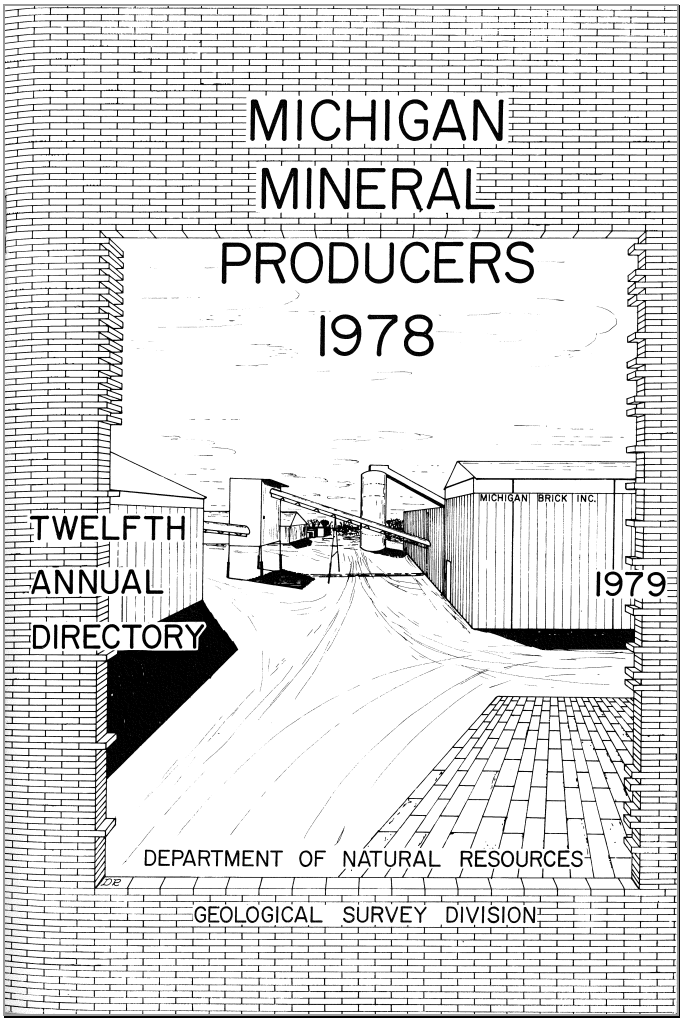


TABLE OF CONTENTS

Cover Illustrations 2
Preface 2
Introduction 3
Brick - A modern Building Product 3
Health and Safety for Mine, Mill and Associated Workers 4
Mineral Production Statistics 5
Background 5
Current Production Data 6
Metallic Minerals 6
Copper 6
Iron Ore 7
Nonmetallic Minerals 8
Cement 9
Clay and Shale 9
Gypsum 10
Lime 10
Marl 11
Natural Brines 11
Peat 12
Salt Deposits 13
Sand and Gravel 14
Construction Sand and Gravel 14
State Owned Pits 15
Industrial Sand 15
Stone 15
Limestone and Dolomite 16
Miscellaneous Stone 16
Sandstone 16
Sulfur 17
Some Suggested Readings 17
Readings Related To Brick 18
Permit Information 18
Geological Survey Division Organization Directory 19

ILLUSTRATIONS

Figures

Figure 1 - Michigan Mineral Operations - 1978 3
Figure 2 - Value of Minerals Mined in Michigan 1910-1977 8
Figure 3 - Mineral Value Distribution by County - 1977 8
Figure 4 - Production and Value of Michigan Copper 1845-1977 8
Figure 5 - Michigan Copper Resources 9
Figure 6 - Michigan Iron Resources 9
Figure 7 - Shipments and Value of Michigan Iron Ore 9
Figure 8 - Michigan Cement Plants - 1978 9
Figure 9 - Michigan Clay and Shale Resources and Mines-1978 10
Figure 10 - Michigan Gypsum Mines - 1978 10
Figure 11 - Production and Value of Michigan Gypsum 1868-1977 10
Figure 12 - Michigan Lime Plants and Marl Pits - 1978 11
Figure 13 - Natural Brine Producers - 1978 12
Figure 14 - Production and Value of Michigan Peat 1938-1977 13
Figure 15 - Michigan Organic Soil Resources and Operations - 1978 13
Figure 16 - Bedded Salt Deposits - 1978 14
Figure 17 - Michigan Industrial Sand Operations - 1978 15
Figure 18 - Michigan Limestone and Dolomite Resources and Quarries - 1978 16
Figure 19 - Michigan Miscellaneous Stone and Sandstone Operations - 1978 16
Figure 20 - Generalized Geologic Map of Michigan 17

Tables

Table 1 - Number of Producers and Operations by Commodity - 1978 6

Table 2 - Mineral Production in Michigan-1977 7

Table 3 - County Mineral Value and Rank-1977.....7

Table 4 - Stratigraphic Succession in Michigan.....19

COVER ILLUSTRATIONS

Mr. Donald E. Raymond of the Geological Survey Division Staff created the covers of this directory. This year the Michigan Brick, Inc., plant at Corunna is featured. The front cover shows part of the brick making plant site. The back cover depicts one of the bricks produced in the plant.

A short description of the brick manufacturing process is included in this booklet. The section covering clay and shale also lists the other producers of this commodity. A map showing the extent of the State's clay and shale resources follows the list of producers.

MICHIGAN MINERAL PRODUCERS 1978

GEOLOGICAL SURVEY DIVISION

ANNUAL DIRECTORY 12

By

Milton A. Gere, Jr.

STATE OF MICHIGAN
William G. Milliken, *Governor*

DEPARTMENT OF NATURAL RESOURCES
Howard A. Tanner, *Director*

GEOLOGICAL SURVEY DIVISION
Arthur E. Slaughter, *Chief*
and *State Geologist*

NATURAL RESOURCES COMMISSION
Hilary F. Snell, *Chairman*, Grand Rapids, 1971
E. M. Laitala, Hancock, 1961
(Mrs.) Joan L. Wolfe, Belmont, 1973
Harry H. Whiteley, Rogers City, 1961
Carl T. Johnson, Cadillac, 1963
Charles G. Younglove, Allen Park, 1972
Dr. Jacob Hoefer, East Lansing, 1979
John M. Robertson, *Executive Assistant*

. . . 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 . . . mining and smelting industries.*

Published by authority of State of Michigan CL '70 s 319 202
Printed by Reproduction Services Section, Office Services Division, Department of Management and Budget

Available from the Information Services Center, Michigan Department of Natural Resources, Box 30028, Lansing, Michigan 48909

On deposit in public libraries, state libraries, and university Libraries in Michigan and other selected localities.

ISSN: 0085-3372

PREFACE

This edition, "Michigan Mineral Producers, 1978", is the twelfth annual directory of Michigan's Metallic and Nonmetallic mineral commodity producers. Included are the names and addresses of the producers, the locations of their operations as of the end of 1978, mineral commodity production and values for 1977, state owned gravel pit locations, and miscellaneous information. Listings are on a commodity basis by operator as well as cross referenced by county. Numerous location maps and historical production and value charts accompany the various commodity material.

Much of the material in this directory is based upon the 1977 annual canvass of the mineral producers by the U.S. Bureau of Mines (U.S.B.M.). Name and location updates were obtained from the U.S. Mine Safety and Health Administration (MSHA), either directly or via the U.S.B.M. Some information on new operations and locations was supplied by the Michigan Department of Transportation (MDOT).

The writer wishes to thank the many mineral producers for their cooperation in submitting the U.S. Bureau of Mines canvass forms and answering inquiries for information pertaining to their operations. Thanks are given to the U.S.B.M. for canvassing the mineral producers and providing the data collected. Special thanks are once again given to the U.S.B.M. State Liaison Office - Michigan, which was closed because of a program change at the end of September, 1979. The Liaison Office, through the former Michigan Liaison Officer, Mr. Edward C. Peterson, and the former Liaison Program Assistant, Ms. Esther A. Middlewood, provided much extra help in the early stages of completing this directory.

The Lansing and Marquette offices of the U.S. Mine Safety and Health Administration are to be thanked for updates on producer names and locations. The Michigan Department of Transportation's Testing and Research Division is to be thanked for additional update information too. The various updates supplied by these agencies help to keep the directory more accurate.

The writer is also indebted to the following persons from the Geological Survey Division and wishes to express his thanks: 1) Authors of previous editions for ideas and formats passed on; 2) Mr. Donald E. Raymond for designing the covers and updating the various maps and

charts; 3) Mr. Harry O. Sorensen, Unit Supervisor and Mr. William A. Walden, Sub-unit Supervisor, both of the Mining and Economic Geology Unit for their helpful suggestions; 4) Mrs. Lois A. Padgett, of the Mining and Economic Geology Unit, for typing the manuscript; and, 5) Various other personnel for their suggestions.

It is hoped that this edition will be useful to those persons interested in Michigan's vast resources of Minerals. Suggestions for additions, deletions, changes, or other improvements for future editions will be gratefully received.

Lansing, Michigan
December, 1979

Milton A. Gere, Jr., Geologist
Mining and Economic Geology Unit
Geological Survey Division

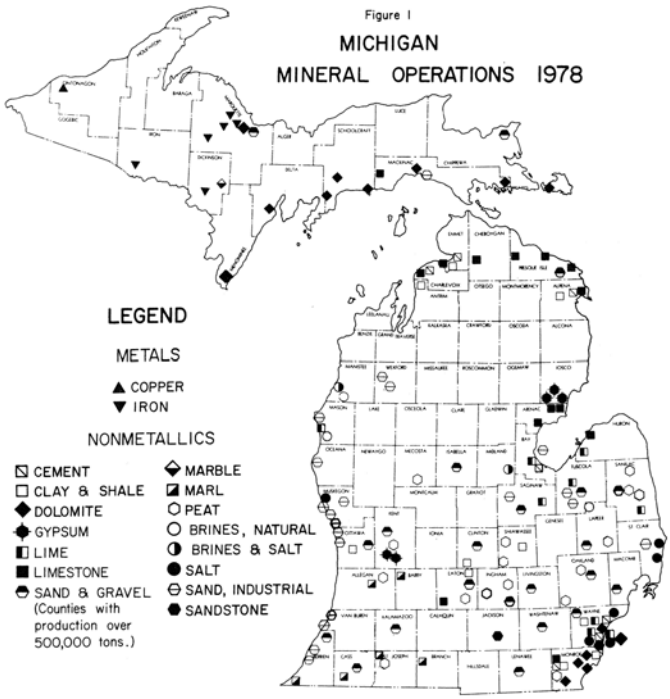


Figure 1 - Michigan Mineral Operations - 1978

INTRODUCTION

The diversity of Michigan's mineral commodity production includes 16 categories of metallic and nonmetallic minerals in addition to petroleum and natural gas. Nearly all 83 counties had some nonmetallic mineral production, and four counties produced metallic minerals in 1978. During the year there were 523 producers with over 771 metallic and non-metallic mineral operations around the State.

Employment in Michigan's mining industry exceeded 12,200 people in 1977, according to statistics from the Michigan Employment Security Commission. This employment figure does not include the large number of owner-operators involved in the mineral industry, nor does it include some processing phases, nor those people involved with the production of petroleum and natural gas. All of these people combined, produced slightly over 11/2 billion dollars worth of materials in Michigan during 1977. The Office of Economic Development of the Michigan Department of Commerce rated Michigan's 1977 Gross State Product at $84.68 billion. They estimated the amount attributed to mining to be $0.72 billion, as compared to that for manufacturing being $34.98 billion.

Michigan's mineral commodity production value during 1977 consisted of $418,666,958 worth of metallic minerals, $612,434,743 worth of nonmetallic minerals, and fuels valued at $506,964,719, totaling $1,538,066,420. The above categories represent 27.2%, 39.8%, and 32.9% of the total value, respectively.

The State's many Great Lakes ports play an important role in the interstate and international trade of mineral products. Some mineral commodities produced in Michigan are shipped out before being processed and some produced elsewhere are shipped in for processing, thus even more diversity is added to the State's total involvement with minerals. The U.S.B.M. has estimated in the past that the processing of raw minerals in Michigan results in products valued at about ten times the value of the State's extracted minerals themselves.

An additional demand for some of Michigan's minerals is created by rock and mineral collectors. Some of these minerals may not be the same as those sought after by industry, and their dollar value may be low, but a growing number of people are interested in their natural beauty and strive to collect them.

Anyone interested in Michigan's mineral commodities and various aspects of the geology of the State are invited to contact the Geological Survey Division offices. Many files of maps, well logs, and other materials of public record are available for office use. A list of the Units within the Division, and the Region and Field offices is located inside the back cover of this directory.

BRICK - A MODERN BUILDING PRODUCT

This edition of the Directory is featuring brick, a product made from one of Michigan's most widespread mineral commodities, clay and shale. Michigan Brick, Inc., is Michigan's only brick producer. Views of the plant and its product are featured on the covers of this booklet.

Apparently there were about 200 brick, tile and pottery plants in Michigan around the turn-of-the-century. In 1911 there were still 138 plants, and by 1949 the number was down to 15 plants. Now there is only one brick plant, one tile plant, and one flower pot plant left in the State. Also, five operations produce clay or shale for use in cement manufacturing.

Michigan Brick, Inc., is located at Corunna, in Shiawassee County. This company is the outgrowth of a brick plant started at Corunna in 1907. Somewhere over the years the production switched to tile and then back to bricks. Besides the Corunna, Michigan plant, Michigan Brick, Inc., has plants at Mansfield, Ohio;

Sanford, Kentucky; Mineral Wells, and San Antonio, Texas. The parent company is Canada Brick, Ltd., of Toronto, Ontario, Canada.

The brick plant at Corunna underwent major changes and additions in the past three years and now has a production capacity of about 100 million bricks a year. Pennsylvanian age shale, with some sandstone, is mined from a quarry on the plant property and is trucked to the crusher. A new, automated, grinding plant crushes the rock, and stockpiles the ground material inside a large building. When raw material is needed, a scraper and conveyor system automatically moves the needed material into the two manufacturing buildings.

One of the two manufacturing buildings was built in the last ten or so years and had the latest equipment in it. The second manufacturing building was added three years ago and is even more modern and uses only about one-half of the fuel, per brick, as the older one. The newest plant is fully automated and requires no hand labor. The raw material enters the building on a conveyer belt where it is dumped into a mixing machine. Water and various additives are mixed with the clay to form a fairly stiff, dough-like material. This material is then extruded onto a conveyer belt in the general length and width shape of the final brick, but in an 8 or 10 foot long "blank". The blank moves along to another machine which, like a giant cheese slicer, cuts the "blank" into many bricks of equal thickness. Another machine stacks the green (raw clay) bricks in alternating layers on a specially shaped car. When the car is full it is moved to one of two holding rooms. The holding rooms help keep the green brick from drying too fast on the surface or undergoing temperature shock while waiting to enter one of the two dryers and kilns.

When the bricks enter the dryer they start on a nearly two day continuous trip through a tunnel of increasing temperature which dries the green brick completely. The brick car moves along and enters the natural gas fired kiln for another 40 plus hours. Here the bricks are raised in temperature until they reach 1950 degrees fahrenheit. They are then slowly cooled until they are nearly room temperature as they leave the kiln tunnel. Each new kiln fires about 100,000 bricks a day, 365 days a year. The finished bricks are then moved to another area where machines stack the brick into 300 to 500 brick "cubes", strap them, and place them in a line for shipping.

The Corunna plant produces three sizes of building brick as well as their new, popular thin brick. The regular brick is made in 8 inch long face brick for building houses, etc., as well as the 10 inch king size and 12 inch utility size, both used for large buildings. The thin brick is only one-half inch thick, but when applied to a wall it looks like regular brick. This is popular for both inside and outside applications.

Brick from the Corunna plant is marketed in Michigan as well as parts of Ohio, Indiana, Illinois, and Southern Ontario. The distance to market is the controlling factor which keeps brick in a somewhat limited sales area.

Bricks, like many other nonmetallic mineral commodities and products, are heavy and there comes a point at which shipping can cost as much as the product itself.

Instead of being considered the last of a formerly widespread industry, the modern brick plant at Corunna should be called the first in what could be a renewed industry in Michigan. The State's widespread resources of clay and shale may deserve more interest from industry in the future. A map showing the areas of clay and shale is included under the clay and shale commodity heading in this directory.

The writer is indebted to Mr. Ed Joy, Plant Manager of Michigan Brick, Inc., for guiding several of the Survey's staff through the modern brick operation and explaining the sequence of processes to us. His assistance in providing photographs and literature and reviewing this material is also appreciated.

* *

Some miscellaneous facts about bricks from the Masonry Institute of Michigan.

Bricks have been used for about 10,000 years.

The Roman Coliseum was built of bricks in 70 A.D. and stood 158 feet high.

The first bricks to be brought to the U.S. came from Europe as ship ballast.

The first bricks made in the U.S. were manufactured at Jamestown, Virginia in 1612.

It is estimated that between 250 and 300 million bricks are used in Michigan each year.

The first U.S. patent on a brickmaking machine was issued in 1800. The first machines could make about 25,000 bricks per day. Now, some machines can make up to 300,000 per day.

Energy usage - it takes 1/12 pound of coal to produce 1 pound of brick, a finished product, while it takes 1 pound of coal to produce one pound of steel ingot, an unfinished product.

A brick wall, with insulation, is supposed to be the most heat efficient wall due to the mass factor. When combined with a glass outer wall, the brick-glass wall becomes an important part of a passive solar heating system.

HEALTH AND SAFETY FOR MINE, MILL AND ASSOCIATED WORKERS

A new feature in this edition is the inclusion of a designation of which agency, Federal or State, that has health and safety inspection responsibility over the various mining operations. The designation, F for Federal and S for State, is placed near the beginning of the company listings where they are all inspected by the same agency. Where companies are inspected by more than one agency, the designation is placed next to the

company name. Some companies have functions which come under partial jurisdiction of both agencies, thus both designations are used.

These designations were placed in this edition of the directory at the request of the State and Federal agencies in charge of the inspections. While the Geological Survey Division of the Michigan Department of Natural Resources is not connected in any manner with these inspection agencies, it is hoped that this Directory will be a convenient manner for the Michigan Mineral Producers to recall which agency has inspection responsibility.

A local agreement for the State of Michigan for mine related health and safety inspections was approved by representatives of the North Central District Manager, Mine Safety and Health Administration (MSHA), the U.S. Department of Labor and Michigan Occupational Safety and Health Administration (MIOSHA), Michigan Department of Labor. In general, MSHA is to be considered as having inspection responsibility over all mining related worker health and safety, unless otherwise designated as being under MIOSHA.

MSHA inspection is handled by two offices in Michigan. The Lansing office takes care of most of the Lower Peninsula, while the Marquette office handles the Upper Peninsula and eight of the most northern counties of the Lower Peninsula. See the accompanying map.

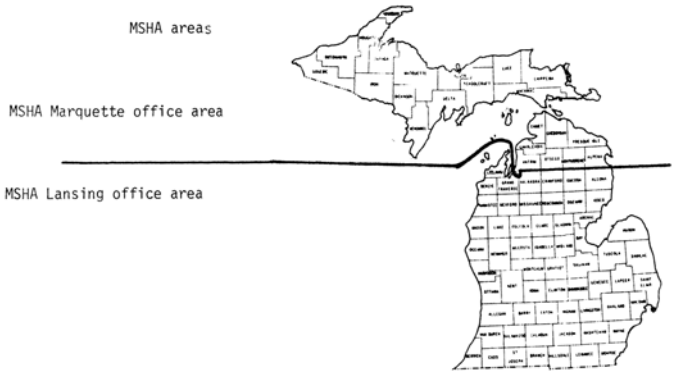
MIOSHA has its main office in Lansing which is in charge of all of their statewide programs.

If in doubt as to which agency has jurisdiction, one of the following officials should be contacted for clarification.

MSHA-Thomas E. Anderson, Supervisory Metal and Nonmetal Mine Inspector, MSHA/U.S. Department of Labor, 300 E. Michigan Ave., Room 305, Lansing, Michigan 48933 - Telephone 517/372-1910, extension 692 (Starting March 1, 1980, - 517/377-1751).

MSHA-William Carlson, Supervisory Mining Engineer, MSHA/U.S. Department of Labor, 309 S. Front Street, Marquette, Michigan 49855 - Telephone 906/228-6805.

MIOSHA-William H. Sebring, Deputy Director, MIOSHA Enforcement Administration, Michigan Department of Labor, Bureau of Safety and Regulation, State Secondary Complex, 7150 Harris Drive, Box 30015, Lansing, Michigan 48909 - Telephone 517/332-1816.



MINERAL PRODUCTION STATISTICS

Background

Michigan mineral production statistics have been officially kept for 101 years. Act 9 of Public Acts of 1877, as amended, was entitled "An act to authorize the appointment of a commissioner of mineral statistics..." Among the duties listed is the following, known as Sec. 5, "Said commissioner is hereby authorized to demand, and it shall be the duty of all corporations or individuals engaged in mining to make such reports under oath, as to product and other matters as shall be required by him on blanks to be furnished by said commissioner for that purpose".

The Commissioner of Mineral Statistics office was abolished and the duties transferred to the Board of Geological Survey by Act 7 of P.A. 1911, as amended. Then Act 17 of P.A. 1921, as amended, transferred the duties of the Board of Geological Survey to the Department of Conservation wherein the Geological Survey Division was formed. Act 380 of P.A. 1965, as amended, known as the Executive Organization Act, changed the name of the Department of Conservation to the Department of Natural Resources (DNR). Thus, the original "commissioner" duties now lie within the DNR.

For the last number of years the Geological Survey Division, DNR, has had a memorandum of understanding with the U.S. Bureau of Mines in which the U.S.B.M. gives the Geological Survey Division copies of the mineral production data which it gathers during its annual canvass of the mineral industry. It is now from this canvass that the state receives most of its mineral production and value data. Copper and iron ore data is collected separately by the Geological Survey Division for tax purposes. Petroleum and natural gas figures are reported directly, and indirectly, to the Geological Survey Division's Production Proration Unit for proration and statistical purposes.

The publication of Michigan mineral statistics is done in several ways. A very brief summary sheet of production and value data is printed in the Annual Directory, such as this publication, but the data is for the year previous to the Directory listing. Also in the directory are a number of historical production and value charts for various commodities and all commodities combined.

A detailed booklet containing yearly mineral statistical data, mineral commodity and industry information is entitled "The Mineral Industry of Michigan". This is a preprint from the annual "U.S. Bureau of Mines Minerals Yearbook". Under a memorandum of understanding between the Geological Survey Division and the U.S. Bureau of Mines, the Geological Survey Division attaches a cover and preface to this "U.S.B.M. Minerals Yearbook" chapter and offers it as the Geological Survey Division's "Annual Statistical Summary" for the minerals industry.

Yearly statistics for Michigan's petroleum and natural gas exploration and production are published as another Geological Survey Division Annual Statistical Summary entitled "Michigan's Oil and Gas Fields". This booklet is compiled by the Petroleum Geology Unit of the Geological Survey Division and is available for $2.00 per copy.

An additional U.S.B.M. publication which also includes some statistical data is "Minerals in the Economy of Michigan". This annual booklet was first published in 1978.

A yearly release of statistical data for iron is produced by the Geological Survey Division as a three page specialty. The title is "General Statistics Covering Production of Michigan Iron Mines". Historical production of iron through 1974 is reported in the Geological Survey Division's Circular 12, "One Thousand Million Tons", by R. C. Reed, 1975, which is sold for 50 cents per copy.

Geological Survey Division publications are available from the following address: Michigan DNR, Information Services Center, Box 30028, Lansing, MI 48909. The Center is located on the 7th floor of the Stevens T. Mason Building and is open for over-the counter sales. Sales within Michigan are subject to 4% sales tax. Payment must accompany all mail orders and should be payable to the "State of Michigan".

Information about U.S. Bureau of Mines publications is available from the U.S. Bureau of Mines, Branch of Publications Distribution, 4800 Forbes Avenue, Pittsburg, PA 15213.

Current Production Data

As of the end of 1978 there were 523 metallic and nonmetallic mineral commodity producers with at least 771 operations in Michigan. We assume more than the 771 operations existed because numerous sand and gravel operators use portable equipment and operate out of several locations in a year's time. Not all of these locations get reported to us. Table 1 lists the number of producers and operations by commodity.

Table 1 - Number of Producers and Operations by Commodity - 1978

TABLE 1 NUMBER OF PRODUCERS AND OPERATIONS BY COMMODITY - 1978

Commodity Produced	Number of Producers	Number of Operations or Pits
Copper	1	1
Iron	3 (1-closed 7/78)	6 (1-closed 7/78)
Clay and Shale	8	9
Gypsum	5	9 (quarries + separate mills)
Marl	6	7
Natural Brines	4	5
Peat	14	17
Salt	8	9
Sand and Gravel		
Construction	414	622+
Industrial	15	27
Stone		
Limestone and Dolomite	25	35
Miscellaneous Stone	1	1
Sandstone	3	4
Cement	8	8
Lime	6	9
Sulfur	2 (refineries)	2
Total	523	771+

The 1977 Production and Value is shown by Table 2. Our figures and those of the U.S. Bureau of Mines may not be the same due to using different categories and criteria.

Historical mineral value information for the years 1910 to 1977 is illustrated by Figure 2. Fuels, Metallic Minerals, Nonmetallic Minerals, and Total values are shown. The 1977 mineral commodity value and rank for each county is included in Table 3. Since the county ranking is based upon dollar values, those counties producing crude oil and natural gas may not have their true production values shown.

The county values for crude oil and natural gas are based upon average values per barrel and thousand cubic feet (M.C.F.), respectively, multiplied by the production figures published in "Michigan's Oil and Gas Fields, 1977". The oil values shown may differ from actual values because crude oil prices depend upon whether the well is classified as "old oil", "new oil", "stripper oil", and "sweet" or "sour" oil. The gas values may differ because the price paid for gas at the wellhead depends upon individual contract agreements and the B.T.U. content of the gas. Thus, counties with large quantities of oil and gas production may in reality have a higher or lower mineral production value and ranking than shown here.

The map in Figure 3 shows 1977 county mineral production value as to category of Fuels, Metallic Minerals, and Nonmetallic Minerals. As mentioned in the Introduction, the 1977 value of Fuels was $506,964,719, Metallic Minerals $418,666,958, Nonmetallic Minerals $612,434,743, and the total value was $1,538,066,420.

METALLIC MINERALS

Michigan's 1978 metallic mineral mining operations produced iron ore and copper with some silver as a byproduct. The seven metallic mineral mines are located in four counties in the western half of the Upper Peninsula of the State. During 1977, over $418.7 million worth of metallic minerals were produced.

The variety of metallic minerals mined in the State was greater in the past, and may expand in the future. Before 1900 there were several gold mines and at least one short-lived manganese mine. As mineral exploration activity continues, it is possible that more deposits of metallic minerals will be found within the State.

COPPER

The White Pine mine, operated by the White Pine Division of the Copper Range Company, was the sole producer of Copper in Michigan again in 1978. Low copper prices for the past several years have forced the company to reduce production and operate with a smaller staff than normal. In 1977 they produced nearly

86 million pounds of copper along with almost 447 thousand ounces of associated silver.

Table 2 - Mineral Production in Michigan-1977

TABLE 2 MICHIGAN DEPARTMENT OF NATURAL RESOURCES

GEOLOGICAL SURVEY DIVISION

Based Upon U.S.B.M. & Company Data

MINERAL COMMODITY	UNIT	-1977- QUANTITY	-1977- $/VALUE	PERCENT CHANGE from 1976 in QUANTITY/VALUE	U.S.B.M. RANK IN VALUE FOR U.S. (PRELIM)
Iron Ore	Long Tons(2240#)	12,015,708	357,565,245	-23.41 -16.15	2
Cement	Short Tons(2000#)	5,815,974	176,701,142	+ 9.09 +10.73	P. 4 M. 7
Petroleum(5)	Barrels(42 gal.)	32,964,503	360,994,743	+ 8.36 + 9.513	10
Sand & Gravel	Short Tons	46,989,467	97,947,811	- 0.70 +23.80	4
Natural Brines(1)	Short Tons	1,267,042	138,711,535	+ 6.21 +11.75	*
Copper	Pounds	85,960,551	59,115,071	- 1.12 - 0.65	6
Salt	Short Tons	3,946,957	78,864,146	- 5.79 - 1.06	3
Lime	Short Tons	1,347,190	42,015,241	- 7.47 + 5.87	5
Stone(2)	Short Tons	40,499,740	84,989,842	- 2.22 + 3.42	8
Natural Gas	Th. Cubic Ft.(M.C.F.)	133,215,209	145,969,976	+10.79 +21.386	N.A.
Gypsum (crude)	Short Tons	1,924,030	10,769,174	+ 4.74 + 4.10	1
Clay & Shale(3)	Short Tons	2,007,391	5,125,835	+ 3.78 + 8.11	Com. 6 All 11
Nat. Gas Liquids(5)	Gallons	(in with oil & gas)			
Peat	Short Tons	290,855	4,753,529	- 3.08 +27.99	1
Marl	Short Tons	28,778	63,213	-47.22 -42.45	In Stone
Miscellaneous(4)	--------		2,842,945	--- +26.92	
SUB TOTAL			$1,566,429,448		
Minus (stone used in manufacturing of lime and cement in Michigan and processed sand-stone included in sand and gravel figures)			-28,363,028		
TOTAL value of Michigan production 1977			$1,538,066,420		

(1) Bromine, Magnesium compounds, Calcium-Magnesium chloride, and Iodine.
*U.S. Rank 1977 as above 2,1,1,2.
(2) Does include 17,404,055 short tons of limestone and dolomite used in the manufacture of cement and lime. See other notes.
(3) Tile, brick, pottery, clay used for cement, lightweight aggregate, and miscellaneous.
(4) Sulfur, natural mineral pigments, silver.
(5) Natural Gas Liquids was figured into Oil and Natural Gas production and values by the Production Proration Unit. They no longer differentiate the three.

The U.S. Bureau of Mines ranked Michigan in 11th place for mineral production value in 1977.

	$ Value		% of Total
Metallic Minerals	418.666.958		27.22
Nonmetallic minerals(raw)	640,797,771(minus process material)	612,434,743	39.82
Fuels	506,964,719		32.96

N.A.- Not Available, P.- Portland Cement, M.-Masonry Cement, Com.-Common Clay and Shale

The low grade copper ore produced at White Pine is mostly chalcocite (copper sulfide) with some native copper and a little native silver. These metallic minerals are deposited in a combination of shale, siltstone, and sandstone. The rock formation is named the Nonesuch Shale and is of Upper Keweenawan (Precambrian) age.

Copper was first mined in Michigan by prehistoric Indians. Some of their early diggings are reportedly still visible in parts of the "Copper Country" today. While their mining methods were crude by present standards, they mined enough native copper to supply their needs. Indian artifacts made of copper from the Upper Peninsula have been found in many states, and are believed to have been widely traded.

Modern day copper mining began in 1845. Many of the "new" mines were actually found by people who located some of the old Indian dug pits and started to mine next to them. A large number of mines were started, about one hundred and ten between 1845 and 1925, but few of them were financial successes. Elusive, discontinuous ore bodies along with fluctuating market prices for copper, and many inexperienced early miners all contributed to the high number of mining failures. However, the state did lead the nation in copper production for many years.

Table 3 - County Mineral Value and Rank-1977

Table 3

W= WITHHELD
*NOTE= DATA WILL NOT ADD UP TO TOTAL SHOWN DUE TO INDEPENDENT ROUNDING

COUNTY MINERAL VALUATION AND RANK ---- 1977

COUNTY	METALLIC: Silver	Iron Ore	Copper	Sulfur	INDUSTRIAL MINERALS: Stone	Total Sand and Gravel	Industrial Sand	Salt	Peat	Natural Saltnes	Marl	Lime	Gypsum	Clay and Shale	Cement	FUELS: Oil	Gas	Natural Gasoline	County Value Rank	MINERAL PRODUCTION VALUE ($) (In thousands)
ALCONA						74													82	66
ALGER						76													83	44
ALLEGAN						27	13		11		1					26	26		52	7,455
ALPENA					3	64								1	1				6	79,411
ANTRIM						59								4		18	14		34	5,397
ARENAC					11	65										20			44	3,229
BARAGA						49													71	221
BARRY						28					4					41			62	999
BAY												6			6	22			23	13,789
BENZIE						75										33	24		69	385
BERRIEN						2	1												31	7,050
BRANCH						84					3								68	419
CALHOUN						26										6	5		17	24,915
CASS						25					2					36			59	3,168
CHARLEVOIX					9	48									3				16	29,318
CHEBOYGAN					14	69													75	206
CHIPPEWA					5	24													32	7,009
CLARE						42										15	22		41	4,002
CLINTON						14								7					56	1,905
CRAWFORD						70										7	15		22	14,241
DELTA						34													66	597
DICKINSON		2			16	38													8	63,639
EATON					12	29			10					8		13	9		25	9,427
EMMET					7	47								5	5				19	16,865
GENESEE						43										35			65	870
GLADWIN						78										19			46	2,988
GOGEBIC						53													73	242
GRD. TRAVERSE						33										3	1		1	97,816
GRATIOT				W		33		4		4						40	28		26	19,243
HILLSDALE						30										8	7		20	16,832
HOUGHTON					17	46													70	298
HURON					10	60						3							55	1,957
INGHAM						19			8							5	6		15	29,222
IONIA						57													26	200
IOSCO						72							2						27	9,794
IRON		3				41													35	5,358
ISABELLA						22										24			50	2,494
JACKSON					15	35										16	10		33	6,802
KALAMAZOO						13													53	2,006
KALKASKA						79										4	2		10	59,101
KENT						5			5				1			30	29		21	15,858
KEWEENAW						23													81	41
LAKE						58										27			61	1,087
LAPEER						20			2	5						25	25		40	4,063
LEELANAU						55													74	218
LENAWEE						21													60	1,148
LIVINGSTON						50										50	16		38	4,310
LUCE						62													77	120
MACKINAC					2	50													24	10,655
MACOMB						11										45	12		37	4,615
MANISTEE						56		2		2							3		2	163,705
MARQUETTE		1			13	15													1	303,429
MASON						9	4			1		2				17	8		7	76,944
MECOSTA						39	11		6							32	23		63	903
MENOMINEE						63													78	118
MIDLAND						-		5		3						23			14	33,218
MISSAUKEE						52										11	17		29	7,816
MONROE					4	-			7					2	4	47			13	35,185
MONTCALM						23										28			57	1,888
MONTMORENCY						66													79	83
MUSKEGON						8	3	6								43			42	3,824
NEWAYGO						71										37			72	847
OAKLAND						1			4							49	19		18	20,791
OCEANA						10	5									34			47	3,105
OGEMAW						45										12	20		30	7,052
ONTONAGON	1		1			54													9	61,327
OSCEOLA						36										21	27		49	2,531
OSCODA						77										51			80	50
OTSEGO						68										2	4		5	82,613
OTTAWA						-	6									29			36	5,159
PRESQUE ISLE					1	18										46			12	35,560
ROSCOMMON						-										14	18		39	4,188
SAGINAW						17	7					5				38			54	2,034
ST. CLAIR						61	12	1								9	13		11	41,314
ST. JOSEPH						31			9		5								64	847
SANILAC						32			1			7							46	3,158
SCHOOLCRAFT					8	62													58	1,724
SHIAWASSEE						37			3					3		48			51	2,384
TUSCOLA						12	9					4				31	21		45	3,214
VAN BUREN						40	10									39			67	566
WASHTENAW						6										48			43	3,347
WAYNE				W	6	-	2	3				1		6	2	42			4	85,638
WEXFORD						16	8									10	11		25	10,510

Michigan remains a vast storehouse of copper mineralization. The copper resources of Michigan have been the object of a recent study by Dr. John T. Wilband of the Department of Geology, Michigan State University, East Lansing. His 1978 report, entitled, "The Copper Resources of Northern Michigan", was done under contract for the U.S. Bureau of Mines for their Minerals Availability System (MAS) Program. The report contains a copper reserves figure arrived at by combining "data believed to be, a) Reliable and conservative, b) Speculative, c) Highly Speculative". The total reported reserves figure is 19.5 billion pounds of copper. The amount ever mined of this large reserves figure would depend upon the price of copper and the type of mining method used. As the price of copper rises, lower grade mineralized rock becomes economical to mine, so more can be removed. The type of mining procedure used determines how much rock needs to be left behind as support structures when underground mining is done. Thus, as least two variables exist in determining how much copper will ever be recovered.

IRON ORE

Six iron ore mines operated in Michigan during the first half of 1978. The Sherwood mine-and the Mather mine were worked as underground mines, while the Groveland, Tilden, Empire, and Republic mines were operated as large open pit mines. The Sherwood mine was closed in July, and ended the iron mining in the Iron

River-Crystal Falls area of Iron County. The Groveland mine, in Dickinson County, and the other four mines in Marquette County continued production as usual. These same six mines produced slightly over 12 million long tons (2240 pounds) of ore valued at over $357.5 million in 1977. Production was lower than in 1976 due to a strike by the miners.

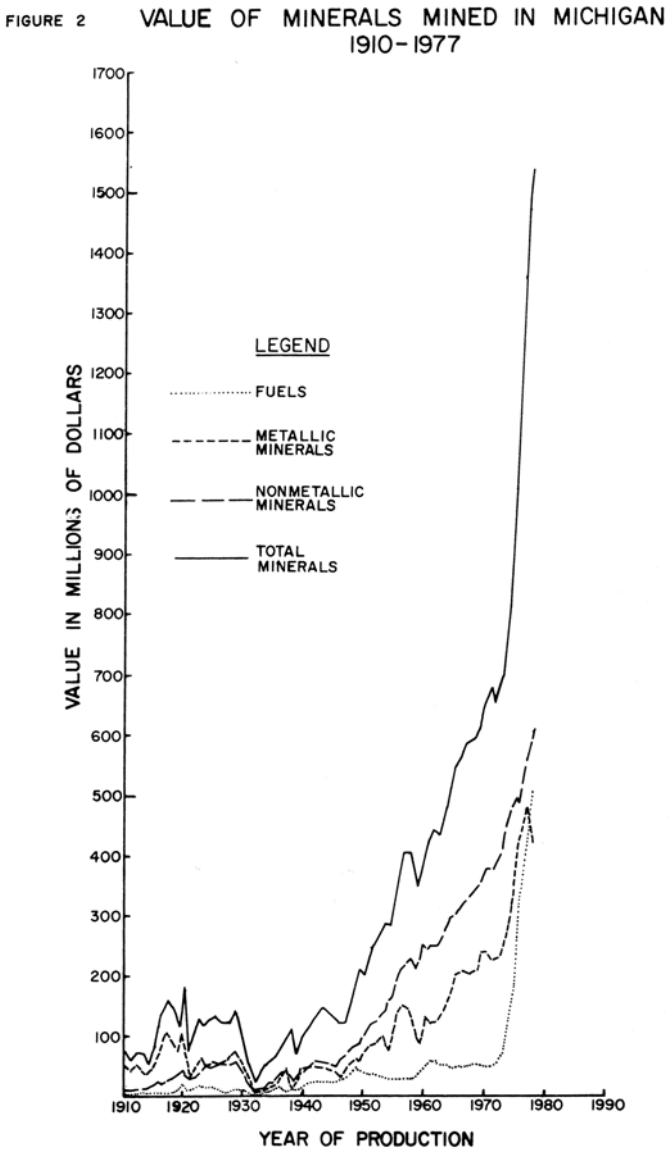


Figure 2 - Value of Minerals Mined in Michigan 1910-1977

The closing of the Sherwood mine ended Michigan's long history of producing direct shipping iron ore. All of the iron ore now being produced is sent through an ore improvement or concentrating process. Most of the ore mined is low grade, 30 to 40 percent iron, and becomes upgraded pellets containing over 60 percent iron. The iron and steel manufacturing industry has adapted to the use of pelletized ore. Now little market remains in the Great Lakes area for the lower grade natural ore.

When natural ore was no longer shipped, other changes had to take place too. For many years the iron mines were taxed on the value of their shipments, based upon ore of 51.5 percent iron content, referred to in the industry as "Old Range Non-Bessemer" ore. The law has now been revised and the actual iron content of the iron ore pellets is the basis for the taxation of the shipments.

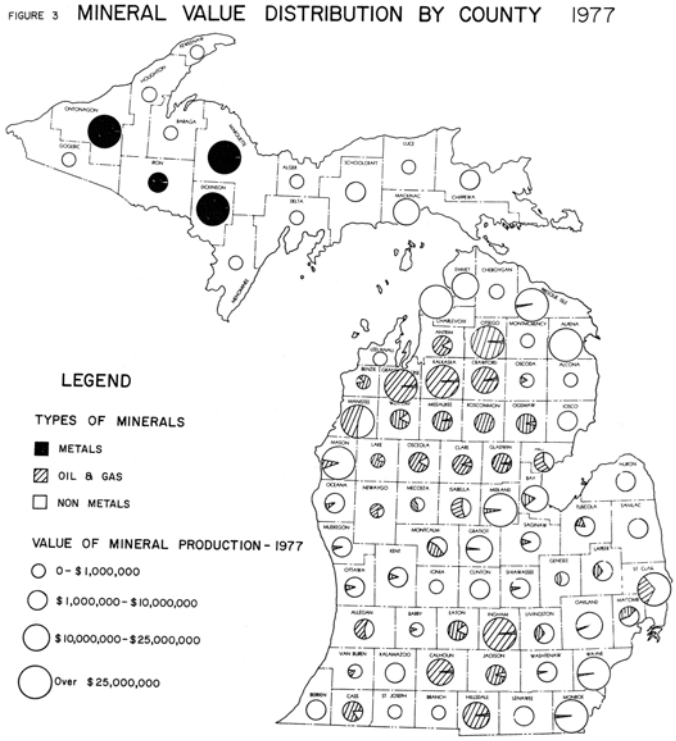
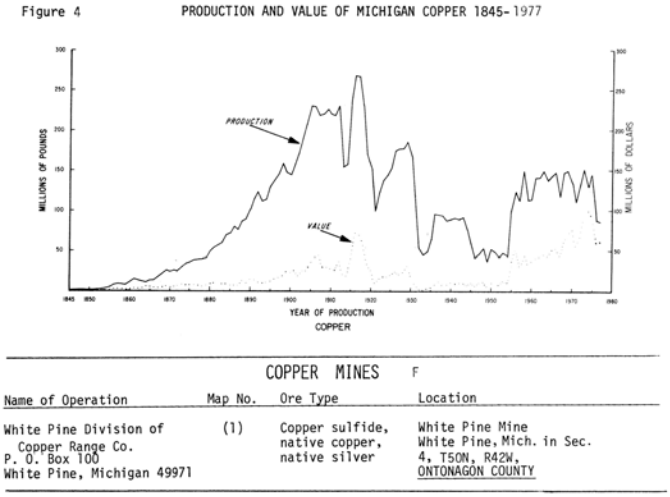


Figure 3 - Mineral Value Distribution by County - 1977



COPPER MINES

Name of Operation	Map No.	Ore Type	Location
White Pine Division of Copper Range Co. P. O. Box 100 White Pine, Michigan 49971	(1)	Copper sulfide, native copper, native silver	White Pine Mine White Pine, Mich. in Sec. 4, T5ON, R42W, ONTONAGON COUNTY

Figure 4 - Production and Value of Michigan Copper 1845-1977

NONMETALLIC MINERALS

Nonmetallic minerals are an important part of Michigan's mineral industry and over 612 million dollars worth of them were produced in 1977. The 1978 list of these commodities includes sand and gravel, natural brines, salt, stone, gypsum, clay and shale, peat, marl 9 and some sulfur. Two additional items for the list are cement and lime. While both of these are processed materials,

they have historically been included with the raw nonmetallic minerals.

Extraction of nonmetallic minerals usually takes place in all 83 of Michigan's counties. The wide variety of commodities in this category and their various occurrences make this possible. Thus, nonmetallic minerals affect part of the economy of the entire state.

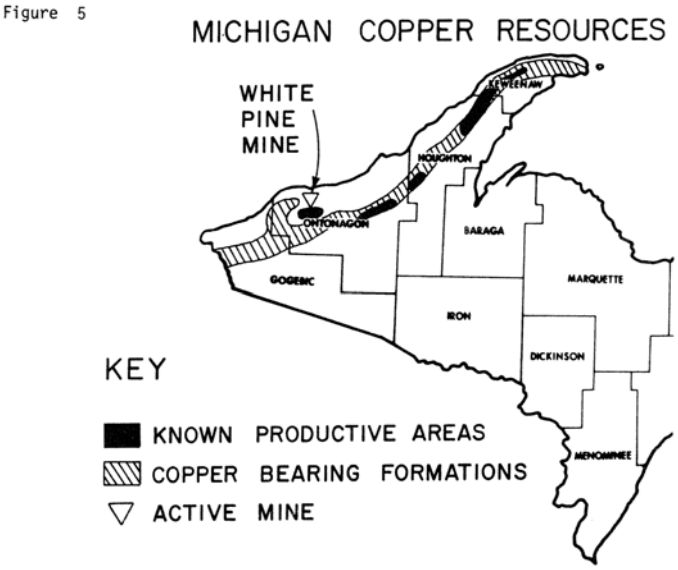


Figure 5 - Michigan Copper Resources

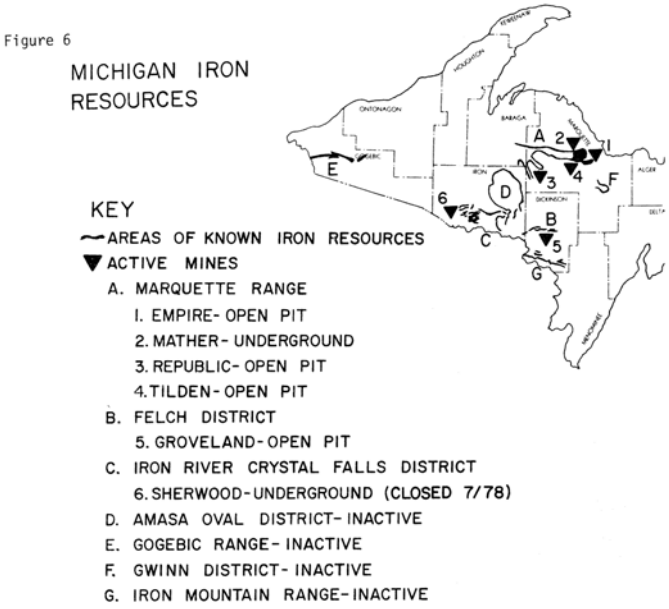


Figure 6 - Michigan Iron Resources

CEMENT

Cement, like lime, is a manufactured mineral product which has been included with nonmetallic mineral production over the years. Simply, Portland cement is made by combining five parts of limestone and one part of shale or clay. The mixture is ground to a powder and passed through a rotary kiln which is fired to a temperature of about 1500°C. In the kiln the materials roll up into gray, ball shaped masses which emerge as hardened clinkers. The clinkers are then ground to a powder and ground gypsum is combined with it to form what we know as Portland cement. Additional ingredients are added to form various other types of cement for specific uses, such as masonry cement, etc.

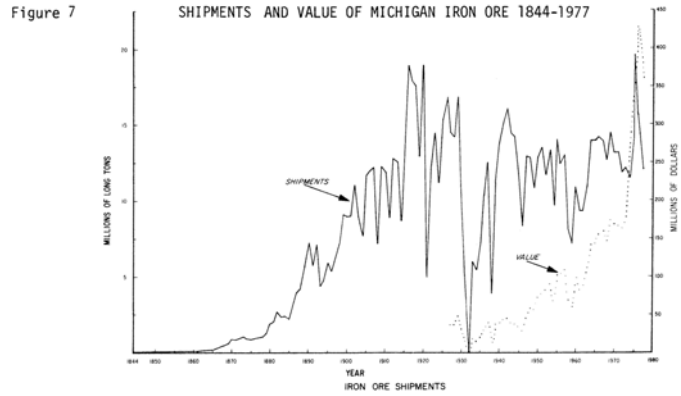


Figure 7 - Shipments and Value of Michigan Iron Ore

Michigan's seven cement plants operate in three different ways in respect to their raw materials: Four plants are located adjacent to their limestone quarries; two receive all of their raw materials from pits and quarries in other locations, some from Canada; one purchases partially processed material (clinker), from other producers and completes the processing at its facility.

During 1977, over 5.81 million tons of cement valued at over $176 million were produced in Michigan.

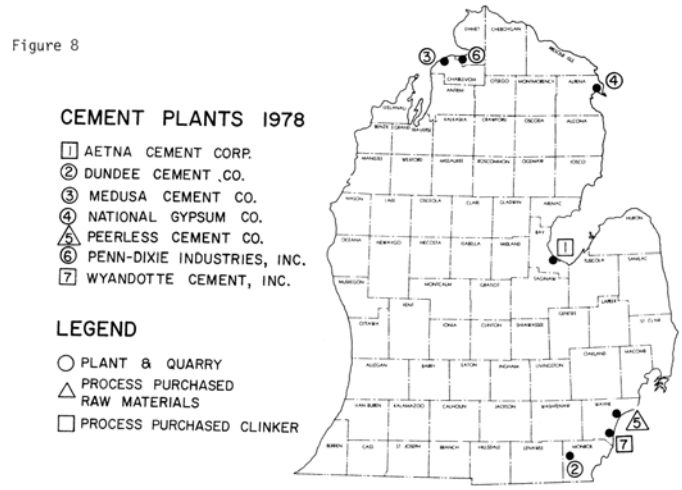


Figure 8 - Michigan Cement Plants - 1978

CLAY AND SHALE

Clay and/or Shale are mined by five companies in Michigan for use as an ingredient in making cement. Three other operators mine clay and/or shale for manufacturing drain tile, sewer pipe and flue linings, bricks and flower pots. Years ago there were many more producers of brick and drain tile, etc. However, changes in technology, building style, rising prices of firing fuel and transportation, have all contributed to a decline in the industry. See Brick story on page 2

Michigan has vast resources of clay and shale which could be utilized if new economic uses are discovered for it. The accompanying map shows the known Michigan clay areas, shale outcrops, and present mine locations.

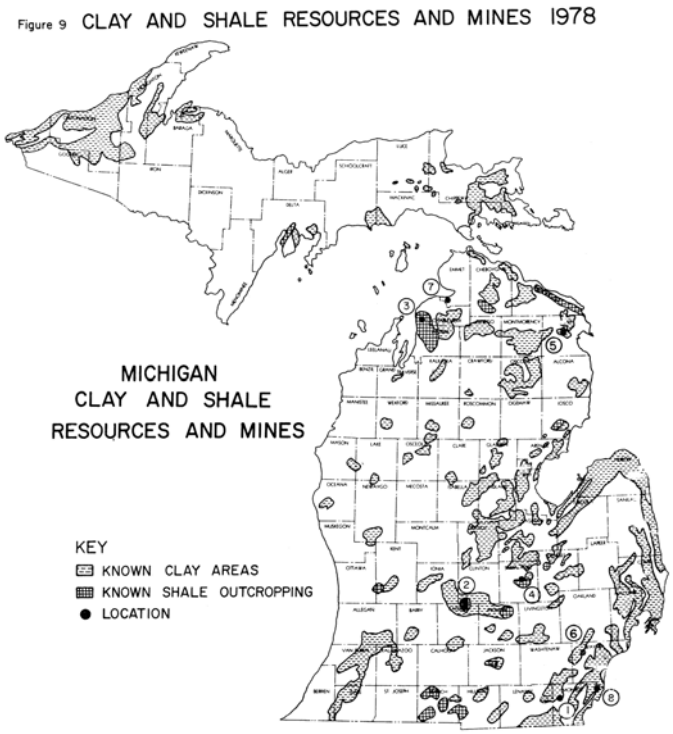


Figure 9 - Michigan Clay and Shale Resources and Mines-1978

GYPSUM

The mineral Gypsum ($CaSO_4 \cdot {}_2 H_2O$), along with some Anhydrite ($CaSO_4$), occurs in some sedimentary rocks. Thick beds of gypsum are mined in both Kent and Iosco counties. Some of the reported uses of gypsum from Michigan are: 1) manufacturing plaster wall board; 2) an important ingredient in Portland cement; 3) agricultural uses (soil treatment, etc.); and 4) decorative stone.

The majority of the gypsum mined in Michigan is used for the manufacture of construction materials, thus the rate of mining is tied in with the economy of the building industry. Figure 11 illustrates the many fluctuations in the production and value of gypsum produced in Michigan between 1868 and 1977.

Michigan is a leading producer of gypsum. The state has been in first or second place for the value of gypsum produced in the U.S. for most of the years since 1930. First place was maintained again in 1977 for both the quantity and value of gypsum produced, 1,924,030 short tons valued at $10,769,174.

The 1976 U.S. Bureau of Mines list of the nation's ten largest producing gypsum mines included two from Michigan. These two Iosco County mines are operated by the National Gypsum Company and the U.S. Gypsum Company. They were ranked, respectively, as the first and third largest producers in the entire United States.

The map in Figure 10 indicates the approximate locations of the two underground mines in Kent County, and the three open pit operations in Iosco County.

The names and addresses for the gypsum companies along with their mine and mill locations are listed below.

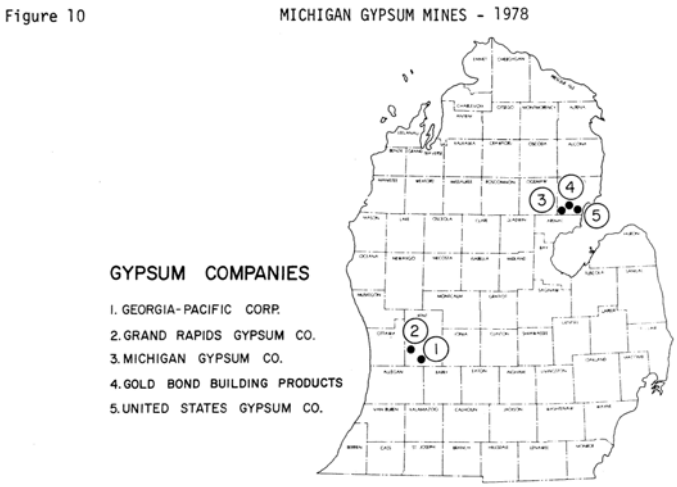


Figure 10 - Michigan Gypsum Mines - 1978

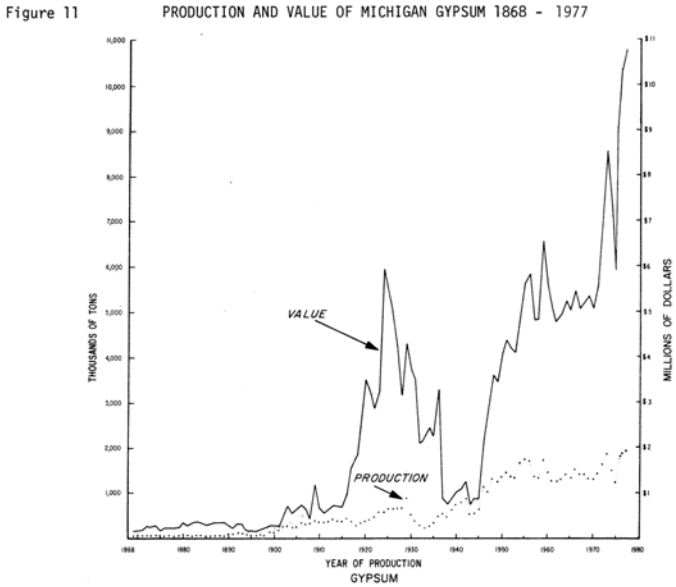


Figure 11 - Production and Value of Michigan Gypsum 1868-1977

LIME

Lime is a mineral product which is produced by heating limestone ($CaCO_3$) or dolomite ($CaCO_3 \cdot Mg\ CO_3$) in a limekiln. In this process, carbon dioxide gas (CO_2) is given off, and quicklime is the end product with the formula of CaO or CaO•MgO, depending upon which material is treated in the first place.

Various books show slightly different versions of the lime making process. The temperature used depends upon the material started with, and may range from about

1800°F to 2400°F. The following is a schematic diagram of the reaction which takes place while converting high calcium limestone to quicklime and carbon dioxide.

$$CaCO_3 \xrightarrow{2000^{o}F} CaO + CO_2 \uparrow$$

This diagram is adapted from the chapter on Lime by R.S. Boynton and K.A. Gutschick in "Industrial Minerals and Rocks", 4th edition, edited by S.J. Lafond, and published by the Society of Mining Engineers of the American Institute of Mining Engineers in 1975.

The U.S. Bureau of Mines ranked Michigan in fifth place among all of the lime producing states for both the quantity and the value of lime produced in 1977. They also placed the BASF Wyandotte lime plant as 8th out of the top ten lime producing plants in the country. These top ratings are quite a distinction because in 1977 there were 161 lime plants operating in 41 states.

The four largest lime producing operations in Michigan reported that in 1977 they made lime which was sold for the following uses: 1) chemical and industrial uses; 2) steel making (basic oxygen converters and electrical furnaces); 3) water purification and softening; 4) sewage and industrial waste treatment (including neutralization of waste acids); and 5) paper and pulp making (as bleach and filler). In past years, two other reported uses were the processing of: 1) alkalies (ammonium, potassium, and sodium compounds); and 2) food and food products.

Five of the nine lime producing operations in Michigan are owned by two sugar manufacturing companies. These two companies convert sugar beets to sugar, and use lime and CO_2 in the processing. Thus, they make their own lime and CO_2 on the site of their sugar refineries.

The locations of Michigan's lime producers are shown on the map containing both lime and marl producers. The reader will note that the limekilns process limestone and/or dolomite which is sometimes transported many miles from where it is mined.

MARL

Michigan Marl was called "bog lime" years ago. It is a non-consolidated calcium carbonate rich material which was deposited in a lake or marsh area by plant and/or animal life. Michigan's glacial overburden has a number of present and former lakes which contain large accumulations of marl. There are now only five companies left which produce marl for use as a soil conditioner for local use. At one time there were a great many marl producers in the state. Marl also used to be produced in Michigan for the manufacture of cement and lime, and to be used as an ingredient in tooth powder, scouring powder, and in paints.

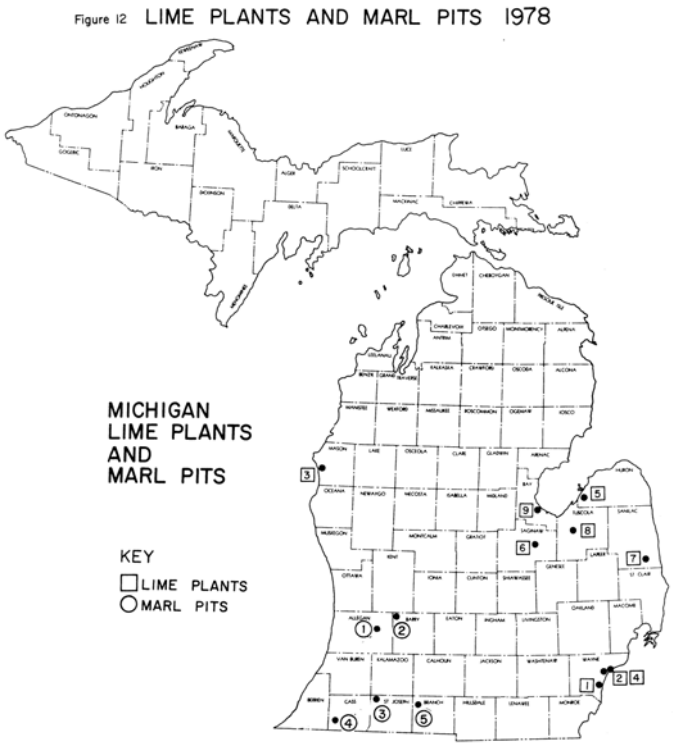


Figure 12 - Michigan Lime Plants and Marl Pits - 1978

NATURAL BRINES

By W. A. Walden

Natural brines, sometimes referred to as natural salines, are naturally occurring salty waters in the earth's crust. These fluids contain varying amounts of calcium, magnesium, and sodium chloride, plus minor quantities of potassium, bromine, and iodine. The natural discharge of these fluids at the earth's surface is referred to as a salt spring or salt lick. Such points of discharge were sources of salt, sodium chloride, for wild animals, Indians, and early settlers.

When Michigan achieved statehood in 1837, one of the first acts of the legislature created a Geological Survey with Dr. Douglass Houghton as State Geologist. The principal mission of the newly created agency was to locate and study salt springs so that adequate supplies of salt could be developed for the people of the state. Monies were also appropriated for the drilling of wells at the sites of salt springs in search of adequate supplies of saline waters. This amounted to $15,000 on two occasions.

No supplies were located, although one private endeavor did locate a small brine source in 1841 which resulted in some salt being produced. It was not until 1859, with the passage of "an act to encourage the manufacture of salt in the State of Michigan" through property tax exemptions and a bounty on salt produced, did the search for natural brines begin in earnest. The incentive was enough to establish a need for natural brine and a salt producing industry in Michigan.

The early growth was rapid. Saginaw County, home of the natural brine industry, experienced an expansion from one producer in 1860 to 23 by mid-1862. Plants also began to appear in Bay and Huron counties. Even amending the law to encourage salt production in 1861 did not discourage expansion of the industry. The amendment limited the property tax exemption to five years, the bounty to $1,000.00, and applied these benefits only to companies in production as of August, 1861. Growth of the industry continued and by 1869 there were 69 companies in existence. It was no longer necessary to have any incentives for salt production, so the "encouragement act" was repealed. The number of companies continued to increase to a maximum of 136 in 1886 and has declined ever since, except for brief periods in the 1890's and in 1901.

The decline in the number of plants reflected the passing of Michigan's lumbering industry. The salt plants were associated with saw mills and used the mill waste, and in some instances exhaust steam, to evaporate the brine. With the closing of the mills, the cheap fuel or heat source was lost, along with the salt producer's competitive edge. Furthermore, salt production was being taken over by the younger, larger, and more efficient plants utilizing artificial brine.

Artificial brine is obtained by injecting fresh water down wells drilled into bedded salt deposits. The water dissolves the salt and forms a sodium chloride rich brine, which is pumped back to the earth's surface and evaporated. Because this brine is rich in sodium chloride, lower fuel costs are realized per ton of salt produced than that experienced with natural brines.

When natural brines are evaporated and sodium chloride forms, a liquor of soluble constituants, called bittern, also remains. The bittern content is a characteristic which detracted from the use of natural brines for salt production, but later enhanced their use by the chemical industry. The bitterns are rich in calcium and magnesium chloride, bromide, and iodide, and are considered an impurity in salt manufacturing. Some of the early operators used the bitterns for manufacture of calcium chloride, sodium chlorate and bromine in conjunction with salt production. This was the beginning of the utilization of natural brines by the chemical industry.

Presently, several chemical companies operate numerous natural brine wells and process the brine into various chemical compounds. Sodium chloride is usually now considered an impurity and is injected back into the earth's crust. Velsicol Chemical Corporation, which concluded operations in Gratiot County in September of 1978, manufactured salt in addition to calcium and magnesium chloride and bromine.

Michigan ranks first in the U.S. in the production of calcium chloride and magnesium compounds. It ranks second in the production of bromine and iodine, being one of only two states producing the latter.

Natural brines are also used for dust control, ice control, and stabilization of unpaved roads. Several county road commissions operate one or more brine wells for these purposes. Oil well operations produce natural brine as a by-product. Some of these operations supply brine for road uses. The remainder of these oilfield brines are returned to the earth's crust through brine disposal wells, or for use in water flooding operations to enhance oil recovery.

Chemical companies produce natural brines from several geologic horizons in Michigan. The geologic horizons are listed in descending order of age. The Marshall Sandstone Formation is the youngest and is of the Lower Mississippian System. The Dundee Limestone Formation and the Detroit River Group, which includes the Filer Sandstone of the Amherstburg Formation and the Sylvania Sandstone Formation, are older and belong to the Middle Devonian System.

The accompanying map shows the locations of the chemical operations and the geologic age of the formation from which the natural brine is utilized.

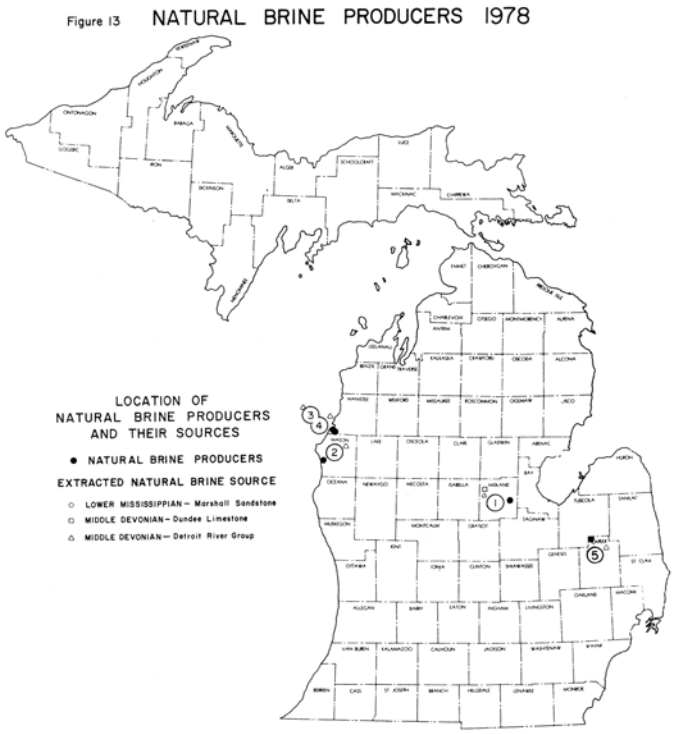


Figure 13 - Natural Brine Producers - 1978

PEAT

Peat is an accumulation of various dead plant materials, particularly mosses, in a bog which forms an organic soil containing less than 30 percent mineral soil. Michigan ranks first in peat production in the U.S. During 1978, there were 17 peat producers which processed various types of peat for use as a soil conditioner. The 1977 production of Michigan peat amounted to 290,855 short tons valued at $4,753,529.

Historically, peat has been used as a fuel and is presently being studied in Minnesota and North Carolina to be used in power plants as it is used in some parts of Europe. With other fuel supplies diminishing and the advancement of technology, peat may become a supplementary fuel of the future in Michigan.

The accompanying map indicates the location of the 1978 peat operations and the approximate acreages of organic soils in the 83 counties of the state. It should be noted that not all organic soils meet the organic content requirements of peat.

In 1976, William A. Walden, a geologist on the Geological Survey Division staff, prepared an Intradivisional Information Circular entitled "Report on Michigan Peat Reserves." This short unedited report is an updating on Michigan's peat reserves and separates peat from organic soils which have sometimes been classified together as peat in the past. Copies of this report are available for reading in the Survey's Lansing office or arrangements may be made for a loan copy.

The U.S. Department of Energy funded the evaluation of fuel grade peat deposits in six states in 1979. Michigan was chosen as one of these states. A grant was given to the Michigan Energy and Resource Research Association to contract with the School of Forestry and Wood Products of Michigan Technological University to study the state's peat resources. The study will continue through part of 1980 and is expected to determine the quantity and location of available fuel grade peat.

SALT DEPOSITS

by W. A. Walden and M. A. Gere

Salt deposits, bedded rock salt, have been utilized as a source of sodium chloride since 1881. This was shortly after the first discovery of salt in Michigan, during the drilling of an unsuccessful oil and gas well at the Town of Manistee in Manistee County. Shortly thereafter, salt was discovered in St. Clair County in 1882 and utilized in 1883.

Since discovery, bedded salt has replaced natural brine as a source of sodium chloride. The higher sodium chloride content of salt deposits makes it more economical to utilize and there is much less waste in the processing.

Bedded salt is extracted by two different methods in Michigan: Dry mining and Solution mining.

Dry mining is the conventional type of underground mining which most people think of when the word mining is used. The International Salt Co., Inc. uses this method to produce rock salt in Michigan. Their Detroit Mine underlies about 900 acres of the cities of Detroit and Melvindale at a depth of approximately 1100 feet. Since 1910 about 36 million tons of salt have been produced from this mine.

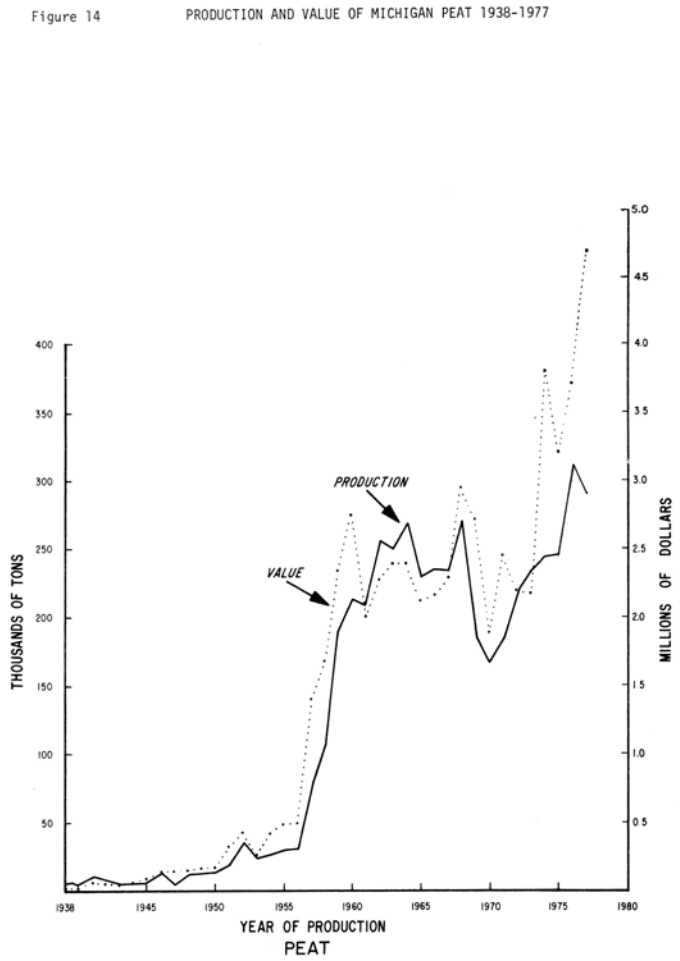


Figure 14 - Production and Value of Michigan Peat 1938-1977

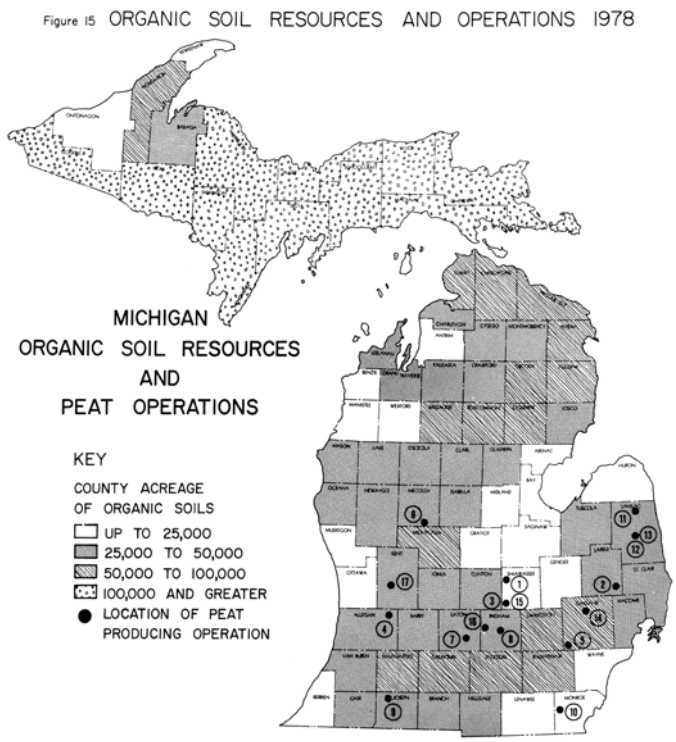


Figure 15 - Michigan Organic Soil Resources and Operations - 1978

Solution mining of bedded salt is done by pumping water into a known bed of solid salt within the bedrock in the ground. The salt is dissolved by the water and produces an artificial brine, or sodium chloride rich water. The artificial brine is then pumped out of the ground and salt and other chemicals are removed from it by different methods. The remaining salt and chemical companies listed use this method.

Michigan's production of artificial brine was reduced somewhat on December 1, 1978. That is when the BASF Wyandotte Corporation ceased producing soda ash by the Solvay process at their chlor-alkali plant at Wyandotte. The company is still using salt brine for the production of chlorine.

The accompanying map shows the extent of the various ages of bedded salt deposits. The location and type of extraction and geologic age of the salt beds are indicated.

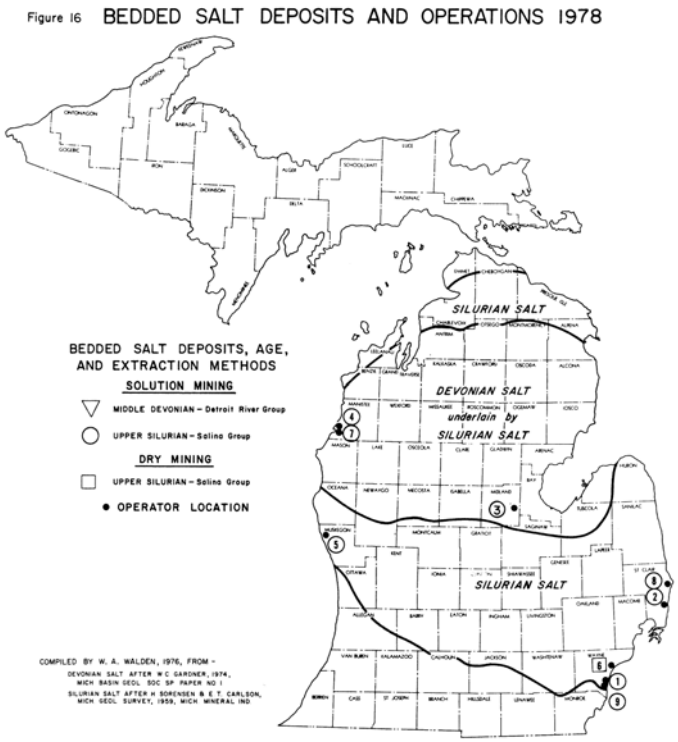


Figure 16 - Bedded Salt Deposits - 1978

SAND AND GRAVEL

Sand and Gravel are important nonmetallic mineral commodities in this State. Michigan consistantly ranks in the top 2nd to 4th place in the U.S. in the value of sand and gravel produced annually. In 1977 over 46.9 million short tons of sand and gravel valued at over 97.9 million dollars were produced. The 1978 preliminary figures are greater for both production and value. These values include both construction sand and gravel and industrial sand.

When the glaciers grew and pushed across the state many thousands of years ago, they bulldozed around a tremendous amount of broken rock, sand, and clay. The glaciers finally melted away about 10,000 to 15,000 years ago and left the materials behind in a number of forms. Some of the material was left as a mixture in the form of end moraines, ground moraines, etc. In other locations the melt waters reworked the material and sorted out areas of sand, areas of gravel, and some of mostly clay. Along the shores of the Great Lakes the water and wave action has done more sorting and breaking down of materials and the prevailing westerly winds have built large sand dunes along the western coast of the state. It is in the sorted out areas where good deposits of clean sand, sand and gravel, or clay are now available for extraction for use by man.

Construction sand and gravel and industrial sand are actually separate commodities with different specifications and uses. Thus, they are handled separately on the following pages.

CONSTRUCTION SAND AND GRAVEL

Nearly 41.1 million short tons of construction sand and gravel, valued at almost 72.6 million dollars, were produced in Michigan in 1977, down slightly in production and up in value from 1976. The production rate rises and falls with the economy. As construction, especially of roads, increases or decreases, so does the rate of production of construction sand and gravel.

Sand and gravel is a relatively heavy, bulky commodity and the per ton value is low, so the cost of transportation becomes a very important item. Thus, the distance between the source pit and the location where it is used is usually kept to a minimum. Not all areas of the state are blessed with abundant sand and gravel deposits, so costs vary greatly depending upon location.

The use of construction sand and gravel is greater in urban areas due to more construction there. However, urban areas frequently build over sand and gravel deposits, forcing the transportation of building materials from more distant, but usable, sites. If more geologic insight were used in urban and highway planning and zoning, known areas of good sand and gravel deposits, or other potentially usable minerals, may be excluded from urbanization until the mineral commodities are extracted and the mining surface reclaimed. This would result in more efficient utilization of our nonrenewable resources. Like the old saying "Gold is where you find it", we do not have the choice of obtaining minerals where we would like them to be, but must be able to obtain them from where they actually are.

Following is a list of the known construction sand and gravel producers in the state, information on their types of operations, and the counties in which they operate. Also included is a list of State owned gravel pits which are periodically leased and worked by various operators. Additional sand and gravel pit locations are frequently established by lease on Federally owned lands.

A comprehensive listing of sand and gravel pits from which material has been tested by the State Department

of Transportation is available. The list is arranged by county, includes county maps showing pit locations, and abrasion and soundness test results are given when available. Copies of the "Aggregate Source Inventory" may be obtained for $12.00 plus postage and sales tax, prepaid, from: Publications Unit, Contract Section, Michigan Department of Transportation, Box 30050, Lansing, MI 48909.

STATE OWNED PITS

There are a number of state owned gravel pits which are sometimes mined by private firms through obtaining a mineral permit and paying a royalty to the state. These pits are on lands under the jurisdiction of the D.N.R. and are mined according to a mine plan which includes the overall reclamation of the pit site upon completion of the gravel removal operations. For information concerning specific locations, contact the nearest D.N.R. Forester, or the D.N.R. Forest Management Division, Box 30028, Lansing, Michigan 48909,

Following is a listing of the current D.N.R. gravel pits arranged by county.

[For tables see unconverted PDF file]

INDUSTRIAL SAND

Michigan's 1977 production of Industrial Sand was nearly six million short tons valued at over 25.4 million dollars. Both the volume and the value were up from the 1976 production figures of just over 5.4 million tons valued at 20.9 million dollars.

Industrial sand uses include the following: Foundry molding, glass making, sand blasting, fire or furnace sand, engine or traction sand, and metallurgical sand. Only sand deposits meeting specific standards of purity, grain size and shape are usable.

The industrial sand mining operations in Michigan produce material from several types of deposits. These include: 1) Sand dunes along the Lake Michigan shore and some inland dunes; 2) Glacial outwash or other meltwater sorted deposits; 3) High purity consolidated sandstone; 4) and sand dredged out of Saginaw Bay of Lake Huron.

The readers interested in further discussions of Industrial Sand are referred to the following publications of the Geological Survey Division, Michigan Department of Natural Resources.

1) "Michigan Industrial Sand Resources", Circular 11, by Jerry D. Lewis, 1975. Cost is 50 cents.

2) "Economic Geology of the Sand & Sandstone Resources in Michigan", Report of Investigation 21, by E. Wm. Heinrich, 1979. Cost is $2.00.

3) "An Economic Study of Coastal Sand Dune Mining in Michigan", Report of Investigation 20, by Ayres, Lewis, Norris and May, Inc., and Michael J. Chapman, 1978. Cost is $2.00.

These publications are available at the above prepaid prices, plus 4% sales tax to Michigan residents, from:

Information Services Center
Michigan Department of Natural Resources
Box 30028
Lansing, Michigan 48909

All payments should be made to the order of "State of Michigan".

Persons interested in the mining of sand dunes for industrial sand and its regulations, may wish to obtain a copy of the booklet "Designated Sand Dune Areas" Series I. This booklet contains Act. No. 222, Public Acts of 1976, the Sand Dune Protection and Management Act. Copies are available free from:

Reclamation and Mining Control Unit
Geological Survey Division
Michigan Department of Natural Resources
Box 30028, Lansing, Michigan 48909

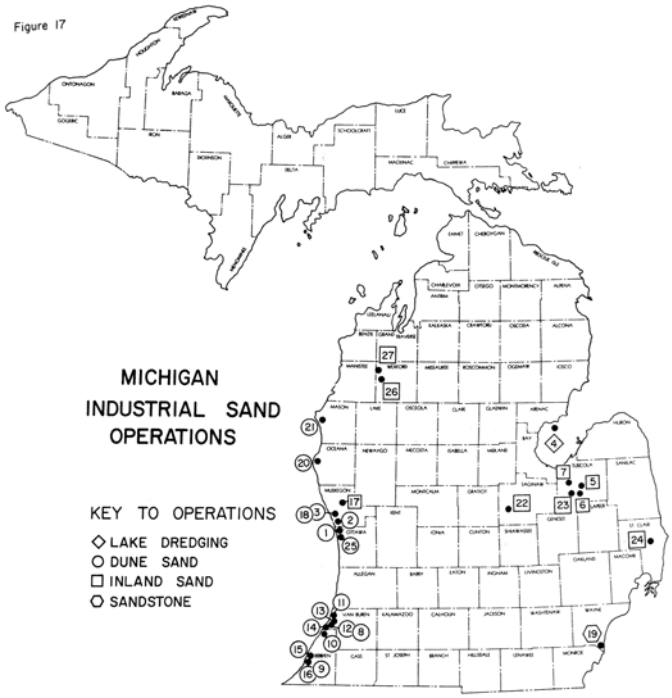


Figure 17 - Michigan Industrial Sand Operations - 1978

STONE

Under this heading we include the subheadings of Limestone and Dolomite, Sandstone, and Miscellaneous Stone. The total stone production in 1977 amounted to nearly 40.5 million short tons valued at just under $85 million.

The U.S. Bureau of Mines placed Michigan in seventh place for volume and eighth place for value for 1977 stone production in the U.S.

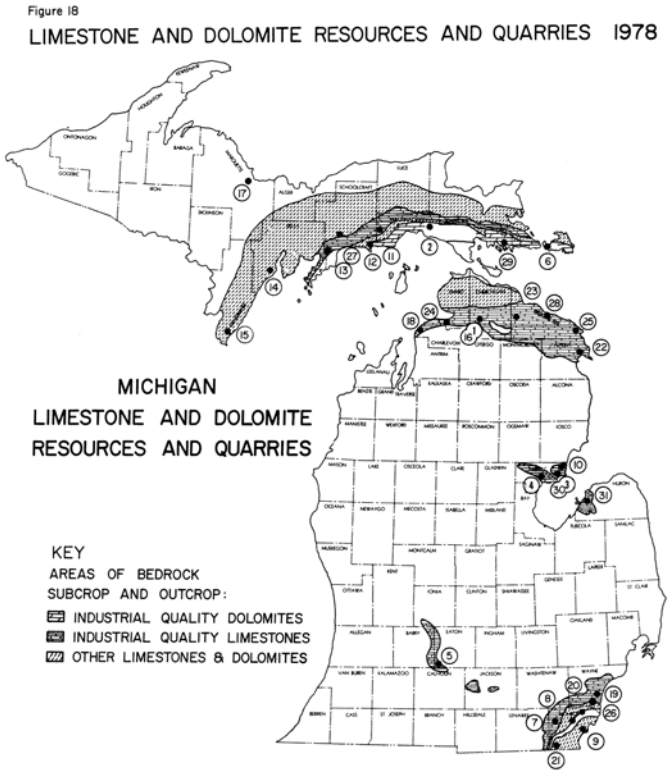


Figure 18 - Michigan Limestone and Dolomite Resources and Quarries - 1978

Figure 19 - Michigan Miscellaneous Stone and Sandstone Operations - 1978

LIMESTONE AND DOLOMITE

Michigan had 31 active Limestone and Dolomite quarries in 1978. These quarries ranged in size from very large to quite small. The U.S. Steel Company quarry at Rogers City is considered by the U.S. Bureau of Mines to be the largest limestone quarry in the country.

Limestone and Dolomite are quarried for a number of uses in Michigan. The largest uses are for crushed construction and road aggregate, flux stone for steel making, and raw material for making cement and lime. Other uses include riprap, dimension building stone, agricultural limestone, and railroad ballast. In 1977, nearly 39.5 million short tons of limestone and dolomite valued at over $80.6 million were produced in the state.

Most of the larger quarries are located along the shores of Lakes Michigan and Huron which allow less expensive boat transportation of the processed stone to the down-lake markets. Many smaller quarries are scattered throughout the state wherever good limestone or dolomite occurs near the land surface in an area of possible economic use. The accompanying map indicates the location of the limestone and dolomite resources and quarries.

MISCELLANEOUS STONE

This heading currently includes only Marble. The Marble is mined mainly for use as landscape aggregate. In the recent past the following were also mined; Basalt or Traprock, Granite, Feldspar, and Amphibolite. The Traprock is actually waste rock from old copper mines and was processed for construction aggregate, as was the Granite. The pink Feldspar and black Amphibolite were produced for decorative stone and terrazzo stone. Many years ago, around the turn of the century, both Verde Antique and Slate were also produced. The dark green Verde Antique was used for fancy dimension stone, such as building fronts and soda fountains. Slate was used to make slate roofing shingles. Some quartzite was also produced for local aggregate uses some years ago.

The only Miscellaneous Stone quarry location is included on the map entitled "Michigan Miscellaneous Stone and Sandstone Operations".

SANDSTONE

Sandstone is currently mined for rough dimensional stone by two producers in Jackson County. There is one sandstone producer in Wayne County that mines sandstone to be processed into industrial sand for use in glass making and as foundry sand. They also produce some sandstone aggregate material.

Around the turn of the century there were at least two large sandstone quarries located in the Upper Peninsula which produced brown and red dimensional sandstone blocks which were used for fancy building fronts. Another abandoned industry quarried a gritty sandstone for the manufacture of grindstones in Huron County. These grindstones were sold all around the world, but the industry closed down with the advent of carborundum abrasives.

The current sandstone producers are located on the map showing "Miscellaneous Stone and Sandstone Operations."

SULFUR

Some sulfur crystals are found in vugs in dolomite rock within the Detroit River Group of middle Devonian age in parts of southeastern Michigan. However, the sulfur produced in Michigan is a byproduct of oil refinery operations.

Figure 20

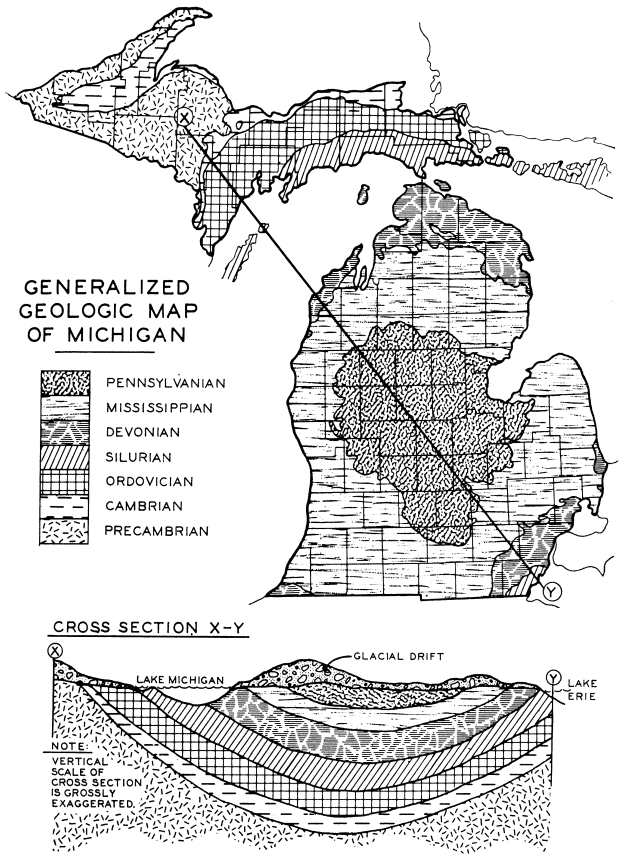


Figure 20 - Generalized Geologic Map of Michigan

SOME SUGGESTED READINGS

FROM MICHIGAN DEPARTMENT OF NATURAL RESOURCES, GEOLOGICAL SURVEY DIVISION

Limestone

Johnson, Allen M., and Sorensen, Harry O.; "Drill Core Investigation of the Fiborn Limestone Member in Schoolcraft, Mackinac, and Chippewa Counties, Michigan", Report of Investigation 18, 1978, 51+ pg., $2.00. From the abstract "Progress on evaluation of high-purity, high-calcium limestones of the Middle Silurian Fiborn member of the Henricks Formation, Burnt Bluff Group in the eastern portion of the Northern Peninsula is presented". This publication covers part of the work done as a joint effort of the Geological Survey Division and the Institute of Mineral Research at Michigan Technological University, Houghton, Michigan.

Reclamation

Shetron, S.G.; et al., "Establishing Vegetation on Alkaline Iron and Copper Tailings" Report of Investigation 17, 1977, 13+ pg., $2.00. This report covers the methods used and results realized from a five year research program to establish vegetation on mine tailings as part of a mine reclamation program.

List of Publications

Currie, William W.; "Annotated List of the Publications of the Michigan Geological Survey 1838-1977", Circular 16, 1978, 38+ pg., $2.00. This well organized list is indexed by author, mineral, and county.

Price Lists

___"Available Maps of the Michigan Geological Survey", Map List 2, 1979, free. A detailed listing of available geological maps and their prices.

___"Publications Available from the Geological Survey Division", List 21, 1979, free. A detailed list of available publications and their prices.

FROM THE U.S. BUREAU OF MINES

Statistics and Industry Information

Peterson, Edward C.; Middlewood, Esther A.; "Minerals in the Economy of Michigan", State Mineral Profiles 7, 1978, 14+ pg., free. This brief booklet includes a number of short accountings of happenings within the State's mineral industry in 1977. Production figures are given, as well as state and federal legislation and program changes, state and federal income from mineral royalties and severance taxes, etc. This will prove to be a handy new annual series produced by the U.S.B.M

Peterson, Edward C.; Middlewood, Esther, A.; "The Mineral Industry of Michigan", from "1976 Minerals Yearbook", 1978, U.S. Bureau of Mines and "Annual Statistical Summary 27, Michigan Department of Natural Resources, Geological Survey Division, 26 pg., free. This annual booklet presents detailed mineral commodity production and value information as well as industry news and law changes which affect the mineral industry.

___"Mineral Commodity Profiles", U.S.B.M 1977 - 1979, free. These short publications are described as "A new series presenting timely data on selected mineral raw materials". As of November 1979 there were 38 booklets in this series, a number of which cover materials found or produced in Michigan. Consult the U.S.B.M. for the current listing.

Popular Books about the Geology of the State

These books may be ordered from your local bookstore.

Dorr, John A., and Eschman, Donald F.; "Geology of Michigan", 1970,
484 pg., $15.00.
The University of Michigan Press
839 Greene Street
Ann Arbor, Michigan 481061

This hardbound textbook explains the geology of Michigan and includes many illustrations and lists of collecting areas, museums, etc. General geology concepts are explained and Michigan examples are given.

Paull, Rachel Krebs, and Paull, Richard A.; "Geology of Wisconsin and Upper Michigan", 1977, 232 pg., $6.95.
Kendall/Hunt Publishing Company
2460 Kerper Boulevard
Dubuque, Iowa 52001

This well written, and illustrated, softbound book describes the geology of Wisconsin and Upper Michigan and parts of adjacent states. Concepts of general geology are explained and a 13 page glossary of geological terms are included. One nice feature of this book is that it covers the geology of an area beyond stateline boundaries.

Popular Books about Mining in Michigan

Boyum, Burton H.; "The Saga of Iron Mining in Michigan's Upper Peninsula", 1977. 48+ pg. $3.75 (plus $.15 sales tax and $.60 postage)
The Marquette County Historical Society, Inc.
213 North Front Street
Marquette, Michigan 49855

This booklet gives a well written, brief history of Michigan iron mining. Many old photographs of mining scenes are included. Two additional features are a glossary of mining terms and a good "selected" bibliography on the subject.

Murdoch, Angus; "Boom Copper", 1943
255 pg. The Copper Country edition, 1964 is available for $7.95, tax paid, plus $1.00 shipping, from:
Quincy Mine Hoist Association, Inc.
Box 265
Hancock, Michigan 49930

"Boom Copper, the Story of the First U.S. Mining Boom" includes over 20 chapters, each one covering different aspects of mining and living in Michigan's Copper Country from prehistoric times up to the 1940's. Some old photographs and drawings help the reader relive the past which is described so well.

Topographic Maps - U.S. Geological Survey
Topographic Maps of Michigan are available through the Michigan Department of Natural Resources. A list of these maps, which are sold by the Information Services Center is available upon request.

Department of Natural Resources
Information Services Center
Box 30028
Lansing, Michigan 48909
(Michigan residents add 4% state sales tax)

U.S. Bureau of Mines
Branch of Publications Distribution
400 Forbes Avenue
Pittsburg, Pennsylvania 15213

Unless a specific address is given, these publications may be ordered from their proper agency above.

READINGS RELATED TO BRICK

The featured product in this directory is Brick. Bricks are made of the mineral commodity clay and shale. Both clay and shale are widely distributed in Michigan.

Three articles and books which discuss Michigan's clay and shale resources and uses are listed below. While these Michigan Geological Survey publications are out-of-print, they should be available at libraries through the interlibrary loan system.

Ries, H.; 1900, "Clays and Shales of Michigan - Their Properties and Uses", part I, vol. VIII, Geological Survey of Michigan 1900 - 1903, 67 p.

Brown, George Granger; 1924, "Clays and Shales of Michigan and Their Uses" Pub. 36, Geological Series 30, Geological Survey Division, Michigan Department of Conservation, 443 p.

Sorensen, Harry O.; 1970, "Michigan's Clay Deposits and Industry", 13 p., in "Proceedings - Sixth Forum on Geology of Industrial Minerals", W.A. Kneller, editor, Miscellany 1, Geological Survey Division, Michigan Department of Natural Resources.

* * * * * * * * * *

PERMIT INFORMATION

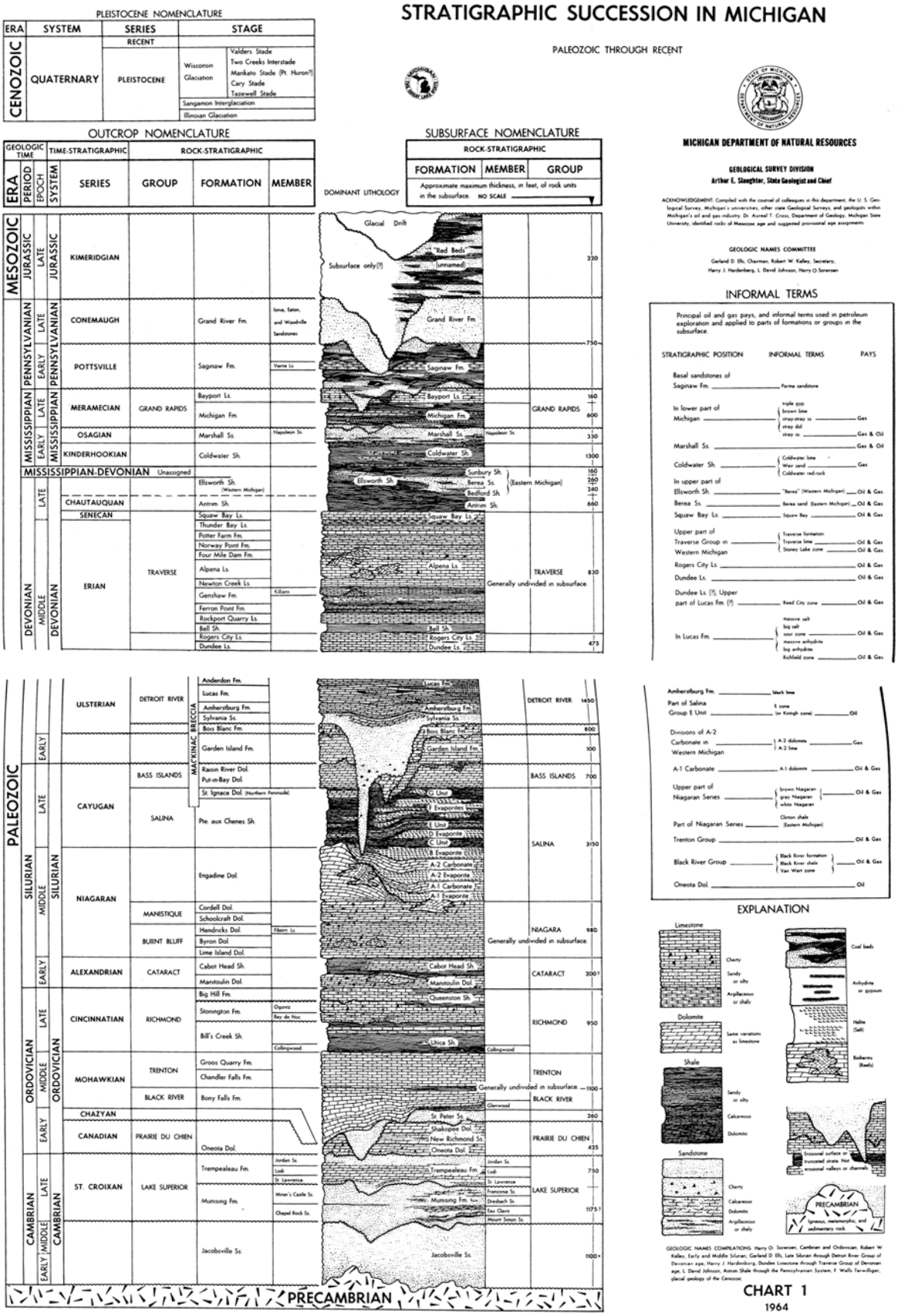
For information concerning what D.N.R. permits may be required when starting a new mining project, contact the following agency:

Michigan D.N.R.
Environmental Enforcement Division
Project Review Section
Box 30028
Lansing, Michigan 48909
Telephone (517) 373-3503

Either Mr. Donald L. Inman, Section Chief, or Mr. Gary M. Gettel will advise you what specific D.N.R. Division to contact directly.

* * * * * * * * * *

Table 4 - Stratigraphic Succession in Michigan



MICHIGAN DEPARTMENT OF NATURAL RESOURCES GEOLOGICAL SURVEY DIVISION

---LANSING OFFICE---
4th Floor Stevens T. Mason Building
(Pine and Allegan Streets)
Box 30028, Lansing, Michigan 48909
Telephone - Area Code "517"
373-1256 or 373-7860

Arthur E. Slaughter, Chief, State Geologist

ECONOMIC AND ENVIRONMENTAL GEOLOGY SECTION	OIL AND GAS SECTION
Mining & Economic Geology Unit - 373-1256	Production & Proration Unit - 373-1256
Geology & Minerals Research Unit - 373-1256	Subsurface & Petroleum Geology Unit - 373-1256
General Geology Unit - 373-7860	Regulatory Control Unit - 373-1256
Mineral Wells Unit - 373-1256	
Reclamation & Mining Control Unit - 373-1256	
Ground Water Geology Unit - 373-7860	

Field Organization

Region 1 - Marquette Regional Headquarters. P.O. Box 190, Marquette, MI 49855(US41-S)
Phone - 906/226-7505

Escanaba Field Office, 201 State Office Bldg., Escanaba, MI 49829
Phone - 906/786-0333

Region II Roscommon Regional Headquarters, P.O. Box 128, Roscommon, MI 48653
Phone - 517/275-5151 (8717 N. Roscommon Rd.)

Cadillac Field Office, R#1, 8015 South 131 Rd., Cadillac, MI 49601
Phone - 616/775-9727

Gaylord Field Office, P.O. Box 576, Gaylord, MI 49735 (1732 W. Main St.)
Phone - 517/732-3541

Mount Pleasant Field Office, 204 Court St., Mt. Pleasant, MI 48858
Phone - 517/773-9965

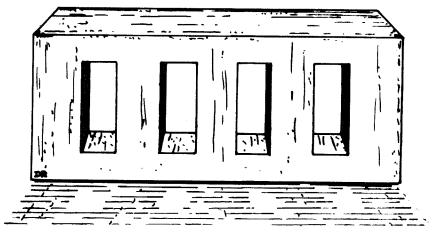
Grayling Field Office, Box 507, 4895 W. County Rd., Grayling, MI 49738
Phone - 517/348-6371

Region III Lansing Regional Headquarters, Box 30028, Lansing, MI 48909 (State Government Secondary Complex-Dimondale)
Phone - 517/322-1300

Imlay City Field Office, P.O. Box 218, Imlay City, MI 48444 (715 S. Cedar St.)
Phone - 313/724-2015

Rose Lake Field Office, R#1, East Lansing, MI 48823 (8562 E. Stoll Rd.)
Phone - 517/339-8638 (641-4071) or (641-6000)

Plainwell Field Office, P.O. Box 355, Plainwell, MI 49080 (621 N.10th St.)

Phone - 616/685-6851

Grand Rapids Office, 350 Ottawa St. NW, Grand Rapids, MI 49503
Phone - 616/456-5071