Eaton	2	1	8	3	1	3	13	49,958
Gladwin	--	--	--	--	--	1	1	3,585
Grand Traverse	5	4	21	6	13	27	76	451,043
Gratiot	--	--	--	--	--	1	1	17,466
Hillsdale	10	--	--	--	--	--	10	40,275
Ingham	4	--	1	1	1	3	10	39,274
Ionia	--	--	--	--	--	2	2	5,770
Isabella	1	--	2	--	--	3	6	22,757
Jackson	--	--	--	--	--	2	2	8,275
Kalamazoo	--	--	--	--	--	1	1	4,080
Kalkaska	5	2	10	5	3	17	42	268,464
Lapeer	2	4	--	--	--	--	6	11,850
Macomb	--	11	3	--	2	13	29	96,825
Manistee	20	1	21	7	7	34	90	424,680
Mason	--	1	--	--	--	4	5	22,372
Mecosta	--	1	2	--	--	2	5	14,539
Midland	--	--	2	--	--	1	3	11,791
Missaukee	2	--	2	--	--	1	5	22,389
Montcalm	--	--	1	--	--	4	5	17,589
Montmorency	--	--	--	--	--	5	5	23,276
Oakland	--	--	--	--	1	3	4	17,048
Oceana	2	--	2	--	--	1	5	13,017
Ogemaw	11	--	--	--	--	5	16	46,847
Osceola	--	1	--	--	--	--	1	1,602
Otsego	6	--	12	2	1	31	52	286,032
Ottawa	--	--	--	--	--	2	2	7,119
Presque Isle	--	--	--	--	2	6	8	24,098
Roscommon	--	--	1	--	--	--	1	4,587
St. Clair	--	--	--	--	--	6	6	14,870
St. Joseph	--	--	--	--	--	2	2	1,880
Sanilac	--	--	--	--	--	2	2	13,347
Shiawassee	--	--	--	--	--	1	1	7,672
Tuscola	1	--	--	--	--	--	1	2,589
Van Buren	1	--	--	--	--	2	3	5,339
Wexford	3	--	2	1	--	2	8	49,942
Total	89	28	99	29	36	217	498	2,312,462

[1] Development wells as defined by American Petroleum Institute.

Source: American Petroleum Institute.

Table 17.—Michigan: Crude oil production and value, by county

(Thousand 42-gallon barrels and thousand dollars)

County	1975		1976	
	Quantity	Value [1]	Quantity	Value [1]
Allegan	111	1,194	127	1,372
Antrim	206	2,211	181	1,961
Arenac	188	2,017	188	2,041
Barry	10	111	9	101
Bay	194	2,079	185	2,002
Benzie	--	--	(2)	3
Calhoun	1,314	14,111	1,559	16,902
Cass	--	--	6	62
Cheboygan	--	--	(2)	2
Clare	331	3,556	302	3,269
Crawford	858	9,213	984	10,662
Eaton	177	1,904	272	2,945
Genesee	12	133	19	207
Gladwin	236	2,536	250	2,713
Grand Traverse	2,152	23,116	3,472	37,637
Gratiot	5	56	10	103
Hillsdale	1,312	14,091	1,142	12,378
Ingham	2,463	26,449	2,410	26,122
Isabella	118	1,263	124	1,345
Jackson	432	4,641	369	3,997
Kalkaska	3,463	37,196	3,118	33,802
Kent	60	641	56	610
Lake	87	936	82	891
Lapeer	78	837	96	1,045
Livingston	1	15	2	25
Macomb	2	23	8	81
Manistee	1,041	11,179	5,150	55,824
Mason	284	3,047	291	3,149
Mecosta	37	392	31	338
Midland	167	1,791	158	1,714
Missaukee	655	7,032	636	6,896
Monroe	6	63	4	43
Montcalm	80	858	76	824
Montmorency	(2)	1	--	--
Muskegon	10	102	8	90
Newaygo	14	154	11	119
Oakland	33	358	44	474
Oceana	33	357	26	276
Ogemaw	509	5,471	555	6,016
Osceola	369	3,960	248	2,685
Oscoda	(2)	8	1	9
Otsego	5,719	61,424	6,352	68,853
Ottawa	65	702	63	679
Presque Isle	(2)	2	--	--
Roscommon	356	3,821	382	4,134
Saginaw	17	181	17	182
St. Clair	1,029	11,055	1,066	11,560
Shiawassee	5	56	6	60
Tuscola	47	503	48	524
Van Buren	9	100	10	111
Washtenaw	2	21	1	13
Wayne	4	43	5	56
Wexford	117	1,260	264	2,859
Total [3]	24,420	262,270	30,421	329,768

[1] County values calculated using State average value per barrel: $10.74 for 1975 and $10.84 for 1976.

[2] Less than ½ unit.

[3] Data may not add to totals shown because of independent rounding.

Source: Michigan Department of Natural Resources, Division of Geology, Petroleum Geology Unit.

Total imports of crude oil to Michigan refineries in 1976 amounted to 36.8 million barrels, a slight decline from 1975 levels. Domestic imports from other States and foreign imports from Libya and Nigeria increased from 15.3 million barrels in 1975 to 19.4 million barrels in 1976. Imports of Canadian crude by way of pipeline from western Canada oilfields continued to decline, reflecting Canadian governmental restrictions on exports to the United States. Canadian imports amounted to 17.5 million barrels in 1976, compared with 22.3 million barrels in 1975.

The bulk of Michigan-produced crude oil goes to Michigan refineries, but some 7.8 million barrels was exported in 1976, compared with 6.9 million barrels in 1975.

Exploration and Development.—Companies and individuals bid $523,026 in bonus cash for 10-year primary term oil and gas leases on 33,944.7 acres at the State lease auction in June 1976, with an average $15.41 per acre. This figure compares with an average of $8.73 per acre at the 1975 sale and the alltime high of $32.79 per acre set in 1974. Interest centered on the offering of 6,799 acres located in Kalkaska County, the only area where every tract offered found a bidder.

Quanex Corp., formerly Michigan Seamless Tube Co. of South Lyon, formed a subsidiary, Arbuckle Corp., to acquire oil and gas leases on property in several counties in southeastern Michigan. Quanex has hired Wenner Petroleum of Denver to review computer data to determine the possibility of finding natural gas on the properties.

American Natural Gas Co. (ANG) announced the formation of a new exploration subsidiary, Michigan Natural Resources Co., in early 1976. The company will engage in gas and oil exploration in Michigan. The new company will purchase 325,000 acres of unexplored leases from its affiliate, Michigan Consolidated Gas Co., also an ANG subsidiary. Michigan Consolidated will have first call on all gas discovered by Michigan Natural Resources and will retain wells and producing acreage developed under the Michigan Consolidated banner. Company officials announced that the firm will permit greater flexibility in financing and directing the search for gas and oil in Michigan.

Michigan Audubon Society members rejected a proposed bylaw change which would have prohibited drilling for oil on Audubon-owned bird sanctuaries. However, no drilling will be done on the Society's Bernard W. Baker Sanctuary in Calhoun County. Mobil Oil Co., through a letter dated before the vote was taken, withdrew its offer to lease the land for oil exploration and possible drilling. For more than a year, the several thousand members of the Society battled over whether to permit limited oil drilling within the 900-acre sanctuary.

Drillers trying to push the Michigan oil boom into Crawford County ran into difficulties during 1976 because much of that area is the National Guard's training area at Camp Grayling. The State is attempting to rescind oil leases on 1,365 acres at the site because they violate terms of a land grant restricting the area to military or recreation areas. The entire Camp Grayling area of about 135,000 acres in Crawford, Otsego, and Kalkaska Counties lies just south of an area where large oil deposits have been tapped.

Canada has asked and the U.S. State Department is cooperating in developing a proposal for a feasibility study by the International Joint Commission that involves oil and gas exploration and drilling in the Great Lakes. The Michigan Natural Resources Commission established a policy against drilling for oil and gas in waters of the State, including the offshore waters of Lakes Superior, Michigan, Huron, and Erie, as early as 1949. That policy was restated and reaffirmed in 1960. An agreement with the Province of Ontario prohibiting oil and gas drilling in the boundary waters of Michigan and Ontario was concluded in 1967. While Michigan has received many requests for permits to explore in State waters, all have been rejected, including sonic boom exploration requested as recently as 1975.

Pigeon River Country State Forest development and exploration continued as an issue of extreme interest during 1976. Shell Oil Co. has filed applications with the Michigan Department of Natural Resources (DNR) for permits to drill 10 Niagaran reef test wells in the area. All sites lie within the hydrocarbon development area established by a consent order and unitization agreement executed in June 1976 by DNR and leaseholders in Pigeon River. The order placed northern reaches of the forest off limits to drilling through a 25-year extension and conversion of leases held by Shell, Amoco Production Co., and Northern Michigan Exploration Co. to nondevelopment status. Additionally, a tract immediately north of the development area was placed in "moratorium" status with leaseholders agreeing not to file for permits to drill there for at least 5 years. Through the June order and unit agreement, Shell was designated as operator in the development tract. Since June, several private landowners and other leaseholders in the development unit joined the agreement and consent order.

Action on a similar agreement between Getty Oil Co. and DNR is still pending. Getty's principal Pigeon River interests lie in the northern part of the forest. In December 1976, the company presented DNR with a proposal for a conversion and lease extension paralleling the agreement made with other companies.

During 1976, the Michigan Court of Appeals ruled that the State can deny oil and gas drilling permits, even on State land leased to private industry, for the development of these resources. The decision gives added strength to efforts by DNR to limit and control gas and oil drilling in the northern part of the Pigeon River Country State Forest.

Pipelines.—U.S. Filter Corp. announced that its unit, Williams Brothers Engineering Co., has been authorized by Dome Pipeline Corp. to prepare for the 1977 construction of a new $140 million, 1,167-mile light hydrocarbon pipeline through North Dakota, Minnesota, Iowa, Illinois, Indiana, Michigan, and Ohio. The Cochin 12-inch pipeline starts near Fort Saskatchewan, crosses the U.S. border near Sherwood, N. Dak., and terminates at both Sarnia, Ontario, and Green Springs, Ohio. Construction of the U.S. section is scheduled for completion in December 1977, coinciding with the completion of the Canadian section of the line.

During 1976, two Michigan refineries indicated an interest in receiving crude oil by way of the Northern Tier Pipeline, according to an announcement from the Northern Tier Pipeline Co. Marathon Oil Co. (Detroit) and TOTAL Leonard, Inc. (Alma), whose refineries both have sour crude capabilities, indicated an interest in an aggregate of 45,000 barrels daily of Alaskan crude oil. Michigan is 1 of the 11 northern tier States that fall under the Alaska Natural Gas Transportation Act signed in 1976 by the President. Estimates by the Federal Power Commission indicating Michigan will fall 8.5% short of its total natural gas requirements in 1977 have stimulated interest in the pipeline as an alternative source of energy supply.

Refineries.—TOTAL Leonard, Inc., reported that its Alma refinery initiated a $13 million modernization program in February 1976, with construction beginning in October. The new systems are expected to be on-stream by the end of October 1977. Included are units for waste heat recovery and gas recovery. A new sulfur removal plant will be installed and the fluid catalytic cracking unit will be expanded. The program is designed to increase gasoline yield from 50% to 67%, meet the Environmental Protection Agency's phasedown schedule for lead additives, and reduce energy consumption. Output at the refinery is 42,000 barrels per day.

In July 1976, Lakeside Refining Co. announced the awarding of a $2 million contract from the Defense Department Fuel Supply Center. Lakeside will supply about 5 million gallons of jet fuel.

Table 18.—Principal producers

Commodity and company	Address	Type of activity	County
Cement:			
Cement Div., National Gypsum Co.	17515 W. Nine Mile Rd. Southfield, Mich. 48075	Quarry and plant	Alpena.
Dundee Cement Co	Box 317 Dundee, Mich. 48131	----do	Monroe.
Medusa Cement Co., a division of Medusa Corp.	Box 5668 Cleveland, Ohio 44101	----do	Charlevoix.
Clay and shale:			
Amcord Inc., Peerless Cement Div.	9333 Dearborn St. Detroit, Mich. 48209	Pit	Wayne.
Copper:			
White Pine Copper Co.[1]	Box 427 White Pine, Mich. 49971	Underground mine and plant.	Ontonagon.
Gypsum:			
Michigan Gypsum Co	2840 Bay Rd. Saginaw, Mich. 48601	Open pit mine and plant.	Iosco.
National Gypsum Co	325 Delaware Ave. Buffalo, N.Y. 14202	----do	Do.
United States Gypsum Co	101 S. Wacker Dr. Chicago, Ill. 60606	Open pit mine Plant	Do. Wayne.
Iron ore:			
Cleveland-Cliffs Iron Co.[2]	504 Spruce St. Ishpeming, Mich. 49849	3 open pit mines, 1 underground mine, plants.	Marquette.
Hanna Mining Co	Star Route 1, Box 131 Iron Mountain, Mich. 49801	Open pit mine and plant.	Dickinson.
Inland Steel Co	Box 232 Iron River, Mich. 49935	Underground mine and plant.	Iron.
Iron and steel:			
Ford Motor Co	The American Rd. Dearborn, Mich. 48121	Plant	Wayne.
McLouth Steel Corp	300 S. Livernois Ave. Detroit, Mich. 48217	----do	Do.
National Steel Corp	2800 Grant Bldg. Pittsburgh, Pa. 15219	----do	Do.
Lime:			
BASF Wyandotte Corp	1609 Biddle Ave. Wyandotte, Mich. 48192	Limekiln	Do.
Detroit Lime Co., a division of Edward C. Levy Co.	8800 Dix Ave. Detroit, Mich. 48209	----do	Do.
The Dow Chemical Co. Ludington Div.	2020 Dow Center Midland, Mich. 48640	----do	Mason.
Marblehead Lime Co., a division of General Dynamics.	300 W. Washington Chicago, Ill. 60606	----do	Wayne.
Natural gas processors:			
Consumers Power Co	212 W. Michigan Jackson, Mich. 49201	Plant	St. Clair.
Michigan-Wisconsin Pipeline Co.	1 Woodward Ave. Detroit. Mich. 48226	----do	Osceola.
Mobile Oil Corp	Box 258 Mason, Mich. 48854	----do	Ingham.
Shell Oil Co	Two Shell Plaza, Box 2105 Houston, Tex. 66001	----do	Kalkaska and Otsego.
Natural salines:[3]			
The Dow Chemical Co	2020 Dow Center Midland, Mich. 48640	Brine wells and plant.	Mason and Midland.
Morton Chemical Co	110 N. Wacker Dr. Chicago, Ill. 60606	----do	Manistee.
Velsicol Chemical Co., a division of Northwest Industries.	351 E. Ohio St. Chicago, Ill. 60606	----do	Gratiot.
Peat:			
Al-Par Peat	9551 Krouse Ovid, Mich. 48866	Bog and plant	Shiawassee.
Anderson Peat Co	332 Graham Rd. Imlay City, Mich. 48444	----do	Lapeer.
Michigan Peat, Inc	Box 66388 Houston, Tex. 77006	Bogs and plants	Sanilac.
Petroleum refineries:			
Consumers Power Co	212 W. Michigan Jackson, Mich. 49021	Refinery	St. Clair.
The Dow Chemical Co	2020 Dow Center Midland, Mich. 48640	----do	Bay.
Marathon Oil Co	1300 S. Fort St. Detroit Mich. 48217	----do	Wayne.
TOTAL Petroleum Inc	East Superior St. Alma, Mich. 48801	----do	Gratiot.

See footnotes at end of table.

Table 18.—Principal producers—Continued

Commodity and company	Address	Type of activity	County
Salt:			
BASF Wyandotte Corp	1609 Biddle Ave. Wyandotte, Mich. 48192	Brine wells and plant.	Wayne.
Diamond Crystal Salt Co	916 S. Riverside Dr. St. Clair, Mich. 48079	----do	St. Clair.
International Salt Co., Inc.	12841 Saunders St. Detroit, Mich. 48217	Underground mine	Wayne.
Sand and gravel—construction:			
American Aggregates Corp.	Drawer 160 Greenville, Ohio 45331	Surface pits and stationary plants.	Kalamazoo, Livingston, Macomb, Oakland.
Grand Rapids Gravel Co	2700 28th St., SW. Grand Rapids, Mich. 49509	Surface pits and stationary plants.	Kent.
Holly Sand and Gravel Co., Aggregate Div. of J. P. Burroughs & Son, Inc.	Box 1468 Saginaw, Mich. 48605	Surface pit, stationary and portable plants.	Oakland.
Western Materials, a division of Medusa Aggregrates Inc.	4200 S. Milford Rd.—Box H New Hudson, Mich. 48165	Surface pit and stationary plant.	Do.
Sand and gravel—industrial:			
Manley Bros. of Indiana, Inc.	Box 67 Chesterton, Ind. 46304	----do	Berrien.
Nugent Sand Co. Inc	Box 566, 2875 Lincoln Muskegon, Mich. 49443	----do	Muskegon.
Ottawa Silica Co	33620 Streicher Rd. Rockwood, Mich. 48173	----do	Wayne.
Sargent Sand Co	2840 Bay Rd. Saginaw, Mich. 48605	Surface pits, and plant.	Mason, Saginaw, Tuscola, Wexford.
Stone:			
Limestone Operations, U.S. Steel Corp.	Rogers City, Mich. 49779	Quarry and plant	Presque Isle.
Presque Isle Corp	Box 426 Alpena Mich. 49707	----do	Do.
Cement Div., National Gypsum Co.	17515 W. Nine Mile Rd. Southfield, Mich. 48075	----do	Alpena.

[1] Also produces silver.
[2] Also produces iron oxide pigments.
[3] Includes bromine, bromine compounds, calcium compounds, iodine, and magnesium compounds.