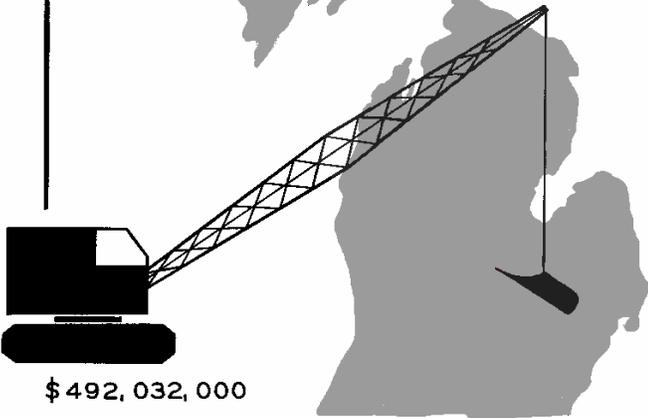




ANNUAL STATISTICAL SUMMARY I
GEOLOGICAL SURVEY

MINERAL INDUSTRY OF MICHIGAN, 1963



\$ 492, 032, 000

1964

STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY

ANNUAL STATISTICAL SUMMARY 1 Mineral Industry of Michigan, 1963

by
Donald F. Klyce
Industry Economist
Bureau of Mines, Minneapolis, Minnesota

Prepared in cooperation with
Bureau of Mines
United States Department of the Interior

1964

Preface

The collecting and reporting of information on the mineral industries of Michigan has been a statutory duty of the State Geological Survey since 1911. In carrying out this work, the State Survey participated originally in a cooperative program with the U. S. Geological Survey. In 1925, however, Congress transferred the federal phase of these responsibilities to the U. S. Bureau of Mines.

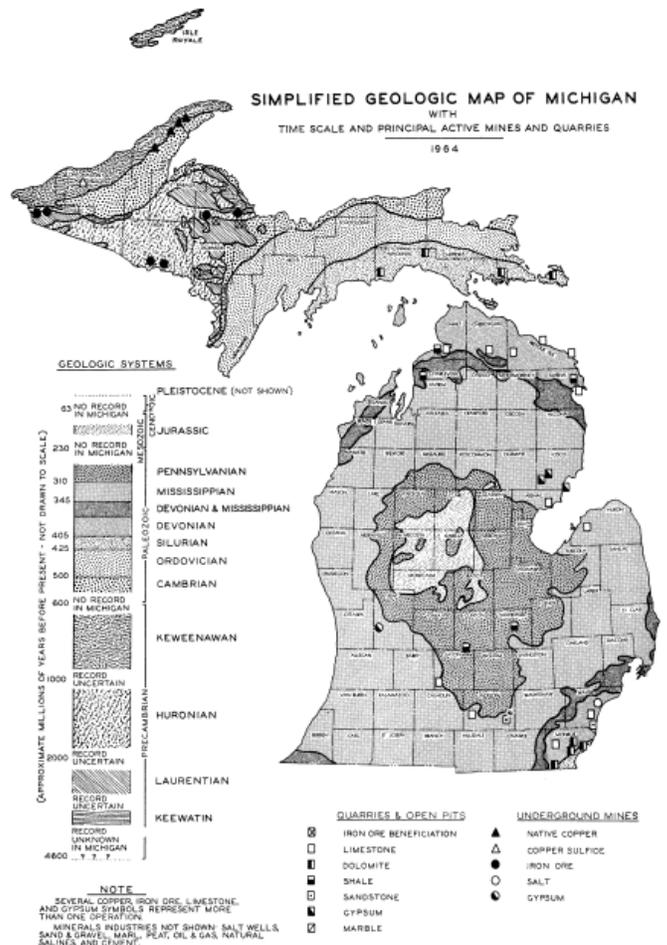
For the last decade, both the State Survey and the U. S. Bureau of Mines have been publishing separate annual reports on the mineral industries in this state. Though not identical in content, their substance, nevertheless, has been similar. Commencing with the current issue, however, the information gathered in this program will be reported in a single publication. The State Survey report for the year 1962, therefore, marks the last of our 8½x11-inch minerals reports begun in 1948.

The U. S. Bureau of Mines provided unbound and untrimmed copies of preprints of the Michigan chapter of their 1963 Minerals Yearbook. The Michigan Dept. of Conservation prepared the covers, the map, and the photographs; and completed the assembly.

The Bureau preprint is also available separately in accordance with the note opposite page 1. In addition, a directory of mineral producers operating in Michigan may be obtained from the Department of Conservation.

Mining and Economic Geology Unit
Geological Survey
Department of Conservation

Lansing, Michigan
Dec., 1964



Simplified Geologic Map of Michigan.

The Mineral Industry of Michigan

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

By Donald F. Klyce¹

MINERAL production in Michigan was valued at \$492 million, 10 percent more than in 1962, and an alltime high. Increased output of all major minerals, except petroleum, contributed to the record. Much of the increase was due to increased value of shipments of metallic ores (copper and iron). Building materials (cement, clays, gypsum, sand and gravel, and stone) also registered substantial gains. Petroleum output continued to fall as the prolific oil fields of the Albion-Pulaski-Scipio trend declined for the 2d consecutive year since their discovery in 1957. Iron ore was first in value, followed by cement, copper, petroleum, and sand and gravel. Nonmetals (construction materials and natural saline minerals) accounted for 56 percent of the State total, about the same proportion as in 1962. The value of metallic minerals increased to over 31 percent, while the remaining percentage represents the value of mineral fuels.

A constant dollar series has been prepared in which the bias caused by price level variations is reduced, thus showing more nearly the real change in the annual value of mineral production. The series is constructed by summing the constant dollar value of several mineral groups. These groups were converted to 1957-59 constant dollars by dividing the group current dollar value by the appropriate group implicit price deflator.

Employment and Injuries. -- Nearly 37.7 million man-hours were worked in the Michigan mineral industries in 1963, excluding employees in the petroleum industry and officeworkers. This represented a 1-percent decrease from the 38.1 million man-hours recorded for 1962. Employment declines in the copper and iron ore industries were chiefly responsible for the decrease.

Ten fatalities, 3 each in the copper and iron ore industries, and 1 each in the coke oven, gypsum, limestone, and sand and gravel industries, occurred in 1963, compared with 11 in 1962. The total number of nonfatal disabling injuries decreased to 467 (preliminary figure), compared with the final figure of 545 for 1962.

The Port Inland quarry, operated by the Inland Lime & Stone Co., won the Sentinels of Safety trophy, the top award, in the quarry group of the 1963 National Safety Competition. The quarry, located near Gulliver, worked 568,711 man-hours in 1963 without a disabling work injury. Other Michigan operations experienced injury-free records in 1963 and received Certificates of Achievement in Safety from the Federal Bureau of Mines.

Table 3 contains a summary of employment and injury data for selected State mineral industries. Certain

industries are excluded from the table, primarily to avoid disclosing individual company confidential data.

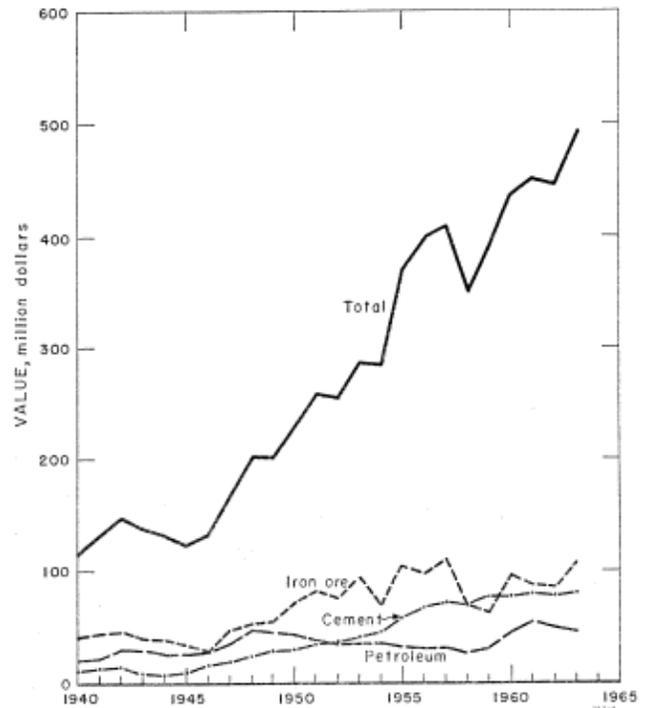


Figure 1. Value of iron ore, petroleum, cement, and total value of mineral production in Michigan, 1940-63.

Water. -- To obtain valid data concerning water use by the mineral industries for 1962, the Bureau of Mines conducted a nationwide canvass in 1963 of virtually all mineral extractive and certain mineral processing industries. Cement plants, lime plants, operations using natural well brines, and other manufacturing type operations were excluded. Table 4 summarizes some of the data collected for the State. As used in the table, "new water" is that entering the plant as makeup water, and when added to the "recirculated water" the total used or required for processing is given. "Water discharged" is used water leaving the plant. "Water consumed" is that which leaves the plant as moisture combined or entrained in the product or lost by evaporation and no longer available for reuse in the vicinity of the plant.

In addition to water use in extracting and processing mineral commodities, indicated in table 4, a substantial amount of water was required by the petroleum industry for well drilling. In 1962 nearly

1.2 million 42-gallon barrels of waters were required for well drilling in Michigan. Of this amount, nearly 75 percent was fresh water, and the remainder was saline water.

Approximately 24 gallons of water were required per foot of well drilled.

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

REVIEW BY MINERAL COMMODITIES

NONMETALS

Cement. -- Shipments of cement increased more than 10 percent and reached an alltime high. Average mill value per barrel continued the decline that began in 1962. Comparative values were: Portland cement -- \$3.08 in 1963, \$3.23 in 1962; masonry cement -- \$2.68 in 1963, \$2.86 in 1962. Portland cement was produced in nine plants in seven counties. At six of these plants masonry cement also was produced. Total capacity of the plants was 34 million barrels, the same as in 1962. Yearend stocks of portland cement at mills were 2.5 million barrels, 822,000 less than the beginning of 1963. About 56 percent of the cement shipped was used in the State. Principal out-of-State shipments were to Ohio, Illinois, Wisconsin, New York, Indiana, and Minnesota.

Ready-mixed concrete companies purchased 53 percent of the cement output, while the balance went principally to contractors, concrete product manufacturers, and building material dealers.

Raw materials used in the manufacture of cement included 5.8 million tons of limestone and 1.8 million tons of clay or shale, as well as sand, gypsum, mill scale, slag, iron ore, grinding aids, and air-entraining compounds.

Nearly 547 million kilowatt-hours of electrical energy was used. The wet process was used at all plants except one that used the dry process.

Clays. -- Miscellaneous clay and shale was mined in 10 counties at 14 pits. Eighty-four percent of the output was used in cement manufacture. The remainder was used in manufacturing lightweight aggregate, heavy clay products (sewer pipe, drain tile), and pottery. The greatest production was from pits in Alpena, Monroe, and Wayne Counties.

Gem Stones. -- Agates, native-copper specimens, goethite, hematite specimens, thomsonite, and Petoskey stone (fossil coral) were collected. Most of the material was found in the northern peninsula, although collectors reported finding Petoskey stone in lower Michigan (Antrim, Cheboygan, and Lenawee Counties).

Gypsum. -- Gypsum was produced from underground mines in Kent County and from quarries in Iosco County. The crude material was processed at plants in Grand Rapids, National City and Detroit, and in plants in other States. Wallboard, exterior sheathing, lath, and plaster were manufactured. A considerable amount of gypsum was sold for use as a portland-cement retarder. Output of gypsum was about 3 percent larger than in 1962.

Lime. -- Lime production increased about 20 percent, both in volume and value from that of 1962. Most of the increase was due to larger demand from steel and chemical manufacturers. Data for regenerated lime

(produced by papermills, water purification plants, and acetylene processors) are excluded from the State total value of production. Principal lime output came from Wayne County. Three-quarters of the lime manufactured was used by the producer, and 95 percent was consumed within the State. Principal uses for lime were in chemical and metallurgical applications, paper and sugar manufacture, and water treatment. Most of the lime manufactured was quicklime; a small amount was hydrated. Annual lime-burning capacity of the Mine plants reporting was about 1.8 million tons.

Natural Salines. -- Bromine, calcium chloride, calcium-magnesium chloride, iodine, magnesium compounds, and potash were extracted from natural well brines at plants in Gratiot, Lapeer, Mason, Manistee, and Midland Counties.

Dow Chemical Co. put on-stream a plant in Midland to produce ethyl bromide by the reaction of ethylene with hydrogen bromide in the presence of gamma radiation emitted from rods containing small aluminum-clad slugs of radioactive cobalt 60.² This is the first time that radiation energy was used as a catalyst in a commercial chemical reaction. The process is the result of several years of pilot plant studies in Dow laboratories.

Perlite. -- Expanded perlite was produced at plants in Iosco and Kent Counties from crude ore mined in Colorado and Nevada. The material was used in building plaster. Both volume of shipments and value were less than in 1962. One manufacturer in Grand Rapids reported that he no longer processed the material.

Salt. -- Salt was mined from an underground deposit in Detroit and processed from natural well brines and artificial brines in Gratiot, Manistee, Midland, Muskegon, St. Clair, and Wayne Counties. The principal uses for salt, were in chemical manufacture (chlorine, soda ash), meatpacking, animal feed, water softening, and ice removal. Volume was slightly less than in 1962, but the distribution pattern changed considerably. Purchase by Government agencies and transit companies for ice control declined by nearly 15 percent. Increased use in chemical manufacture and food processing absorbed most of the loss.

Sand and Gravel. -- Michigan sand and gravel output exceeded 50 million tons for the second time, and ranked second in the Nation in production and third in value. Sand and gravel production was reported from all counties except Monroe. The Detroit area accounted for 40 percent of the value and 36 percent of the State sand and gravel production. Production exceeding 1 million tons was also reported from Allegan, Ingham, Kalamazoo, Kent, Ottawa, and Tuscola Counties.

Sand and gravel output increased by 6 percent over 1962. Larger requirements for paving material and fill accounted for much of the increase. More than 92 percent of the sand and gravel was processed or treated. Nearly 47 million tons of sand and gravel was

transported by truck, and the remainder was moved by rail and water. Production was reported from 339 commercial operations and 262 Government-and-contractor operations.

The 10 leading producers of sand and gravel, in alphabetical order, were:

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

Stone. -- Basalt, marl, limestone, and sandstone were produced. Nearly all (99 percent) of the material was limestone, quarried in 15 counties by 20 commercial producers and 4 county highway agencies. A very large proportion of the limestone was quarried and crushed in a few very large quarries in Alpena, Chippewa, Mackinac, Monroe, and Presque Isle Counties. Nearly 24 million tons of stone was moved by water from company-operated ports on Lakes Huron and Michigan to steel mills, cement and lime plants, and other industrial consumers. Shipments were nearly 7 percent larger than in 1962 due to larger demand from steel mills, cement plants, other industrial users, and roadbuilders. Of the 30.1 million tons of crushed limestone produced, 11.1 million tons was used for flux; 14.5 million for cement, lime, and other industrial uses; and 3.9 million for roadstone and concrete aggregate. The largest producers of limestone, in alphabetical order, were:

Dummond Dolomite, Inc. (Chippewa County).
Dundee Cement Co. (Monroe County).
The France Stone Co. (Monroe County).
Huron Portland Cement Co. (Alpena County).
Inland Lime & Stone Co. (Mackinac County).
Michigan Stone Co. (Monroe County).
Penn-Dixie Cement Corp. (Emmet County).
Presque Isle Corp. (Presque Isle County).
United States Steel Corp. (Mackinac and Presque Isle Counties).
The Wallace Stone Co. (Huron County).

Basalt was quarried for road use by the Houghton County Road Commission. Marl was produced in 15 counties at 34 operations. The largest output was reported from Allegan, Barry, Calhoun, Cass, and Kalamazoo Counties.

Sandstone, principally for building use, was quarried and milled in Baraga and Jackson Counties. The Alcona County Road Commission quarried and crushed sandstone for road use.

Sulfur. -- Byproduct sulfur was recovered from crude petroleum in Detroit by the Marathon Oil Co., using the

Parsons process. At Alma, Leonard Refineries, Inc., used the hydrofining process to recover sulfur.

Vermiculite. -- Crude vermiculite, produced in Montana and South Carolina, was exfoliated at the Dearborn plant of Zonolite Division, W. E. Grace & Co.

² Dow Diamond. Winter Issue 1963. Published by the Dow Chemical Co., Midland, Mich., v. 26, No. 1, pp. 26-27.

METALS

Metals accounted for over 31 percent of the total value of mineral production, up from 29 percent in 1962.

Copper. -- Production of copper in terms of recoverable metal was 2 percent larger than in 1962. The value of output increased in the same proportion, as the price remained stable throughout the year.

Copper producers operated throughout the year without interruption. Output was reported from 10 underground mines and 3 tailing reclamation plants.

Calumet & Hecla, Inc., operated seven mines, one reclamation plant, and one smelter in Houghton and Keweenaw Counties. Copper Range Co. operated the Champion mine and the Freda, mill in Houghton County. The mill concentrated ore from the mine and tailings from the Redridge and Atlantic mill sands. As the company White Pine smelter was taxed to capacity throughout 1963, the Freda mill concentrates were refined at the Calumet & Hecla, Inc., smelter at Hubbell. White Pine Copper Co., a wholly owned subsidiary of Copper Range Co., operated two mines, a mill, and a smelter in Ontonagon County. Quincy Mining Co. operated a tailing reclamation plant and smelter in Houghton County.

The average weighted price of copper was 30.8 cents per pound, the same as in 1962. The price quoted by primary producers for delivered electrolytic copper at the beginning of 1963 was 31 cents per pound and remained at that price throughout the year.

Iron Ore. -- Shipments of iron ore from Michigan mines increased 1,368,000 tons over that of 1962, nearly 15 percent. The value of shipments increased by 25 percent because of a larger proportion of jaspilite concentrate and pellets. Concentrate produced from jaspilite accounted for more than 43 percent of iron ore shipments and 54 percent of value of shipments in 1963. A total of 15 underground and 5 open-pit mines were active all or part of the year, 4 fewer underground mines than were operated in 1962.

More than 64 percent of the ore mined came from open-pit operations, compared with 50 percent in 1962. Average iron content of usable ore produced was 57.21 percent natural. The average weighted mine value of Michigan iron ore, without respect to grade, was \$9.94, compared with \$9.08 per long ton in 1962. Vessel freight rates to lower Lake ports were reduced 10 cents per ton in August. This reduction did not change the

mine value, as the freight saving was passed on to the buyer.

Michigan iron ore was shipped to producers of pig iron and steel except for a small quantity used in manufacturing iron oxide pigments. About 97 percent of the iron ore was shipped by rail to ore docks in Ashland, Wis., and Escanaba and Marquette, Mich., and then by boats to lower Lake ports. The balance was all-rail shipments to consuming districts. The lake shipping season for Michigan ores opened at Escanaba on April 19 and closed at the same port on December 16.

At yearend, estimated reserves of iron ores in Michigan totaled 83 million long tons,³ not including about 1.8 billion tons of low-grade hematite ore.

Manganiferous Ore. -- Manganiferous ore (containing 5 to 35 percent manganese, natural) was shipped from the stockpile at the Cannon mine. The mine was closed in September 1962 and manganiferous ore had not been mined since 1961.

Pig Iron and Steel. -- Pig iron and steel were manufactured in the Detroit area. Pig iron shipments increased 22 percent in volume and 19 percent in value over 1962. Basic and bessemer grades were produced. According to the American Iron & Steel Institute. Michigan steel production was more than 8.4 million tons, about 18 percent higher than in 1962.

Silver. -- Silver was recovered from copper ore mined at the White Pine mine. High silver-bearing concentrate from a silver-recovery circuit in the White Pine mill was smelted separately for delivery to electrolytic refineries where the silver was recovered.

³ Geological Survey Division, Michigan Department of Conservation. General Statistics Covering Costs and Production of Michigan Iron Mines. June 1964, 15 pp.

MINERAL FUELS

Natural Gas and Natural Gas Products. -- About 56 percent of the State gas production came from oil well gas; the remainder, from gasfields. About 43 percent of the gas came from gas and oilfields in St. Clair County. Another 30 percent came from the fields of the Albion-Pulaski-Scipio Trend in Calhoun, Hillsdale, and Jackson Counties. Other major gas-producing areas were in Macomb, Missaukee, and Roscommon Counties. The above areas yielded 85 percent of the State total. The remainder came from fields in 22 counties. Seven new gasfields opened in 1963, increasing the producible dry gasfields to 80.

Production of both natural gasoline and liquefied petroleum gases increased substantially over that of 1962. The value of natural gas products was one-third higher than in the previous year. Extraction of LP gas products from wet gas processing was centered in Albion-Pulaski-Scipio Trend and Belle River Mills fields where nearly 75 percent of the total was produced. The increase was partially due to extraction of residual LP

gas from gas delivered via interstate pipeline from Southwestern States. Extraction from interstate pipeline gas began at the Willow Kun plant in December 1963.

Peat. -- Peat production was down 2 percent from 1962, while the value increased by 6 percent. Michigan was the leading peat-producing State with 46 percent of the national output.

Peat was produced in 15 counties, with 96 percent coming from Lapeer, Oakland, Sanilac, and St. Clair Counties. Peat was marketed principally as a soil conditioner. None was sold for fuel.

Petroleum. -- Decline in petroleum production, which began in 1962, continued, and output dropped more than 1.1 million barrels. More than half the loss was sustained in the Albion-Pulaski-Scipio-Trend fields, which accounted for 58 percent of State production.

According to data published in the Annual Statistical Summary of Michigan's Oil and Gas Fields, 1963, by the Geological Survey, Michigan Department of Conservation, no significant new oil reserves were found in 1963. Leasing activities dropped off sharply from previous years.

In 1963, a total of 1.8 million acres under lease at yearend was reported by 24 companies, compared with 3.6 million acres by 26 companies at the end of 1962. A decrease in the number of acres of State mineral lands under lease also was reported.

Geophysical exploration continued at about the same level as in 1962. Much of the geophysical surveying was done in the eastern and northern parts of the State. Most discoveries (Niagaran reefs) in eastern Michigan were found by gravimeter, or gravimeter and subsurface study. New oilfield discoveries during 1963 increased the active oilfields to 179. In addition, three new pools or pays were added to older fields. There were seven fields or pools abandoned during the year. New well completions, including reworks and wells deepened to new pay zones, increased the yearend total of producible wells to 4,598.

In 1963, 48 percent of the exploratory wells were completed in the Silurian or Ordovician formations. Emphasis in exploration seemed to be on locating structural traps rather than reefs or fracture reservoirs.

Petroleum was produced in 44 counties all in the lower peninsula. Fourteen operating crude oil refineries had a crude-oil refining capacity of 172,739 barrels daily as of January 1, 1963.

Fluid injection was used in producing about 3.7 million barrels of petroleum and nearly 3 billion cubic feet of gas. More than 46 million barrels of fluid, mostly brines, were injected into producing formations through 282 wells. From the same fields, more than 47 million barrels of fluid, nearly all brine, was produced.

REVIEW BY COUNTIES

Mineral production was reported from all counties in Michigan. The value of output increased in 46 counties and decreased in 37 counties. Output exceeded \$1 million in 44 counties. Marquette County led in value of production.

Allegan. -- Natural gas, peat, petroleum, sand and gravel, and marl were produced. More than 1.5 million tons of sand and gravel were mined by several commercial operators and the county road commission. Marl for agricultural use was dug at three sites. Natural gas production continued to decline and was 38 percent of the 1.6-billion-cubic-foot output in 1962. Petroleum production of 262,000 barrels was slightly more than in 1962. A small quantity of peat was dug from a bog near Wayland.

Alpena. -- Portland and masonry cements were manufactured in Alpena by Huron Portland Cement Co. An automated loading system to reduce shiploading time at the largest cement plant in the world was installed. Bulk loading of lake steamers is accomplished in 3 hours, compared with 8 hours for the former system. Sand and gravel for road use and clay and limestone for cement were also produced in the Alpena area.

Antrim. -- Shale was mined by Penn-Dixie Cement Corp. for use at the Petoskey plant. Road materials were produced for the county and State road departments.

Arenac. -- Sand and gravel for building and road use were produced near Standish and Twining. The county road commission quarried and crushed stone for its own use. The Deep River, Standish, and Sterling fields produced the major part of the petroleum output.

Baraga. -- Sandstone for building use was quarried at Arnheim by Superior Natural Bed Stone Quarry. The Fox Valley Construction Co. operated sand and gravel pits at Baraga, L'Anse, and Michigamme and produced road materials. The county and State highway departments also obtained materials for their own use from pits throughout the county.

Barry. -- Marl was dipped from deposits near Caledonia and Nashville and was sold for agricultural use. Pits throughout the county yielded sand and gravel for road use, building, fill, and ice control. Small quantities of peat and petroleum also were produced in the county.

Bay. -- Aetna Portland Cement Co. Division, Martin Marietta Corp., produced portland and masonry cements at Bay City. Monitor Sugar Division of the Robert Gage Coal Co. produced lime for its own use in sugar refining. The Essexville and Kawkawlin fields yielded most of the petroleum produced in the county. Bay Refining Co. refined crude oil at Bay City. The county and State road departments obtained gravel for road use.

Berrien. -- Molding and blast sand and material for building and road use were produced at several sites in

the county. Output exceeded 400,000 tons. Marl was obtained from pits near Three Oaks and sold for agricultural use.

Branch. -- Sand and gravel for building, paving, and fill was produced at fixed plants in the Coldwater area and at portable plants throughout the county. Frisbie Bros, of Colon dipped marl from a lake and sold it for agricultural use.

Calhoun. -- The county maintained second place in petroleum production, although output dropped 600,000 barrels. Natural gas production increased from 3.6 to 4 billion cubic feet. Over 200,000 tons of sand and gravel, mostly for building and road use, was produced at fixed plants at Battle Creek and Tekonsha and at several portable plants throughout the county. Pits near Burlington and Union City yielded marl for agricultural use.

Cass. -- Petroleum production from the Jefferson field declined to 15,000 barrels from 42,000 in 1962. Six wells were drilled during the year, resulting in two producers and four dry holes. Fixed plants at Dowagiac and portable plants throughout the county, processed several hundred thousand tons of sand and gravel for building and road use. Marl was produced at several pits near Cassopolis, Dowagiac, Edwardsburg, and Jones.

Charlevoix. -- The Charlevoix Lime & Stone Co. closed its operation near Charlevoix and moved to a quarry in Cheboygan County. Sand and gravel was produced with portable plants at several sites in the county for road and building purposes.

Cheboygan. -- Afton Stone & Lime Co. quarried limestone near Afton for road use. Charlevoix Lime & Stone Co. operated the Campbell quarry near Afton and produced limestone for flux and agricultural use. A quarter million tons of sand and gravel, mostly for road use, was produced.

Chippewa. -- Drummond Dolomite, Inc., operated a quarry and crushing plant on Drummond Island in Lake Huron and produced flux-stone, agricultural limestone, and road material. Over 700,000 tons of sand and gravel was produced with portable plants throughout the county. Most of the material was used in road construction.

Clare. -- Over half a million barrels of petroleum was produced, about 40,000 barrels more than in 1962. Gas production dropped sharply from 507 million to 198 million cubic feet. Most of the oil and gas came from the Hamilton and Headquarters fields. Road and fill materials were obtained from several sand and gravel pits for the county and State highway departments.

Clinton. -- Clay was mined near Grand Ledge and used in the manufacture of sewer pipe by Grand Ledge Clay Product Co. and American Vitrified Products Co. About 300,000 tons of sand and gravel was produced, mostly for paying and building use. Gillette Sand & Gravel,

formerly of DeWitt, moved its sand and gravel operation to Shiawassee County. Al-Par Peat Co., Ovid, produced peat for horticultural use.

Crawford. -- Beaver Creek field yielded both petroleum and natural gas. Production was down about 10 percent from 1962. The county and State highway departments produced and purchased sand and gravel for road construction and maintenance.

Delta. -- Bichler Bros., Escanaba, quarried and crushed limestone for concrete aggregate and roadstone and produced sand and gravel for building and paving use. Road gravel was produced with portable plants at several other sites in the county.

Dickinson. -- The Hanna Mining Co. operated the Groveland open-pit iron mine and concentrator near Randville. In March, the company began operation of its new pelletizing plant. The plant has an annual capacity of 1.25 million tons of pellets. Felch Quarry Co. Division, North Range Mining Co., operated the Felch quarry and produced limestone for roofing granules and ornamental aggregate. Superior Rock Products Co. operated the Randville Quarry and produced limestone used for terrazzo and ornamental concrete. Sand and gravel was produced for building and road use.

Eaton. -- Grand Ledge Clay Product Co. manufactured sewer pipe from clay mined near Grand Ledge. Cheney Limestone Co. operated a quarry near Bellevue and produced agricultural limestone, roadstone, and a small quantity of rubble. Sand and gravel was produced throughout the county, mostly with portable plants. Most of the material was used for road construction and maintenance. Hilu Peat Co. produced humus peat near Charlotte.

Emmet. -- Penn-Dixie Cement Corp. produced masonry and portland cements at Petoskey. Late in 1963 the company announced plans for an extensive modernization program which will include a large kiln as well as installation of grinding, coal-handling, and auxiliary equipment. Completion is set for 1965. Limestone was quarried near the plant for use in making cement. The county road commission produced sand and gravel for its own use.

Genesee. -- The Otisville field yielded a small quantity (2,423 barrels) of petroleum. More than 900,000 tons of sand and gravel was produced from pits throughout the county. Most of it was used for building, paving, and fill.

Gladwin. -- Petroleum production (431,000 barrels) was about the same as in 1962. Most of the output came from the North Buckeye field. The Butman field was abandoned in 1963 after producing a quarter million barrels since 1949. Also abandoned was the Grant field with a cumulative production of 760,000 barrels. Gravel for road use was mined in the county.

Gogebic. -- Pickands Mather & Co. operated the Geneva and Peterson mines. Sand and gravel production dropped to 200,000 tons from 354,000 in

1962. Nearly all of the material was used for road maintenance and construction.

Gratiot. -- Michigan Chemical Corp. produced bromine, calcium-magnesium chloride, magnesium compounds, and salt from natural well brines at St. Louis. At Alma crude oil was refined at Leonard Refineries, Inc., and byproduct sulfur was recovered by hydrofining process. About 71,000 barrels of petroleum was produced from the Sumner field. North Star field produced a small amount of natural gas. Sand and gravel, for building and paving, was produced by four operators.

Hillsdale. -- The county again was the leading petroleum producer in the State, having an output of nearly 4.3 million barrels. Nearly 3.5 billion cubic feet of natural gas was produced. During the year 105 wells were drilled of which 39 were producing oil wells and 66 were dry holes. Pits near Allen and Mosherville yielded marl for soil conditioning. More than 600,000 tons of sand and gravel were mined for building, paving, and fill.

Houghton. -- Copper was produced by Calumet & Hecla, Inc., Copper Range Co., and Quincy Mining Co. Calumet & Hecla operated the Allouez No. 3, No. 4 Ahmeek Peninsula, Centennial No. 2, Centennial No. 3, Kingston, Osceola No. 13, and Seneca. Ore from the waste rock stockpile of the Ahmeek Peninsula was also processed. Development of the Kingston conglomerate lode continued during the year. Copper Range Co. operated the Champion mine throughout the year. Ore from the Champion and tailings from the Atlantic and Redridge sands were treated at the Freda mill. Quincy Mining Co. operated a reclamation plant at Hubbell and a smelter at Hancock. The smelter was kept in operation during the year with several short shutdowns because production at the reclamation plant was not sufficient to keep the smelter going full time. The Limestone Mountain Co. operated a quarry at Pelkie and produced agricultural limestone. The county road commission quarried basalt for road use. Sand and gravel for building and paving was mined at several sites.

Huron. -- Michigan Sugar Co. produced hydrated lime for its own use in sugar refining at Sebewaing. At Bay Port, The Wallace Stone Co. quarried and milled rough construction stone and crushed stone for railroad ballast, roadstone, and agricultural limestone. Some broken stone was sold for riprap. Sand and gravel for building, paving, and fill was produced at several sites. A small quantity of petroleum was produced from the Dwight and Grant fields.

Ingham. -- Peat was produced from a bog near Delhi by Winn's Peat Corp. of Lansing. About 1 million tons of sand and gravel was produced, most of it for road construction and maintenance, building, and fill. The Lansing Board of Water & Light recovered lime from calcium carbonate precipitated in its water purification process.

Iosco. -- Gypsum was quarried at Tawas City and processed at a plant at National City by National Gypsum Co. At this plant also, crude perlite, mined in Colorado, was expanded for use in plaster. United States Gypsum Co. operated a gypsum quarry at Alabaster. The company manufactured gypsum products at plants in Detroit and Grand Rapids. Road material and sandfill were produced at several sites. Michigan Gypsum Co. operated a quarry near Turner. The crude gypsum was sold as a cement retarder.

Iron. -- The Hanna Mining Co. mined and shipped iron ore from the Hiawatha, Homer, and Wauseca mines and shipped from the stockpile at the closed Cannon mine. Manganiferous ore also was shipped from the Cannon stockpile. Inland Steel Co. operated the Bristol and Sherwood mines. At the Bristol a larger compressor was installed. The Republic Steel Corp. shipped from stock at the Tobin Group and exhausted the stockpile. The Book mine of the North Range Mining Co. remained idle. Road gravel and sandfill were produced at several pits in the county.

Isabella. -- Petroleum and natural gas output continued to decline. Petroleum production totaled 402,000, compared with 487,000 in 1962. Natural gas production dropped from 107 million cubic feet to 6 million. Crude oil was refined at Mount Pleasant by Leonard Refineries, Inc. Marl for agricultural use was dug from a pit near Weidman. Sand and gravel for building and road use was produced.

Jackson. -- Petroleum output continued to decline to about 2.3 million barrels from 2.6 million in 1962. Natural gas production was virtually unchanged at 2.2 billion cubic feet. More than 500,000 tons of sand and gravel for fill, building, and paving use was produced. Roadstone and agricultural limestone was quarried and crushed near Parma. Three quarries near Napoleon yielded sandstone which was milled for building use and crushed for foundry use. Broken stone was used for riprap. Marl was dug from a pit near Horton.

Kalamazoo. -- Peat was dug from bogs near Kalamazoo and Scotts. Pits near Climax and Vicksburg yielded marl which was dried and sold for soil enrichment. Over 1.2 million tons of sand and gravel was produced at three fixed and several portable plants. Much of the material was used for road construction and maintenance. The last oil-producing field in the county, the Alamo, was abandoned in 1962.

Kalkaska. -- Natural gas and petroleum were produced from the Beaver Creek field. The yield was smaller than in 1962 and totaled 19,000 barrels of oil and 47 million cubic feet of gas. The county road commission produced sand and gravel for its own use.

Kent. -- Two underground mines operated by Bestwall Gypsum Co. and Grand Rapids Plaster Co. yielded gypsum. The crude material was processed at company-owned plants where wallboard, lath, sheathing, and plaster were produced. Bestwall Gypsum Co. also

expanded perlite mined in Nevada. The material was used in building plaster. Peat was dug from bogs near Grand Rapids and Wyoming. Over 2.7 million tons of sand and gravel was produced from large fixed plants in the Grand Rapids area and from portable plants throughout the country. Natural gas and petroleum were produced from the Walker field.

Lapeer. -- Wilkinson Chemical Corp. extracted calcium-magnesium chloride from natural well brines at Mayville. Reed-sedge peat production was reported from three operations near Imlay City. About 400,000 tons of sand and gravel was produced with portable plants throughout the county. Oil production totaled 23,357 barrels, up from 1,528 barrels in 1962. All production was from the Rich field which was opened in 1962. During the year six wells were drilled, resulting in five oil wells and one dry hole.

Lenawee. -- Masonry and portland cements were manufactured at Cement City by Peninsular Portland Cement Division, General Portland Cement Co. Drain tile was manufactured from miscellaneous clay by Comfort Brick & Tile Co., Tecumseh. About 700,000 tons of sand and gravel was produced in the county, mostly for road construction and maintenance. Peat production was reported at two sites. The Medina field yielded a small quantity of petroleum.

Mackinac. -- Inland Lime & Stone Co., Division of Inland Steel Co., operated the Port Inland quarry. United States Steel Corp. operated the Cedarville quarry. Both companies have developed extensive processing plants and port facilities nearby on the north shore of Lake Michigan to handle the output of the very large quarry operations. Nearly all of the material was shipped by boat to industrial consumers. Much of the output was used as blast furnace flux. Large quantities also were shipped to chemical plants, cement mills, lime plants, and other industrial consumers. More than 300,000 tons of sand and gravel was produced, mostly for road use. Output was less than half that of 1962 because of completion of highway contracts.

Macomb. -- Because of increased building and road construction activity in the northern Detroit metropolitan area, sand and gravel production increased to 3.5 million tons from 1.1 million in 1962. About 2 million tons came from fixed plants and the remainder from portable plants. About three-fifths of the material was used in road construction while the balance was used for building and fill. Natural gas production increased to 1.7 billion cubic feet from 500 million in 1962. Nearly half of the output came from the Bay gas reef which is being steadily developed into a much larger productive area than expected earlier. The remainder of the gas came from the Lenox field. In 1963, 9 gas wells and 21 dry holes were drilled.

Manistee. -- Natural well brines of the Filer formation were processed and yielded bromine, calcium-magnesium chloride, and magnesium compounds. In the Manistee area chemical plants were operated by

Great Lakes Chemical Corp., Michigan Chemical Corp., Morton Chemical Co., and Standard Lime & Cement Co. Division, Martin Marietta Corp. Value of output was 14 percent larger than in 1962. Salt was recovered from artificial brines by Manistee Salt Works and Morton Salt Co. The Packaging Corp. of America produced regenerated lime for its use by calcining calcium carbonate sludge in a rotary kiln. Industrial sand, as well as building and paving sand and gravel, was produced in the county.

Marquette. -- The county maintained its position as the leading mineral producer in the State. Iron ore mines were operated by Cleveland-Cliffs Iron Co., Inland Steel Co., Jones & Laughlin Steel Corp., and North Range Mining Co. Cleveland-Cliffs Iron Co. began producing pellets at its new Empire project, 4 miles south of Negaunee. Initial annual capacity of the Empire plant is 1.2 million tons of pellets, having an expected ultimate capacity of 3 million tons. Cleveland-Cliffs also began construction of an addition to the Republic concentrator that will expand annual capacity of the plant by 400,000 tons. Upon completion, in 1964, total annual capacity of the Republic concentrator will be 2.8 million tons of concentrate. Of this amount, 2 million tons will be agglomerated at the Republic mine site and the remainder at the Eagle Mills pelletizing plant. In December, plans were announced for a \$15 million pelletizing plant at the Cleveland-Cliffs Mather underground mine. The project was expected to increase annual production of the mine from 700,000 tons to 2.4 million tons by 1966. The plant will be the first in the Lake Superior District to pelletize high-grade underground ores. Inland Steel Co. ceased mining operations at the Greenwood underground mine at Ishpeming on April 30. Overall shipments of iron ore from the county increased 30 percent. Output of underground mines was only 4 percent larger than in 1962, while production from open pits increased more than 50 percent. Sand and gravel production totaled 745,000 tons and was used principally for road maintenance and construction.

Mason. -- Bromine, calcium chloride, calcium-magnesium chloride, magnesium compounds, and lime were produced by Dow Chemical Co. at plants in the Ludington area. Harbison-Walker Refractories Co. produced refractory magnesia from purchased magnesium hydroxide. Industrial sand (molding, grinding, and polishing), as well as paving sand, was produced. Petroleum output continued to increase -- 264,000 barrels, compared with 168,000 in 1962. During the year 39 wells were drilled, resulting in 12 oil producers and 27 dry holes. The largest oil production came from the Eden, Scottville, and Wiley fields. Natural gas was recovered from the Eden field; production dropped to one-third of the 1962 output.

Mecosta. -- Marl was recovered from deposits in Brockway Lake and Burden Lake. Sand and gravel was produced at fixed plants near Big Rapids and at portable plants throughout the county. Nearly 30,000 barrels of

petroleum and 152,000 million cubic feet of natural gas, about the same quantity as in 1962, was produced.

Menominee. -- Quicklime and hydrated lime for chemical and industrial use was produced by Limestone Products Division of North Western-Hanna Fuel Co. at Menominee. About 472,000 tons of sand and gravel was produced, mostly for building and paving use.

Midland. -- Dow Chemical Co. produced bromine, calcium chloride, calcium-magnesium chloride, iodine, magnesium compounds, and potash from natural brines; salt was produced from artificial brines. Kaiser Aluminum & Chemical Corp. produced refractory magnesia from purchased magnesium hydroxide. Molding sand and sand and gravel for fill, paving, and building was produced near Midland. About 268,000 barrels of petroleum and 15 million cubic feet of natural gas was produced.

Missaukee. -- About 500,000 barrels of petroleum was recovered, principally from the McBain and East Norwich fields. About 1 billion cubic feet of natural gas was produced, mostly from the Enterprize and East Norwich fields. Gravel was produced for road construction and maintenance.

Monroe. -- Portland and masonry cements were produced at Dundee by the Dundee Cement Co. Clay and limestone deposits near the mill were used for raw material. Clay mined near South Rockwood was used for manufacturing art pottery by F. W. Ritter Sons Co. Limestone quarried at Maybee, Monroe, and Ottawa Lake was crushed and sold for flux, ballast, roadstone, and agricultural limestone. Broken stone was used for riprap. Peat was obtained from bogs near Ida and sold for soil conditioning. About 11,000 barrels of petroleum was recovered from the Deerfield field.

Montcalm. -- Petroleum (343,000 barrels) and natural gas output (137 million cubic feet) continued to decline. Most of the petroleum production, as in 1962, came from the Elmore and Reynolds fields. During the year the Day and Pine fields were abandoned. A bog near Lakeview yielded peat (reed-sedge and moss). About 265,000 tons of sand and gravel was produced for building and road use. Crude oil was refined by Crystal Refining Co. of Carson City, Inc.

Muskegon. -- Salt was produced from artificial brines at Montague by Hooker Chemical Co. In the Muskegon area industrial sand production was reported by The Nugent Sand Co., Inc. Building and paving sand also was produced in the county. About 13,000 barrels of petroleum and 11 million cubic feet of natural gas were produced. Crude oil was refined at Muskegon by Marathon Oil Co. and by Naph-Sol Refining Co.

Newaygo. -- About 119 million cubic feet of gas was recovered from the Ensley gasfield. Nearly 30,000 barrels of petroleum was produced. About 150,000 tons of sand and gravel, mostly used for road construction and maintenance, was recovered from pits throughout

the county. A pit near Grant yielded marl for agricultural use.

Oakland. -- Nearly 7.9 million tons of sand and gravel was produced at fixed and portable plants throughout the county, more than 23 percent higher than in 1962. The increase was due to greater demand for building and road materials in the Detroit metropolitan area. About 445 million cubic feet of natural gas and a small quantity of petroleum was recovered from the Oakland County portion of the Northville field. Bogs near Clarkston, Farmington, New Hudson, and Novi yielded humus peat, which was processed for horticultural use and soil conditioning.

Oceana. -- About 274,000 barrels of petroleum was produced. El-bridge, Pentwater, and Stony Lake fields were the principal producers. A small quantity of natural gas was recovered from the Crystal Valley field. More than 640,000 tons of sand and gravel was produced at fixed and portable plants in the county. Most of the output was used for road construction and maintenance.

Ogemaw. -- More than 364,000 barrels of petroleum and 673 million cubic feet of natural gas were produced. Nearly all of the output came from the Rose City and West Branch fields. Osceola Refinery at West Branch refined crude oil. Sand and gravel for building and road use was produced.

Ontonagon. -- White Pine Copper Co. (a wholly owned subsidiary of Copper Range Co.) operated a mine, mill, and smelter at White Pine. The company has selected the longwall mining method to gradually supersede the room-and-pillar method now in use. The longwall method will permit maximum extraction from the ore body by permitting controlled caving of the ground after the ore is mined out. Ore will not be left in pillars for roof support. It will take several years to convert the entire operation to this method. In the meantime, the room-and-pillar method will provide ore for the mill while engineering and equipment design will continue to develop ways of improving the costs of longwall mining. Mill capacity was increased 10 percent by the addition of two new rod mills. Concentrate drying equipment was installed which permitted the smelter to achieve the highest level of production in its history. To maintain a balance between mine output and mill and smelter, a computerized study was initiated in 1963. The initial study indicated moves that should help materially to achieve maximum efficiency of operations. In 1962, a semicontinuous casting machine was installed in the smelter for experimental purposes. This unit is now producing and an additional unit is planned to augment production in 1964. Development of the Southwest ore body was suspended; machinery was removed; and the level was allowed to flood. Subsequent discovery of additional ore along the periphery of the main ore body, as well as better grade control and lower mining costs, made it unnecessary to incur the heavy capital costs of putting the new ore body into production. This ore body will be considered part of the future reserve. The silver

recovery circuit was operated and the high-silver-bearing concentrates from the circuit were smelted separately for delivery to electrolytic refineries where the silver could be recovered.

More than 500,000 tons of sand and gravel was produced -- all of it for fill and road use.

Osceola. -- Sand and gravel was produced from pits at Hersey and Reed City. The material was used chiefly for building, paving, and fill. A pit near Tustin yielded marl for soil enrichment. Petroleum output totaled 302,000 barrels, and 235 million cubic feet of natural gas was produced. A major portion came from the Reed City field. Osceola Refining Co. at Reed City refined crude oil.

Ottawa. -- Nearly 2.5 million tons of sand and gravel was produced, up from 1.8 million in 1962. Industrial sand as well as sand and gravel for building, paving, and fill was reported. Marl was dug near Hudsonville and Jenison. More than 192,000 barrels of petroleum and 138 million cubic feet of natural gas was recovered. The largest production was reported from the Walker field.

Presque Isle. -- Large limestone quarries and processing and port facilities were operated at Rogers City by United States Steel Corp. and at Alpena by Chemstone Corp., agents for Presque Isle Corp. Most of the shipments were by water to steel mills, cement plants, chemical and lime plants, and sugar and paper mills. Substantial quantities also were shipped for concrete aggregate, roadstone, and agricultural limestone. Rough construction stone was quarried at Onaway by Onaway Stone Co. Straits Aggregate & Equipment Corp., Oscoda, operated sand and gravel pits in the Millersburg area and at Rogers City. Road materials were produced. The county and State highway departments also obtained sand and gravel for road maintenance and construction.

Roscommon. -- More than 1.2 billion cubic feet of natural gas and 190,000 barrels of petroleum were recovered, much of it from the St. Helens and Headquarters fields. Sand and gravel, totaling 274,000 tons, for fill, building, and paving was obtained from pits in the county.

Saginaw. -- Clay for use in manufacturing cement was mined by Aetna Portland Cement Co. Division, Martin Marietta Corp. Michigan Sugar Co. produced hydrated lime for its own use in sugar refining at Saginaw. The county and State highway departments obtained sand and gravel for road construction and maintenance. About 38,000 barrels of petroleum were recovered from Birch Run, Birch-Bela, and Saginaw fields.

St. Clair. -- Peerless Cement Co. Division, American Cement Corp., produced portland cement at Port Huron. The company mined clay at Smith Creek for use at the plant. Salt was recovered from artificial brines at St. Clair by Diamond Crystal Salt Co., and at Marysville by Morton Salt Co. Reed-sedge peat was dug from a bog near Capac. Nearly 470,000 tons of sand and gravel

was produced at sites throughout the county. It was used chiefly for building and road construction. More than 900,000 barrels of petroleum and nearly 14.3 billion cubic feet of natural gas was produced. The gas output was the largest in the State.

St. Joseph. -- Marl was produced from pits near Colon, Nottawa, and Three Rivers. Moss peat was dug from a bog in the Three Rivers area. Sand and gravel was produced from fixed plants at White Pigeon and Three Rivers. The county and State highway departments contracted for sand and gravel for road construction.

Sanilac. -- Hydrated lime was produced at the Crowell plant of Michigan Sugar Co. for use in sugar refining. Bogs near Minden City and Sandusky yielded moss and reed-sedge peat for horticultural use. More than 500,000 tons of sand and gravel were produced, most of it for road construction and maintenance.

Shiawassee. -- Michigan Vitrified Tile Co. mined clay near Corunna for use in manufacturing vitrified sewer pipe. About 345,000 tons of sand and gravel was produced at both fixed and portable plants throughout the county.

Tuscola. -- Hydrated lime was produced at Carp by Michigan Sugar Co. for use in refining sugar. Nearly 1.5 million tons of sand and gravel was produced. Although much of the material was used in building and road construction, a large amount of molding sand was produced. About 85,000 barrels of petroleum output was reported from four fields, with the major portion coming from the Akron field.

Van Buren. -- Industrial sand (molding and engine) was produced at two fixed plants near Covert and South Haven. Road gravel was produced with portable plants at a number of sites throughout the county. About 28,000 barrels of petroleum was recovered. The Paw Paw and Bloomingdale fields yielded the major portion of the output.

Washtenaw. -- Nearly 1.5 million tons of sand and gravel was produced from deposits, largely in the Ann Arbor and Ypsilanti area. The material was used primarily for building and road construction. About 24,000 barrels of petroleum was produced from the Northville field. Natural gas production of 345 million cubic feet was less than half of the 1962 output.

Wayne. -- The county ranked second in value of mineral production, after Marquette and Houghton Counties. The total was about \$2 million more than in 1962. Peerless Cement Co. Division, American Cement Corp., manufactured portland and masonry cement at two plants in Detroit. The company mined clay for its own use from a pit near Allen Park. Wyandotte Chemicals Corp. produced port-land cement at Wyandotte. Flat Rock Clay Products Co. mined clay for use in manufacturing drain tile. At Livonia, Light Weight Aggregates Corp. mined clay for its own use. Quicklime was produced at Wyandotte by Wyandotte Chemicals Corp. and at Detroit by Solvay Process Division of Allied

Chemical Corp. Most of the output was used in chemicals manufacture. Salt was recovered from artificial brines, formed by dissolving salt from the Salina formation, at plants in Wyandotte by Pennsalt Chemicals Corp. and Wyandotte Chemicals Corp. International Salt Co. operated an underground mine in Detroit and produced rock salt. Limestone for concrete and roadstone was quarried at the Sibley quarry at Trenton by the Michigan Foundation Quarry Co., Inc. More than 2.2 million tons of sand and gravel was produced from both fixed and portable plants at sites throughout the county. Industrial sand (glass, molding, and blast), as well as building and paving material and fill, was produced in large quantities.

About 13,000 barrels of petroleum and 644 million cubic feet of natural gas were recovered from the Northville field. Crude oil refineries were operated at Detroit by Marathon Oil Co.; at Flat Rock by Petroleum Specialties, Inc.; at Trenton by Socony-Mobile Oil Co., Inc.; and at Wyandotte by Wyandotte Chemicals Corp. Byproduct sulfur was recovered from petroleum by the Parsons process at the Marathon refinery in Detroit. Zonolite Division, W. K. Grace & Co., exfoliated vermiculite at a plant in Dearborn. The crude vermiculite was shipped in from Montana and South Carolina. United States Gypsum Co. operated a calcining and board plant in Detroit.

TECHNICAL STAFF

Michigan Department of Conservation Geological Survey

Gerald E. Eddy, State Geologist and Chief

OIL AND GAS

L. W. Price, *Geologist in Charge*

Regulatory Control

R. M. Acker, *geologist and head*

MT. PLEASANT FIELD OFFICE

V. F. Sargent, *oil and gas supervisor*

C. R. Brown, *oil and gas inspector*

S. A. Dyer, *oil and gas inspector*

B. N. Gunning, *oil and gas inspector*

R. D. Shaver, *oil and gas inspector*

P. J. Sheponski, *oil and gas inspector*

LANSING FIELD OFFICE

F. W. Terwilliger, *oil and gas supervisor*

S. L. Alguire, *oil and gas inspector*

D. R. Brackenbury, *oil and gas inspector*

R. M. Lorenz, *oil and gas inspector*

H. E. Rickard, *oil and gas inspector*

CADILLAC FIELD OFFICE

R. F. Wiles, *oil and gas supervisor*

J. M. Snider, *oil and gas inspector*

J. B. Frisbey, *oil and gas inspector*

M. P. Greenwald, *oil and gas inspector*

PLAINWELL FIELD OFFICE

B. C. Ackerman, *oil and gas supervisor*

R. L. Breed, *oil and gas inspector*

M. L. Crego, *oil and gas inspector*

Pollution and Fire Control

H. A. Young, *oil and gas supervisor and head*

MT. PLEASANT FIELD OFFICE

D. C. Sanback, *oil and gas supervisor*

Production and Proration

W. G. Smiley, *geologist and head*

J. L. Lorenz, *geologist*

T. L. Culver, *geologist*

R. Dixon, *geologist*

Petroleum Geology

R. E. Ives, *geologist and head*

G. D. Ells, *geologist*

B. L. Champion, *geologist*

W. E. Mantek, *geologist*

MINING and ECONOMIC GEOLOGY

H. J. Hardenberg, *Geologist in Charge*

R. C. Reed, *geologist*

H. O. Sorensen, *geologist*

J. R. Byerlay, *geologist*

WATER

J. G. Rulison, *geologist and head*

L. D. Johnson, *geologist*

R. P. Bissell, *geologist*

GENERAL GEOLOGY

R. W. Kelley, *geologist and head*

E. A. Kirkby, *geologist*

UPPER PENINSULA AREA

ESCANABA FIELD OFFICE

A. E. Slaughter, *geologist and head*

J. H. Kent, *geologist*

The *STATE GEOLOGICAL SURVEY* was one of the first offices established when Michigan attained statehood in 1837. The First Legislature charged it ". . . to make an accurate and complete geological survey of this state, which shall be accompanied with proper maps and diagrams, and furnish a full and scientific description of its rocks, soils and minerals . . . and geologic productions" -- work pursued to this very day.

In 1921 the several state agencies then exercising independent jurisdiction over natural resources were combined into a single organization. Thus, the Geological Survey, headed by its chief administrative officer, the State Geologist, became part of the Department of Conservation.

Assisting the Supervisor of Wells (Director of Conservation) in enforcing regulatory practices prescribed by Michigan's oil and gas conservation laws comprises the greater part of the Survey's work. Some assistance is also given the State Public Utilities Commission which regulates the transmission and use of natural gas.

The Survey constitutes a bureau of continuing information and service in the field of earth science. This function is manifested through publications, maps, reference files, and personal consultation -- efforts that aid materially in delineating potential areas of economic mineral deposits, and in achieving understanding of the state's geologic history.

Iron and copper mining properties are appraised annually for general property tax purposes. From time to time appraisals of other mineral properties are made for the State Tax Commission. Evaluations of mineral venture securities being promoted in the state are prepared upon the request of the State Securities Commission.

Mineral statistics are compiled, in cooperation with the U.S. Bureau of Mines, and published annually along with information on the progress and development of the industry. Also cooperative assistance is provided in the development of public water supplies and in conducting surface and ground water studies.



Michigan Statutes prescribe that the *STATE GEOLOGICAL SURVEY*

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

--Compiled Laws Mich. 1948 s.319.202



UNITED STATES DEPARTMENT OF THE INTERIOR
Steward L. Udall, *Secretary*

BUREAU OF MINES
Marling J. Ankeny, *Director*

This publication is a chapter from Volume III, *MINERALS YEARBOOK*, 1963. The complete volume, covering all domestic area reports, may be purchased from the Superintendent of Documents, Washington D.C., 20402, at a date to be announced later. Volume I (Metals and Minerals (Except Fuels)), Volume II (Mineral Fuels), and Volume IV (Area Reports: International) also will be available from the Superintendent of Documents.

*For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington D.C., 20402*



STATE OF MICHIGAN
GEORGE ROMNEY, *Governor*

DEPARTMENT OF CONSERVATION
RALPH A. MACMULLAN, *Director*

GEOLOGICAL SURVEY
GERALD E. EDDY, *State Geologist and Chief*

COMMISSION OF CONSERVATION
HARRY H. WHITELEY, *Chairman*, Rogers City, 1961-67
ROBERT F. BREVITZ, Battle Creek, 1953-65
STANLEY A. CAIN, Ann Arbor, 1959-65
LELAND W. HOOKER, Houghton, 1963-69
CARL T. JOHNSON, Cadillac, 1963-67
E. M. LAITALA, Hancock, 1961-67
ROBERT C. McLAUGHLIN, Detroit, 1983-69
ROBERT J. FURLONG, *Secretary*

Published by Authority of State of Michigan CL '48 s.319.202
Printed by Speaker-Hines and Thomas, Inc., Lansing, 1964.

*Available from Publications Room, Dept. of Conservation,
Lansing, Mich. 48926*



Mineral	1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:				
Portland -- thousand 376-pound barrels	22,682	\$73,267	25,016	\$76,944
Masonry -- thousand 280-pound barrels	1,517	4,335	1,684	4,519
Clays -- thousand short tons	1,751	1,917	1,958	2,149
Copper (recoverable content of ores, etc.) -- short tons	77,099	45,645	75,262	46,361
Gypsum -- thousand short tons	1,278	4,791	1,315	4,938
Iron ore (usable) -- thousand long tons, gross weight	9,422	85,597	10,789	107,201
Lime -- thousand short tons	1,153	15,371	1,371	18,431
Magnesium compounds -- short tons	(²)	(²)	266,740	23,062
Manganiferous ore (5 to 35 percent Mn) -- short tons, gross weight	--	--	152,957	(²)
Natural gas -- million cubic feet	28,987	6,174	32,850	8,902
Peat -- short tons	⁴ 257,693	2,277	251,809	2,413
Petroleum (crude) -- thousand 42-gallon barrels	17,114	48,775	³ 15,973	³ 45,523
Salt -- thousand short tons	4,274	33,343	4,244	33,656
Sand and gravel -- do.	47,563	42,029	50,458	43,433
Silver (recoverable content of ores, etc.) -- troy ounces	401,491	436	338,997	434
Stone -- thousand short tons	28,440	29,055	30,316	32,065
Value of items that cannot be disclosed: Bromine, calcium chloride and calcium-magnesium chloride, gem stones, iodine, natural gas liquids, potassium salts, and values indicated by footnote 2	--	53,500	--	42,001
Total	--	⁴ 446,512	--	492,032

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

² Figure withheld to avoid disclosing individual company confidential data.

³ Preliminary figure.

⁴ Revised figure.

⁵ Includes friable sandstone.

Table 1. Mineral production in Michigan ¹

Year	Value	Year	Value
1952	\$308,067	1958	\$352,461
1953	322,692	1959	383,787
1954	306,127	1960	431,205
1955	384,801	1961	444,141
1956	395,862	1962	440,025
1957	411,885	1963	480,908

Table 2. Value of mineral production in constant 1957-59 dollars (Thousands)

Year and industry	Average number of men working	Total man-hours	Total number of disabling injuries		Total number of days lost or charged	Injury frequency rate ²	Injury severity rate ³
			Fatal	Nonfatal			
1962:							
Cement ⁴	1,403	3,666,084	1	10	6,378	3.00	1,740
Clays ⁵	234	509,255	--	4	59	1.96	116
Coke ovens	365	2,785,015	--	14	(⁶)	5.03	(⁶)
Copper	1,931	4,660,447	3	113	21,835	24.89	4,685
Gypsum	305	465,838	--	1	243	2.15	522
Iron ore	3,795	7,097,688	4	216	33,582	31.00	4,731

Limekiln ⁷	137	364,653	--	4	63	10.97	173
Limestone ⁸	1,428	2,560,090	1	17	6,633	7.03	2,591
Marl	57	35,302	--	--	--	--	--
Sand and gravel ⁹	2,683	4,739,299	1	86	9,729	18.36	2,053
Sandstone	61	136,524	--	6	177	43.95	1,296
Smelters	257	623,317	--	3	20	4.81	32
1963: ¹⁰							
Cement ⁴	1,376	3,767,529	--	21	(6)	5.57	(6)
Clays ⁵	225	510,993	--	5	(6)	9.78	(6)
Coke ovens	987	2,880,196	1	8	(6)	3.12	(6)
Copper	1,670	4,110,838	3	126	(6)	31.38	(6)
Gypsum	260	515,824	1	1	(6)	3.88	(6)
Iron ore	3,422	6,929,331	3	177	(6)	25.98	(6)
Limekiln ⁷	162	445,489	--	2	(6)	4.49	(6)
Limestone ⁸	1,314	2,566,428	1	14	(6)	5.84	(6)
Marl	57	45,080	--	--	--	--	--
Sand and gravel ⁹	2,654	4,569,822	1	60	(6)	13.35	(6)
Sandstone	75	161,479	--	3	(6)	18.58	(6)
Smelters	251	634,198	--	5	(6)	7.88	(6)

¹ Excludes office workers.

² Total number of injuries per million man-hours.

³ Total number of days lost or charged per million man-hours.

⁴ Includes cement plants and quarries or pits producing raw material used in manufacturing cement.

⁵ Excludes pits producing clay used in manufacturing cement.

⁶ Data not available.

⁷ Includes quarries producing limestone used in manufacturing lime.

⁸ Excludes quarries producing limestone used in manufacturing cement and lime.

⁹ Excludes friable sandstone, which is included under "sandstone."

¹⁰ Preliminary data.

Table 3. Employment and injuries for selected mineral industries ¹

Industry	New water	Water recirculated	Total water used	Water discharged	Water consumed
Copper	20,268	17,599	37,867	20,226	42
Iron ore	4,894	8,241	13,135	4,756	138
Sand and gravel	12,616	10,796	23,412	12,276	340
Stone	7,008	--	7,008	6,359	649
Other nonmetals	2,467	--	2,467	2,467	--
Total	47,253	36,636	83,889	46,084	1,169

Table 4. Water statistics for selected mineral industries in 1962 (Million gallons)

Year	Active plants	Production	Shipped from mills		Stocks at mills Dec. 31
			Quantity	Value	
1954-58 (average)	8	19,244	19,072	\$58,306	1,844
1959	8	21,561	21,862	72,198	2,912
1960	9	20,971	21,187	73,082	3,023
1961	9	21,661	21,948	75,172	2,737
1962	9	23,070	22,682	73,267	¹ 3,354
1963	9	24,194	25,016	76,944	2,532

¹ Revised figure

Table 5. Finished Portland cement produced, shipped, and in stock (Thousand 376-pound barrels and thousand dollars)

Class of operation and use	1962		1963	
	Quantity	Value	Quantity	Value
Commercial operations:				
Sand: ¹				
Molding	² 1,998	² \$3,456	2,178	\$3,896
Building	4,715	3,706	4,827	3,444
Paving	4,167	3,912	5,049	4,535
Fill	1,722	680	3,092	1,383
Undistributed ²	² 708	² 1,700	721	1,707
Total	13,310	⁴ 13,455	15,867	14,965
Gravel:				
Building	4,441	5,362	4,920	6,293
Paving	17,021	14,803	16,480	13,818
Railroad ballast	187	193	⁽⁵⁾	⁽⁵⁾
Fill	374	228	291	163
Other	² 214	258	438	423
Total	22,237	20,844	22,129	⁴ 20,696
Total sand and gravel	35,547	34,299	37,996	⁴ 35,662
Government-and-contractor operations:				
Sand:				
Paving	2,056	1,048	1,965	1,014
Fill	1,386	474	1,497	516
Other	86	35	143	71
Total	⁴ 3,529	⁴ 1,556	3,605	1,601
Gravel:				
Building	139	69	66	30
Paving	7,610	5,810	8,257	5,947
Fill	564	226	355	121
Other	175	68	179	72
Total	⁴ 8,487	6,173	8,857	6,170
Total sand and gravel	12,016	⁴ 7,730	12,468	7,771
All operations:				
Sand	16,839	⁴ 15,012	19,472	⁴ 16,567
Gravel	30,724	⁴ 27,018	30,986	⁴ 26,867
Grand total	47,563	⁴ 42,029	50,458	⁴ 43,433

¹ Includes friable sandstone.

² Revised figure.

³ Includes blast, glass, engine, foundry, grinding and polishing and other construction and industrial sands.

⁴ Data do not add to total shown because of rounding.

⁵ Figure withheld to avoid disclosing individual company confidential data; included with "Other"

747-535--64-----2

Table 6. Sand and gravel sold or used by producers, by classes of operations and uses (Thousand short tons and thousand dollars)

Year	Limestone		Sandstone		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1959	6,503	\$58,120	21,779	\$154,510	28,282	\$212,630
1960	6,801	58,889	11,615	97,395	18,416	156,284
1961	27,516	119,950	7,045	54,057	34,561	174,007
1962	7,798	51,603	15,223	65,406	23,021	117,009
1963	4,938	60,371	8,937	62,348	13,875	122,719

Table 7. Dimension stone sold or used by producers, by kinds

Kind and use	1962		1963	
	Quantity	Value	Quantity	Value
Basalt: Concrete aggregate and roadstone	73	\$73	15	\$15
Limestone:				
Flux	10,513	11,069	11,194	12,785
Concrete aggregate and roadstone	3,730	4,609	3,860	4,616
Agriculture	485	801	484	838
Cement	7,834	6,255	8,157	6,455
Lime	2,572	2,327	2,387	2,128
Other ¹	3,054	3,701	4,029	4,987
Total	² 28,187	² 28,763	² 30,110	31,809
Marl: Agriculture	146	88	169	109
Sandstone:				
Riprap	10	12	(3)	(4)
Concrete aggregate and roadstone	--	--	7	9
Other ⁵	1	1	(3)	(4)
Total	11	13	² 8	9
Grand total	28,417	² 28,938	30,302	31,942

¹ Includes limestone for whiting or whiting substitutes (1962), miscellaneous filler and stone sand (1963), riprap, railroad ballast, asphalt filler, dust for coal mines, mineral food, poultry grit, chemical and other uses.

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

³ Less than 500 short tons.

⁴ Less than \$500.

⁵ Includes sandstone for fill (1962), and foundry.

Table 8. Crushed and broken stone sold or used by producers, by kinds and uses (Thousand short tons and thousand dollars)

Month	Short tons	Month	Short tons
January	6,460	August	5,975
February	5,845	September	5,735
March	6,495	October	6,405
April	6,480	November	6,305
May	6,920	December	6,422
June	6,460	Total	75,262
July	5,760		

Table 9. Mine production of copper in 1963, by months, in terms of recoverable metal

Year	Mines producing		Material treated		Copper	
	Lode	Tailing	Ore (short tons)	Tailing (short tons)	Short tons	Value
1954-58 (average)	12	2	5,224,358	1,848,154	50,318	\$33,846,727
1959	10	3	5,666,533	1,940,455	55,300	33,954,200
1960	9	3	5,600,290	2,192,818	56,385	36,199,170
1961	10	3	7,109,924	2,122,286	70,245	42,147,000
1962	9	3	7,555,357	1,812,530	74,099	45,644,984
1963	10	3	7,211,387	2,226,129	75,262	43,361,392

Table 10. Mine production of copper, in terms of recoverable metal

County and range	Stocks of crude ore Jan. 1	Production		Shipments		Stocks of crude ore Dec. 31
		Underground	Open pit	Direct to consumers	To beneficiation plants	
County:						
Dickinson	--	--	2,536	--	2,536	--
Gogebic	548	902	--	813	--	637
Iron	931	2,814	--	3,067	--	678
Marquette	2,387	2,199	8,068	972	9,306	2,375
Total ²	3,865	5,914	10,604	4,852	11,842	3,689
Range:						
Gogebic	548	902	--	813	--	637
Marquette	2,387	2,199	8,068	972	9,306	2,375
Menominee	931	2,814	2,536	3,067	2,536	678
Total ²	3,865	5,914	10,604	4,852	11,842	3,689

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

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

Table 11. Crude iron ore¹ data, in 1963, by counties and ranges (Thousand long tons)

Year	Marquette range	Menominee range (Michigan part)	Gogebic range (Michigan part)	Total
1954-58 (average)	5,144	3,833	2,548	11,525
1959	3,530	2,469	1,249	7,247
1960	4,881	4,018	1,892	10,792
1961	4,141	3,881	1,362	9,384
1962	4,479	3,462	1,480	9,422
1963	5,809	4,168	813	10,789

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

Table 12. Usable iron ore shipped from mines, by ranges¹ (Thousand long tons)

Year	Marquette range	Menominee range (Michigan part)	Gogebic range (Michigan part)	Total
1954-58 (average)	5,324	3,804	2,499	11,627
1959	2,851	2,616	1,663	7,129
1960	6,619	4,079	2,169	12,866
1961	3,205	4,097	1,062	8,364
1962	4,563	3,460	1,237	9,259
1963	5,706	3,729	902	10,336
Total 1954-1963	322,909	² 265,963	² 247,484	836,355

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

² Distribution by range partly estimated before 1906.

Table 13. Usable iron ore produced, by ranges¹ (Thousand long tons)

Year	Long tons	Year	Long tons
1954-58 (average)	44,901	1961	15,253
1959	--	1962	--
1960	161,125	1963	136,569

Table 14. Manganiferous iron ore (containing 5 to 10 percent manganese, natural) and ferruginous manganese ore (containing 10 to 35 percent manganese, natural) shipped from mines

County	1962	1963	Minerals produced in 1963 in order of value
Alcona	\$155,617	\$158,935	Sand and gravel, stone.
Alger	66,532	54,253	Sand and gravel.
Allegan	1,518,243	² 1,860,432	Sand and gravel, petroleum, peat, stone, natural gas.
Alpena	⁽³⁾	⁽³⁾	Cement, stone, clays, sand and gravel.
Antrim	263,008	204,664	Clays, sand and gravel.
Arenac	1,340,990	1,315,214	Petroleum, stone, sand and gravel.
Baraga	373,653	242,320	Sand and gravel, stone.
Barry	411,811	406,172	Sand and gravel, petroleum, stone, peat.
Bay	⁽³⁾	7,585,143	Cement, petroleum, lime, sand and gravel.
Benzie	32,418	139,901	Sand and gravel.
Berrien	1,044,180	567,968	Sand and gravel, stone.
Branch	184,461	94,622	Do.
Calhoun	10,017,935	² 8,081,390	Petroleum, sand and gravel, stone, natural gas.
Cass	419,957	370,244	Sand and gravel, petroleum, stone.
Charlevoix	47,568	23,469	Sand and gravel.
Cheboygan	219,351	246,165	Sand and gravel, stone.
Chippewa	4,642,069	4,236,858	Stone, lime, sand and gravel.
Clare	1,409,580	² 1,579,679	Petroleum, sand and gravel, natural gas.
Clinton	452,518	269,239	Sand and gravel, clays, peat.
Crawford	417,820	² 417,593	Petroleum, sand and gravel, natural gas.
Delta	287,604	195,834	Sand and gravel, stone.
Dickinson	4,189,933	12,252,971	Iron ore, sand and gravel, stone.
Eaton	490,978	548,814	Sand and gravel, stone, clays, peat.
Emmet	9,990,220	9,810,176	Cement, stone, sand and gravel.
Genesee	634,346	746,675	Sand and gravel, petroleum.
Gladwin	1,245,354	1,248,025	Petroleum, sand and gravel.
Gogebic	12,199,452	6,696,225	Iron ore, sand and gravel.
Grand Traverse	⁽³⁾	84,226	Sand and gravel.
Gratiot	⁽³⁾	⁽³⁾	Salines, salt, petroleum, sand and gravel, natural gas.
Hillsdale	11,576,534	² 12,773,619	Petroleum, sand and gravel, stone, natural gas.
Houghton ⁴	46,494,436	47,586,022	Copper, sand and gravel, stone.
Huron	995,810	1,046,163	Stone, sand and gravel, lime, petroleum.
Ingham	995,837	1,005,097	Sand and gravel, peat.
Ionia	530,058	217,362	Sand and gravel, petroleum.
Iosco	⁽³⁾	4,349,206	Gypsum, sand and gravel.
Iron	⁽³⁾	24,451,943	Iron ore, manganiferous ore, sand and gravel.
Isabella	1,914,020	² 1,467,209	Petroleum, sand and gravel, stone, natural gas.
Jackson	7,976,510	² 6,999,256	Do.
Kalamazoo	1,187,671	1,184,488	Sand and gravel, stone, peat.
Kalkaska	263,448	² 68,245	Petroleum, sand and gravel, natural gas.
Kent	2,802,534	² 3,945,931	Sand and gravel, gypsum, petroleum, peat, natural gas.
Keweenaw	⁽⁵⁾	⁽⁵⁾	Copper, sand and gravel.
Lake	⁽³⁾	56,098	Sand and gravel, petroleum.
Lapeer	1,239,625	1,287,262	Peat, sand and gravel, salines, petroleum.
Leelanau	66,978	100,828	Sand and gravel.
Lenawee	1,915,866	1,154,032	Cement, sand and gravel, clays, petroleum, peat.
Livingston	3,674,134	² 2,901,954	Sand and gravel, natural gas.
Luce	14,420	50,220	Sand and gravel.

Mackinac	(3)	(3)	Sand and gravel.
Macomb	935,991	² 2,657,366	Sand and gravel, petroleum, natural gas.
Manistee	13,760,826	16,507,558	Salines, salt, sand and gravel.
Marquette	(3)	(3)	Iron ore, sand and gravel.
Mason	(3)	(3)	Salines, lime, petroleum, sand and gravel, natural gas.
Mecosta	209,192	² 190,627	Sand and gravel, petroleum, stone, natural gas.
Menominee	824,964	673,832	Lime, sand and gravel.
Midland	(3)	(3)	Salines, salt, petroleum, sand and gravel, natural gas.
Missaukee	1,883,808	² 1,466,781	Petroleum, sand and gravel, natural gas.
Monroe	(3)	(3)	Cement, stone, clays, petroleum, peat.
Montcalm	1,481,155	² 1,119,196	Petroleum, sand and gravel, peat, natural gas.
Montmorency	(3)	97,888	Sand and gravel, petroleum.
Muskegon	1,785,779	² 2,077,078	Sand and gravel, salt, petroleum, natural gas.
Newaygo	225,151	² 227,599	Sand and gravel, petroleum, stone, natural gas.
Oakland	6,181,348	² 6,839,509	Sand and gravel, peat, petroleum, natural gas.
Oceana	898,659	² 1,236,000	Petroleum, sand and gravel, natural gas.
Ogemaw	1,190,998	² 1,091,672	Do.
Ontonagon	(5)	(5)	Copper, silver, sand and gravel.
Osceola	1,257,386	² 985,614	Petroleum, sand and gravel, stone, natural gas.
Oscoda	25,789	53,148	Sand and gravel, petroleum.
Otsego	39,982	² 29,714	Sand and gravel, natural gas.
Ottawa	2,141,762	² 256,226	Sand and gravel, petroleum, stone, natural gas.
Presque Isle	(3)	(3)	Stone, sand and gravel.
Roscommon	761,597	² 667,528	Petroleum, sand and gravel, natural gas.
Saginaw	387,524	452,054	Clays, petroleum, lime, sand and gravel.
St. Clair	16,330,653	² 16,486,562	Salt, petroleum, cement, peat, sand and gravel, clays, natural gas.
St. Joseph	215,158	(3)	Sand and gravel, stone, peat.
Sanilac	1,105,411	966,130	Peat, sand and gravel, lime.
Schoolcraft	146,622	95,981	Sand and gravel.
Shiawassee	302,044	369,228	Sand and gravel, clays.
Tuscola	1,895,629	2,003,801	Sand and gravel, petroleum, lime.
Van Buren	371,753	355,564	Sand and gravel, petroleum.
Washtenaw	1,267,648	² 1,332,645	Sand and gravel, petroleum, natural gas.
Wayne	39,834,025	² 41,805,111	Lime, cement, salt, sand and gravel, clays, stone, petroleum,
Wexford	79,948	59,275	Sand and gravel.
Undistributed ⁶	⁷ 217,266,613	219,535,171	
Total	⁷ 446,512,000	492,032,000	

¹ Natural gas liquids not listed by counties as data are not available; included with "Undistributed."

² Excludes value of natural gas.

³ Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."

⁴ Includes value of mineral production in Keweenaw and Ontonagon Counties.

⁵ Value of mineral production is included in that of Houghton County.

⁶ Includes some petroleum (1963) and some sand and gravel not assigned to specific counties, and values indicated by footnotes 1, 2, and 3.

⁷ Revised figure.

Table 15. Value of mineral production in Michigan, by counties¹