

FIGURES AND TABLES

VALUE OF MINERALS MINED IN MICHIGAN 1910-1974 4
 MINERAL PRODUCTION OF MICHIGAN 1974 4
 COUNTY MINERAL VALUATION AND RANK 4
 COUNTY MINERAL DISTRIBUTION BY VALUE 4
 PRODUCTION AND VALUE OF MICHIGAN COPPER 1845-1974 8
 PRODUCTION AND VALUE OF MICHIGAN IRON ORE 1844-1974... 9
 PRODUCTION AND VALUE OF MICHIGAN GYPSUM 1868-1974... 11
 PRODUCTION AND VALUE OF MICHIGAN PEAT 1938-1974 13

MAPS

MICHIGAN MINERAL OPERATIONS 3
 MICHIGAN COPPER RESOURCES AND MINES 8
 MICHIGAN IRON RESOURCES AND MINES 9
 MICHIGAN CEMENT PLANTS 10
 MICHIGAN CLAY AND SHALE RESOURCES AND MINES 10
 MICHIGAN GYPSUM MINES 11
 MICHIGAN LIME PLANTS 11
 MICHIGAN MARL PITS 11
 MICHIGAN BRINE PLANTS 12
 MICHIGAN ORGANIC SOIL RESOURCES AND OPERATIONS 12
 MICHIGAN SALT PLANTS AND MINE 13
 MICHIGAN INDUSTRIAL SAND OPERATIONS 14
 MICHIGAN LIMESTONE AND DOLOMITE RESOURCES AND QUARRIES 14
 MICHIGAN MISCELLANEOUS STONE AND SANDSTONE OPERATIONS 15
 GENERALIZED GEOLOGIC MAP OF MICHIGAN 15

TABLE OF CONTENTS

INTRODUCTION 3
 INTRODUCTION 3
 NEWS ITEMS AND DEVELOPMENTS IN 1974-75 5
 Field Investigations 5
 Metallic Minerals 5
 Nonmetallic Minerals 6
 Miscellaneous 7
METALLIC MINING OPERATIONS 7
 Copper 7
 Iron 8
NONMETALLIC MINERAL OPERATIONS 10
 CEMENT 10
 CLAY AND SHALE 10
 GYPSUM 11
 LIME 11
 MARL 11
 NATURAL SALINES 12
 PEAT 12
 SALT 13
 SAND AND GRAVEL 13
 Construction Sand and Gravel 13
 Industrial Sand 13
 STONE 14
 Limestone and Dolomite 14

COVER ILLUSTRATION

The front cover is a drawing of the Centennial Mines No. 6 headframe by staff artist Jim Campbell. The mine is located north of Calumet in the Keweenaw Peninsula. It is at this mine that Homestake Copper Company is presently involved in a joint venture with the American Copper and Nickel Company, a wholly owned subsidiary of the International Nickel Company of Canada. Homestake has reopened the Centennial Mine to do exploratory work for native copper. If the preliminary exploration work proves worthwhile the mine will be put back into full scale operation.

The mine was originally operated by the Calumet and Hecla Mining Company until May 1968 when the company merged with Universal Oil Products (U.O.P.). The new operator U.O.P., continued to run the mine and took control of all mineral and land holdings. In August 1968 a labor dispute resulted in the closing of the mine. The dispute remained unsettled in December 1970 when

the company (U.O.P.) decided to pull the pumps and allow the mine to flood.

In July 1972 Homestake Copper Company reached an agreement with U.O.P. to lease their mineral holdings, on a royalty basis, and explore for minerals. Following the lease agreement Homestake formed a joint venture with the American Copper and Nickel Company. Homestake would retain 60 percent of the venture and act as manager of the exploration and development program.

The company started dewatering the mine during April 1973, as part of an initial \$5 million program which also included renovation of the No. 3 and No. 6 shafts and surface equipment.

Once the initial project was completed \$4.3 million more was spent on the building of a pilot plant. The plant included a concentrator to mill ore along with other new equipment the company wanted to try out. Information gathered from the pilot plant will be used to establish ore processing costs in addition to serving as a design model for a larger plant.

More money will be spent as shaft sinking and drifting is continued. The No. 6 shaft is being deepened at the rate of 100 to 130 feet per month. The shaft is on a 38° incline. As of December 1975 the inclined shaft was nearing 6700 feet (Approx. 4150 vertical feet). It is hoped, that the 7700 foot mark (also known as the 55th level) will be reached by September 1976. Once the 55th level is reached the company plans to drive drifts outward from this and two or three other levels to evaluate the ore body. They will look at the grade of ore encountered and the depth, width, size and location of the ore body. If sufficient ore is found, a vertical shaft will be sunk. Ore mined from the body will be brought to the vertical shaft and lifted to the surface. New methods of mining are being tried in an attempt to improve mining technology and lower mining costs.

Ore is presently being mined in drifting operations from the No. 3 shaft. As the drifts are driven toward the No. 6 shaft the ore is removed and brought to the surface where it is then crushed and processed in the new pilot plant. The plant is working well so far with reported recoveries ranging from 91 to 92 percent of the copper in the ore. Until recently the ore had never been processed in modern conventional mills. The new milling process grinds the ore finer than the stamp mill methods of years past. The finer grinding allows for better recovery.

Local citizens of the Copper Country are watching Homestake's closely. A new era of copper mining may be on the verge of actuality should exploration efforts prove favorable in this old copper mining district.

MICHIGAN MINERAL PRODUCERS 1975

GEOLOGICAL SURVEY DIVISION

ANNUAL DIRECTORY 9



By

Jerry D. Lewis

STATE OF MICHIGAN
William G. Milliken, *Governor*

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

GEOLOGICAL SURVEY DIVISION
Arthur E. Slaughter, *Chief*

NATURAL RESOURCES COMMISSION

Carl T. Johnson, *Chairman, Cadillac*

E. M. Laitala, *Hancock*

Harry H. Whiteley, *Rogers City*

Dean Pridgeon, *Montgomery*

Charles G. Younglove, *Allen Park*

Joan L. Wolfe, *Belmont*

Hillary F. Snell, *Grand Rapids*

Charles J. Guenther, *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.

—Compiled Laws Mich. 1948 s.319.202

Published by Authority of State of Michigan

Available from the Publication Room, Geological Survey Division, Department of Natural Resources, Lansing, Michigan 48926. Also deposited in libraries throughout the state and other selected areas.

PREFACE

Michigan Mineral Producers is an annual compilation of the names and addresses of operators, and the location of active mineral operations during 1975. The information used in this directory is obtained from the U. S. Bureau of Mines yearly canvass.

This directory is intended for use as a reference by industry, government and the general public. It lists operators according to mineral commodity and county of production. This year the sections on selected commodities contain background discussions and/or production-value charts. Some mineral resource maps are also included as well as the usual reference maps. A new section, added to the introduction, contains a

discussion of developments in the mineral industry during 1974-75. It is hoped that this added information will help the reader to a better grasp of Michigan's mineral resources and operations.

The author wishes to thank the Michigan mineral industry for its excellent cooperation. And the U. S. Bureau of Mines has been very helpful in providing addresses, locations, and production statistics for Michigan mineral operators.

A special note of thanks is given to Mrs. Lynda Craft of the Michigan Geological Survey, and Miss Esther Middlewood of the U. S. Bureau of Mines, Lansing Liaison Office. Without their patient help and assistance this directory could not have been completed.

A note of thanks is also given to the staff of the Mining and Economic Geology Unit of the Geological Survey. Their assistance and suggestions in the preparation of the discussions and charts is greatly appreciated.

Jerry D. Lewis
Geologist
Mining and Economics Geology Unit

Lansing,
January, 1976

sand and gravel (-4%), cement (-5.7%), and gypsum (-21.3%), materials usually associated with the construction industry. Other minerals with lower yearly production include salt (-7.7%) and lime (-1.1%), iron ore (-6.4%), copper (-13.6%). Production of these minerals has been down, but should again increase steadily if and when the state and national economy gets back to normal.

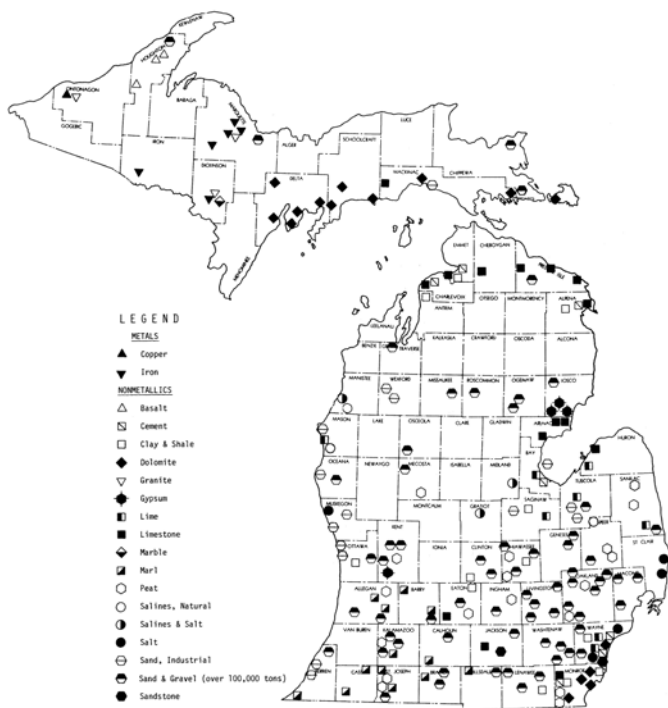
Prices on most mineral commodities are expected to increase due to inflation and higher production costs. Iron ore, petroleum and natural gas are prime examples. Iron ore was raised in price three times in 1974 and twice in 1975, with yet another price rise anticipated in the near future. During 1974 production of iron ore decreased -6.4% while value increased 43.2% over the previous year. Petroleum and natural gas increased in production 24.6% and 59.7%, whereas value increased 160% and 103%, respectively, over 1973.

The nonmetallic minerals accounted for 47% or \$497,335,605 of the total 1974 state mineral value. This was an increase of 7.5% over 1973. Metallic minerals were valued at \$369,831,837, or 35% of the total, which was an increase in value of 33.6% over the previous year. The largest advance was made by oil and natural gas. They accounted for 18% or \$190,133,924 of the total dollar value. The group increased 137% over the 1973 value.

Iron ore again led all mineral commodities with a value of \$257,943,788. Petroleum, cement, natural salines, and copper followed iron in dollar value.

Marquette leads all counties with a produced mineral value of \$213,495,883. Iron ore was the largest contributor followed by sand and gravel, and stone. Ontonagon was second with a mineral value of \$111,469,634. The leading commodity was copper, followed by silver, sand and gravel, and stone. The last of the top three counties was Wayne with a mineral value of \$69,551,591. The counties major mineral values resulted from cement, lime and salt, followed in order by stone, sand and gravel, clay, sulfur and petroleum.

MICHIGAN MINERAL OPERATIONS



[INTRODUCTION]

Introduction

Michigan's mineral industry continued on its record breaking pace for the eleventh straight year. During 1974 mineral production was valued at an all time high \$1,057,301,366. In contrast, however, the production of raw materials was down. This was especially true for

NEWS ITEMS AND DEVELOPMENTS IN 1974-75

FIELD INVESTIGATIONS

The Michigan Geological Survey has been busy the last two field seasons. The survey has been working in a cooperative effort with personnel from Michigan Tech's Institute of Mineral Research (IMR). The joint venture is conducting its program in the eastern half of the northern peninsula. The program involves the core drilling and analyses of the high purity Fiborn limestone in the Hendricks formation of the Burnt Bluff Group and the high quality Engadine dolostone of the middle Silurian Niagaran Series. The intent of the work is to evaluate potential industrial quality limestone and dolostone resources; determining their regional extent, chemical quality and reserves. Future work will involve the study of high quality Devonian age limestones in the northern lower peninsula.

Michigan Technological University is busy these days. The Institute of Mineral Research (IMR) at Tech. was awarded a \$5,000 grant by Quincy Mining Company for studies on underground leaching of native copper ores. Another project involves the study of mine drainage in Iron River - I.M.R. will conduct an 18-month study into mine subsidence and acid water drainage in the Iron River Valley. A \$62,500 appropriation to finance the study through the Department of Natural Resources was recently authorized by the Michigan Legislature. State Senator Joseph Mack, a sponsor of the project in the legislature said, "The Upper Peninsula has been plagued with cave-ins caused by underground mines and by acid too long. Michigan Tech. experts have been charged with looking for ways to clean up these kinds of pollution in our area". The Department of Geological Engineering has been awarded a one year contract by the Energy Research and Development Administration (successor to Atomic Energy Commission) to evaluate the uranium and thorium potential of precambrian rocks in Michigan and Northeast Wisconsin. In a similar move the department was awarded a grant by the U. S. Bureau of Mines to investigate Michigan's coal resources.

METALLIC MINERALS

COPPER

Renovation continues on White Pine's (Copper Range) South West Shaft. The shaft will be used for lifting men and equipment into newly proposed development areas in the southwest side of the mine.

Homestake Copper Company has been busy during the last year conducting a large exploration program in Keweenaw County. The company has flown several airborne surveys, and conducted geologic mapping and geochemical sampling, over the area. Anomalous areas have been tested by diamond drilling. No results have been reported to date.

The company is also involved in renovating several mine shafts in the area to conduct subsurface mineral exploration. At the Centennial Mine deepening and development of the number 6 inclined shaft continues at a slower than anticipated rate. The inclined shaft is presently near the 6600 foot mark. Completion of the shaft is contemplated sometime in the Fall of 1976. Development and exploration drifting are planned after the shaft is completed.

The company has reconstructed the Seneca mine down to the second level for the U. S. Bureau of Mines. The Bureau people are conducting drilling and blasting studies in an attempt to improve mining technology.

In another activity Homestake has joined forces with the Quincy Mining Company. They plan on doing subsurface exploration in the old Quincy Mine. The work will be done on the tenth level of the old No. 8 shaft. At present the hoist engine is in place, and the engine house, headframe and collar have all been reconstructed. They plan on having the engine running by December 1, 1975. Diamond drilling is scheduled to start in April after the shaft is renovated.

Investigations into potential Copper deposits in Kona dolomite were increased in 1974 by Cleveland Cliffs. Extensive field surveys have been conducted, and a course of action for the development of a joint venture is being carefully considered.

GOLD

Reopening of an old gold mine may soon be a reality. The old Ropes gold mine located north of Ishpeming was recently sold by local investors to the Callahan Mining Company of Darien, Connecticut. Several companies bid for the mine but Homestake was the only company promising to undertake mining operations. With today's gold prices and efficient mining methods the company hopes to mine more than \$1 million worth of gold it estimates are still present. The Ropes mine was originally opened in 1883 and ran until 1897 when the mine went bankrupt. Over \$700,000 of \$28 per ounce gold was mined during that period.

IRON

Exploration for base, precious and radioactive minerals continues at a stepped up pace. The Beth-Cliffs joint venture are continuing to explore for non-ferrous minerals in the Lake Superior region. The venture between Bethlehem Steel Company and Cleveland Cliffs Iron Company was formed to explore various geologic environments in Upper Michigan and Wisconsin. The venture has done extensive airborne and ground geophysics, geochemistry and geologic mapping in the western upper peninsula. Several areas have been tested by diamond drilling. The exploration and drilling program is expected to continue through 1975.

The Mather Mine is nearing an all time production record for north American mines as the 50 millionth ton of iron ore was lifted from the mine on May 12, 1975. Only the "various ownership" property of the Norrie-Pabst-Aurora

group at Ironwood produced more iron ore (53,802,316 gross tons) until being closed in 1935. The Mather Mine is solely owned by the Negaunee Mining Company and is operated by Cleveland-Cliffs Iron Company.

Commercial operations began at the mine in February of 1944 and have continued since.

Cleveland-Cliffs Iron Company, operators for the Tilden Mining Company, formally dedicated the Tilden Mine and mill in mid-August. The Tilden Project cost CCI and associated partners \$200 million. The mine is expected to produce 4,000,000 gross tons of pellets annually with future anticipated expansion pushing the total to around 12,000,000 tons annually. The ore reserve is estimated to be large enough to produce more than 360,000,000 tons of pellets.

At the adjacent Empire Mine recent expansion work was completed around the first of the year. The new expansion boasted production of pellets by 1,800,000 tons to an annual rate of 5,300,000 gross tons. The expansion required a capital investment of \$67 million. Consideration is now being given to an additional 2.8 million ton expansion.

Cleveland-Cliffs Iron Companies future expansion plans hinge on construction of three additional 80 Mw power units at Marquette's Presque Isle Station. H. Stuart Harrison, CCI chairman said, "Expansion of the Tilden, south of Ishpeming, and the Empire, located in Palmer, would add 500 permanent jobs by the late 1970's but construction of the power units is essential to any expansion plans". He also said the Tilden Mine and pelletizing plant are presently running at 70 to 75 percent capacity, attributing the low production to problems with electronic equipment at the newly-opened project. However, he said CCI is confident they will get the Tilden running flat out before the end of the 1975 year.

The demand for iron ore is still strong, according to Cleveland-Cliffs officials. The company will probably have a record year during 1975. Cliffs' Marquette Range properties consisting of one underground and three open-pit mines and four beneficiation and five pelletizing plants will produce an all time high of more than 14 million tons of pellets. A new high of 3,800 to 3,900 persons will be employed by the company during 1975. In addition the company payroll reached \$43,276,193 during 1974 and is expected to climb to a new record of \$50,000,000 during 1975.

Cleveland-Cliffs officials say that it is conceivable that there will be another Tilden-type project on the Marquette Range during the next five years. Preliminary exploration results on the Cascade East iron formation have been very promising to date. Studies are presently underway to study the availability of fuel, possible plant and tailings discharge locations, and the length of life of the iron formation, amongst others. The new cascade project is located east of the Empire Mine near Palmer.

URANIUM

The Tennessee Valley Authority (TVA) is backing an exploration program for uranium in the upper peninsula. The TVA has hired David S. Robertson and Associates of Blind River, Ontario to conduct the investigation. A spokesman for the Robertson Company said their principle area of investigation is on the land west from Marquette to Iron River. The Detroit Free Press has recently printed an article stating the company has applied for a uranium lease. This is the first known uranium exploration since the Kerr McGee Company flew an airborne survey in the same area three years ago.

NONMETALLIC MINERALS

CEMENT

Martin-Marietta Cement Company has announced the consolidation of its Great Lakes Division in Michigan with the Midwest Division located in Iowa. The new unit will be known as the Northern Division and will be located in Davenport, Iowa. In other developments the company plans on introducing imports of clinker from Canadian and Spanish sources to its Bay City plant. Lake Ontario Cement will supply the plant with \$20 million worth of clinker as provided in a new contract to be signed in April 1976. Further developments by the company include the proposal for two new wet process kilns at its Bay City plant. Kaiser Engineers are in the process of drawing up plans for the kilns and related facilities.

Huron Cement's Alpena plant is scheduled to go on line in late 1975 with new replacement equipment for 12 old small kilns. New equipment includes two 17 X 19'6" X 500' Fuller rotary dry-process kilns with clinker coolers. Two Wheelabrator-Frye glass baghouses for the new kilns are now in place.

The Federal Trade Commission has given final approval to a federal court order requesting St. Lawrence Cement Company to divest itself of the Wyandotte Michigan Cement Division acquired three years before from BASF Wyandotte.

COAL

The first coal mining operation to commence since the closing of the Swan Creek Mine in 1952 near Unionville, Saginaw County, was opened by the Michigan Aggregates Corporation. The company reopened a coal strip mine near Williamston in early February 1975. The mine was originally closed in the 1930's. The present mine is located on approximately 5 of the 80 acres the company holds. The coal is presently being used by a local electric generating utility in Lansing. Six men are presently employed full time.

NATURAL SALINES

Martin-Marietta Chemicals will reopen a magnesite plant on South Saginaw Road in Midland. The plant will produce a form of magnesium oxide used to maintain steel producing furnaces. It will employ 35 to 40 people

with an estimated annual payroll of \$600,000. The plant has been idle since 1971 when Kaiser Aluminum and Chemical Company shut down operations.

PETROLEUM

DNR Director Opposes Great Lakes Oil Exploration. The director of the Department of Natural Resources (DNR) is opposed to a request from a Canadian firm to be allowed to explore for oil in Lakes Erie, Huron and Michigan. Kenting Exploration Services, Ltd., of Calgary, Alberta, has asked for permission to take seismic soundings, normally a preliminary to drilling. The firm wrote to DNR Director Howard Tanner that the soundings could help locate nearby oil pools inland. Tanner says that DNR will not permit exploration for oil and natural gas in Michigan's portion of the Great Lakes. The Natural Resources Commission, DNR's policy making body, supported Tanner's decision. Once drilling firms obtain evidence of oil pools under the lakes, Tanner said that it would become politically more difficult to continue the drilling ban.

SAND AND GRAVEL

The first phase of American Aggregate's construction of a sand and gravel processing plant in Milford (Oakland County) is nearing completion. The pit area, dredge, and desander are placed and ready to begin operation. The second phase, the modified plant production equipment, is scheduled for completion in early fall of 1975, thus completing the construction program. The production from this plant will supply the market during the relocation of the Brighton plant, which is in the same general area.

STONE

During June a new stone cargo record of 35,256 net tons was set by the M/V H. Lee White of the American steamship Company. The self unloader carried dolomite from Port Dolomite Michigan to Conneaut, Ohio. The vessel is 704 feet long with a beam of 78 feet and a depth of 45 feet. The White joined the ASC fleet in mid 1974.

MISCELLANEOUS

Year around shipping on the Great Lakes has been called a success. During the past winter twenty-four vessels operated into January and sixteen into February on the Great Lakes. Army Brig. Gen. Walter Bachus, chairman of the Great Lakes -St. Lawrence Seaway Winter Navigation Board, said another year of tests will be made before recommendations go to Congress. Once Congress approves, he said, hardware permitting year round shipping could be in place within a couple of years. He predicted that the St. Lawrence Seaway could be opened to 12-month ocean traffic in a decade.

Metallic Mining Operations

COPPER

The Lake Superior copper district of Michigan was the first American copper field of importance and now is one of the oldest of the leading copper producing districts in the world. While the copper-bearing formations of Lake Superior outcrop to the east in the Algoma district in Ontario, and to the west traverses northern Wisconsin, the larger productive mines lie wholly within the limits of Michigan.

Although copper sulfides are extensively mined at the White Pine mine of the White Pine Copper Company, the most intriguing ore mineral in the region is the unique native copper. Michigan is fortunate to be one of the very few places in the world where pure native copper exists in any quantity. The discovery and primitive use of the native copper has been assigned to the aboriginal people commonly termed "The Moundbuilders". These tribes known as the Adena and Hopewell cultures had evidently used the copper for tools, weapons and ornamental uses. It is speculated that these people found the pieces of copper in stream beds or lying loose as float on the surface. Later, after it became increasingly difficult to find free copper, the Indians worked shallow pits where copper-bearing rock outcropped. The Mound-builders in North America lived as much as 8,000 years ago and it is to their credit that many of the pits they worked eventually resulted in productive mines. It is interesting to note that the Ojibways, who were the inhabitants of the southern shore of Lake Superior knew very little of the copper deposits and when questioned by the first white men to visit the area, had no legends regarding the mining done by their predecessors.

The first white man to actually see the pure copper in place was Father Claude Allouez who was a French Jesuit Priest. Soon after Father Allouez reported the copper, Father Marquette and Father Mesnard visited the Lake Superior area. However, the Jesuits purpose was the conversion of the natives to Christianity and not to mine copper.

Although minor attempts by the French and English were made to try to develop the copper deposits, nothing of much merit resulted until about 175 years later. In 1841 Dr. Douglass Houghton, after exploring and mapping the copper-bearing area for the State of Michigan published a report dealing with the economic potential of the 400 square mile area now known as "Copper Country". Dr. Houghton who by then had become the first State Geologist and Chief of the Geological Survey of the newly-formed State of Michigan, intended to promote the development of the copper deposits but at the same time, wished to avoid the inevitable avalanche of ill-prepared prospectors by stating that, "I would caution those persons who would engage in this business in the hope of accumulating wealth suddenly and without

patient industry and capital, to look closely before the step is taken."

Dr. Houghton's warnings were wise, well-intended, carefully written and as is usually the case where potential wealth is involved, generally unheeded. By March 1843 America's first mining boom was under way and many hopeful miners were arriving and staking mining locations. Later that year a federal land office was opened at Copper Harbor to process the growing number of claims. Since many of the prospectors reaching the area had no mining experience, it would be reasonable to assume that they were also unaware as to how to go about surveying location boundaries. The latter was evidently the case as the mining locations were of immense area and individual claim lines overlapped causing much confusion and most likely very heated arguments among the prospectors. Needless to say, the Federal Land Office, became inundated with miners wanting to gain mineral leases so that mining could begin as soon as possible. The entire leasing procedure became so confusing that the Land Office ended up selling the mineral lands outright to the prospectors.

By 1844 more inexperienced mineral seekers had arrived in the copper country. However, along with the novices, came some professional mining men. Among the latter group perhaps the most notable were the Cornishmen. The Cornishmen were the first real miners to reach the district and it is no small coincidence that the first actual mining began shortly after their arrival.

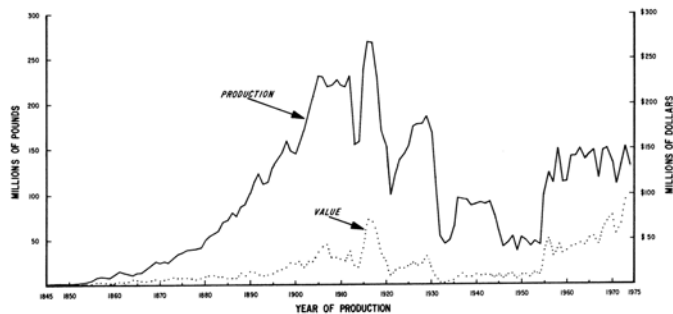
The first mine to open in 1844 extracted only a few tons of ore taken from a copper sulfide vein deposit near Copper Harbor but the operation was short-lived and was quickly abandoned. During the following year however, a company discovered a vein near Eagle River on a greenstone cliff. The vein widened near the base of the cliff and an adit was driven into the vein. Soon after the adit was underway, workers encountered the first mass of native copper thus confirming that the float copper in the area was indeed derived locally. The mine, known as the Cliff marked the first deposit found by systematic mining and also marked the first mine in the world to mine native copper. The Cliff mine had repaid the initial investment to its backers and in 1849 paid its first dividend to its stockholders.

Nearly all of the early miners worked the fissures or vein-type massive native copper deposits. The stratified, disseminated native-copper and copper sulfide deposits in the shales, conglomerates and lavas which are presently mined, were neglected in the early years. Even though the lower grade, higher volume deposits were initially neglected due to a lack of fissures and veins, the mining had to begin at some point and, as is the case in any new mining district, the more accessible high grade ore is extracted first.

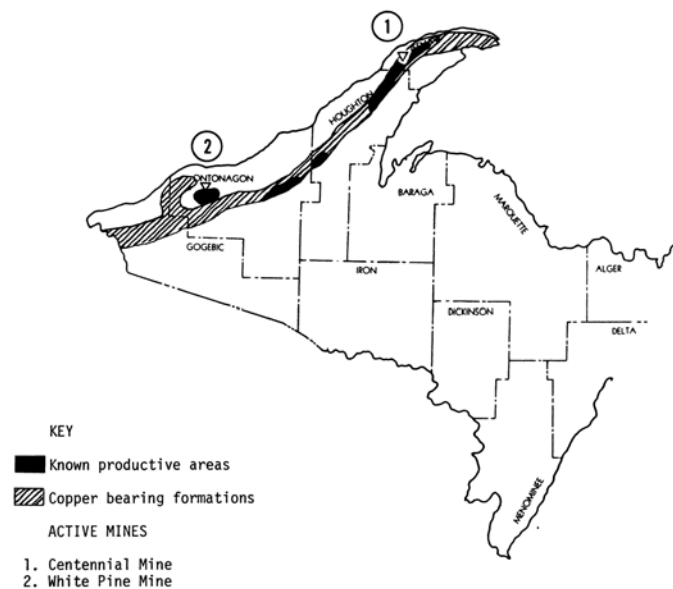
Michigan copper production has continued to grow from the initial production of about 4,000 pounds of copper in 1844 to 131,037,602 pounds in 1974. The growth of

Michigan copper production has indeed had its peak and valleys. Initially, and continuing until 1887, Michigan was the nation's main source of copper. Although the Lake Superior copper no longer holds such prominence when compared to the large western operations, the area is still believed to contain the largest "inferred" reserve source of copper in the country. Should modern exploration, mining and milling methods continue to improve, Michigan may again become one of the leading producers of copper in the nation.

PRODUCTION AND VALUE OF MICHIGAN COPPER 1845-1974



MICHIGAN COPPER RESOURCES AND MINES



IRON

One of the most basic commodities required for an industrialized nation is iron. Without this metal a country would have little choice but to remain in endeavors centered around agriculture rather than to progress into a more mechanized industry-oriented society. From about 1760 to the mid 1800's the United States had limited supplies of high-grade iron ore deposits. However, too often the demand outstripped the supply and hence America seemed destined to an economy centered on agricultural products. The discovery of the great iron ore deposits in the Lake Superior Region was undoubtedly the greatest single factor in shaping the century which followed.

The earliest discoveries of commercial deposits of iron ore were made at Negaunee, Marquette County, Michigan, in 1844. A party of federal surveyors under the direction of William A. Burt encountered difficulties in surveying owing to deflections of their compass needles. It was soon determined that the deflection was caused by the magnetic attraction of beds of iron ore. Upon learning of extensive iron deposits, twenty citizens from Jackson, Michigan, formed The Jackson Iron Company and in 1845 under the direction of P. M. Everett of Jackson, opened the Jackson Pit. The first iron shipment consisted of two hundred pounds of ore. The ore shipped during 1846 to Jackson, Michigan. A local blacksmith converted the ore into iron - the first iron derived from Lake Superior ore.

Initial discoveries for the various mining districts or ranges are as follows:

The Marquette Range - Negaunee, Michigan in 1844.

The Gogebic Range - Between Hurley and Melen, Wisconsin, in 1848.

The first ore found on the Michigan side was at the Colby mine at Bessemer, Michigan, and had its first shipment in 1884.

The Menominee Range - Old Menominee at Iron Mountain, Michigan in 1848.

- New Menominee at Stambaugh and Crystal Falls, Michigan in 1851.

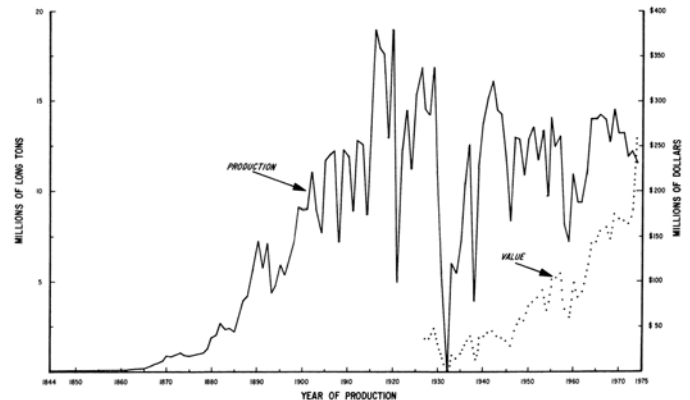
Michigan iron mining has grown from the first shipment of a scant 200 pounds of ore in 1846 to 993,000,000 tons in 1974. This later figure could not have been so large were it not for an ore - milling process called beneficiation.

Since iron mining commenced in Michigan's iron ranges, the various mining companies were extracting ore that would average as much as 55 percent iron. However, after nearly one hundred years of mining, the high grade ore became depleted. The rich iron ore in that period of time, had brought this country through two major wars and helped raise our standard of living to such a high level that no other country could be considered our equal. Yet the demand for more iron and steel increased every year. Knowing that the high-grade iron ore reserves were running out, mining companies conducted research into the possible use of the great untapped reserve of lower ore grades in the United States. Much of the untapped reserve had an iron content of 30 to 40 percent or less. The concern of the mining companies was how to keep the cost of beneficiation of low-grade ores low enough to compete with natural high-grade ores. From foreign markets.

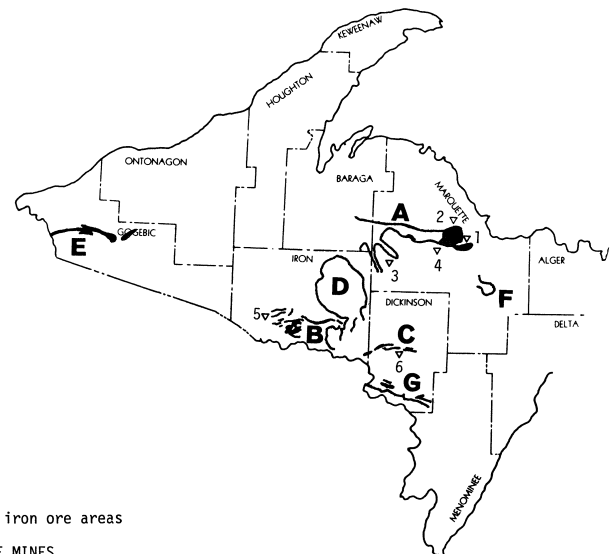
After much work, a process was derived wherein low-grade ores could be processed economically. The process consisted of finely crushing and then separating the iron ore from its host rock. The separated iron ore was then concentrated into pellets having an iron content of 55 to 60%.

The process of beneficiation therefore has effectively guaranteed the nation a steady future supply of iron ore for hundreds of years.

PRODUCTION AND VALUE OF MICHIGAN IRON ORE 1844-1974



MICHIGAN IRON RESOURCES AND MINES



KEY

Known iron ore areas

ACTIVE MINES

- A. MARQUETTE RANGE
 - 1. Empire-open pit
 - 2. Mather-underground
 - 3. Republic-open pit
 - 4. Tilden-open pit
- B. IRON RIVER CRYSTAL FALLS DISTRICT
 - 5. Sherwood-underground
- C. FELCH DISTRICT
 - 6. Groveland-open pit
- D. AMASA OVAL DISTRICT
 - Inactive
- E. GOGEBIC RANGE
 - Inactive
- F. GWINN DISTRICT
 - Inactive
- G. IRON MOUNTAIN RANGE
 - Inactive

Nonmetallic Mineral Operations

CEMENT

The cement industry in Michigan began in 1872 when the Eagle Portland Cement Company built a cement plant about two miles northeast of Kalamazoo, Michigan. The factory continued to produce cement until about 1882, at which time the factory closed down and dismantled the equipment. Fourteen years would elapse before another venture into the cement business took place. The manufacture of cement began in earnest with the forming of three companies starting in 1896. The first company was the Peerless Portland Cement Company which began in Union City. It was followed by the Bronson Portland Cement Company at Bronson in 1897, and the Michigan Portland Cement Company at Coldwater, in 1898.

During 1897 the production from the infant cement industry was 7,520 tons, all of which came from the Peerless Portland Cement Company. More cement was being manufactured than was being used during the first few years of operation. Workers in the construction industry used the cement mainly for sidewalks and building foundations. As more uses were found for cement, new companies formed and the industry began to grow. It grew steadily throughout the 1900's.

Today, Portland cement has become as essential to the modern construction industry as lumber was at the turn of the century. Michigan now ranks fourth in the nation in production of cement. During 1974 Michigan cement companies produced over 6.1 million tons of cement valued at nearly \$147 million.

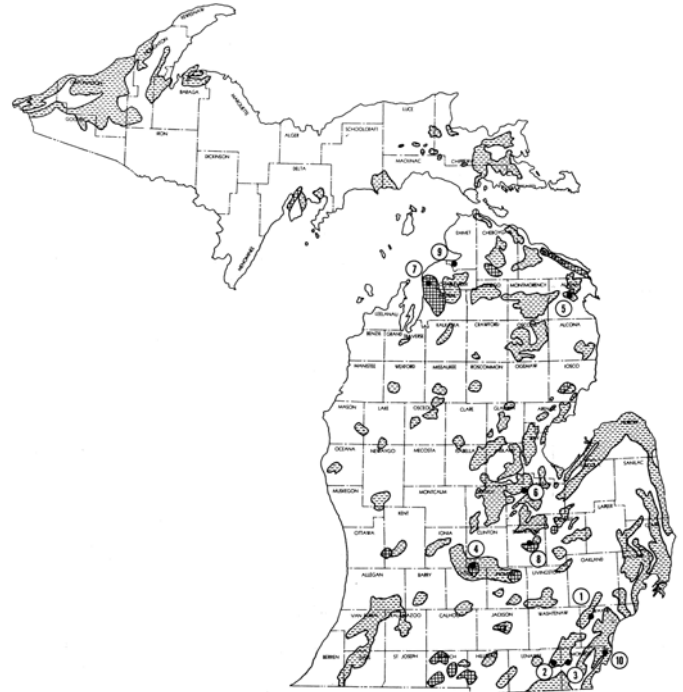
MICHIGAN CEMENT PLANTS



Materials needed for the manufacture of Portland Cement include a mixture of finely pulverized limestone or marl, gypsum, and clay or ground shale. This mixture is heated to extreme temperatures thus forming a "clinker". The clinker is ground into a fine powder we know as cement.

CLAY AND SHALE

MICHIGAN CLAY AND SHALE RESOURCES AND MINES

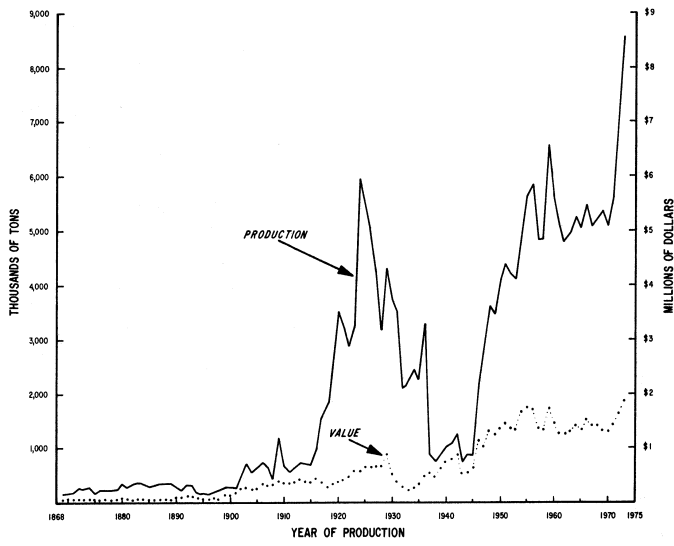


KEY

- Known clay areas
- Known shale outcropping

GYPSUM

PRODUCTION AND VALUE OF MICHIGAN GYPSUM 1868-1974

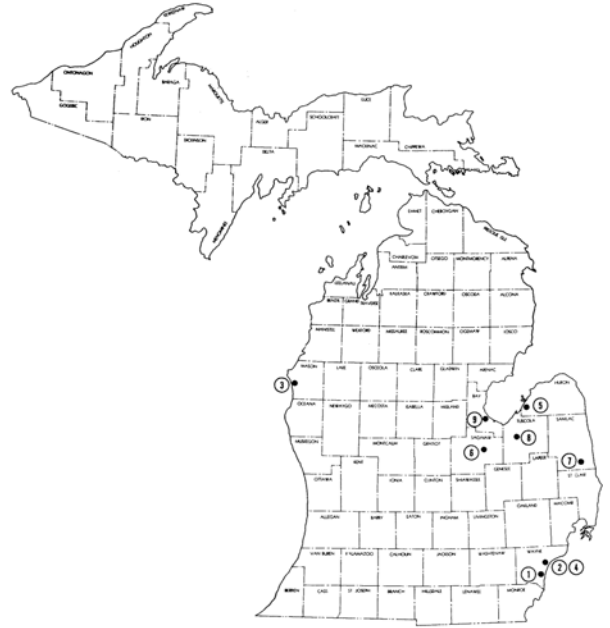


MICHIGAN GYPSUM MINES



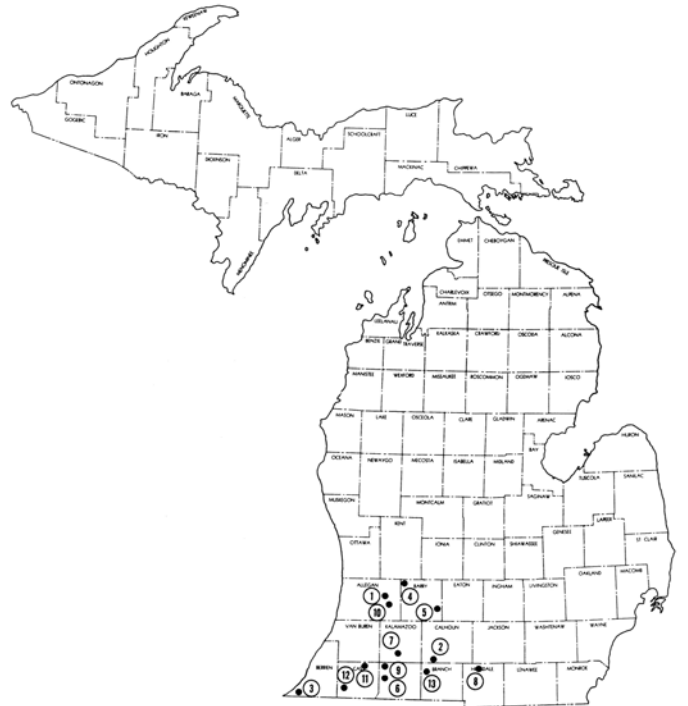
LIME

MICHIGAN LIME PLANTS



MARL

MICHIGAN MARL PITS



NATURAL SALINES

While Michigan's salines or natural brines have been a commercial source of sodium chloride or common salt since the middle 1800's, it was only during the first years of this century that they became an equally important source of additional elements and compounds. In the early days of the industry, the bitterns or "mother liquors" resulting from the production of salt were discarded even though it was realized these solutions were rich in bromine and other chemical values. The increasing sophistication of the science of chemistry and brine processing which came with the turn of the century led numerous companies, large and small, to install the necessary equipment and processes to extract and market these formerly wasted products.

Soon such large quantities of bromine and the other chemicals were being produced that over supply quickly resulted in severe price erosion. At about the same time the German chemical cartels entered the market and prices were driven so low that just prior to World War I the production of bromides and calcium chloride was almost completely abandoned by the majority of operators. The Dow Chemical Company of Midland, however, continued to produce large quantities of bromine and other chemicals and, with the advent of World War I, increasing demand for chemicals and the exclusion of Germany from the world market caused dramatic price increases which revitalized the brine chemicals industry in Michigan.

MICHIGAN BRINE PLANTS



The most common chemicals presently extracted from natural brines are: bromine, iodine, calcium chloride, and magnesium compounds. The end products resulting in whole, or in part, from these constituents are numerous

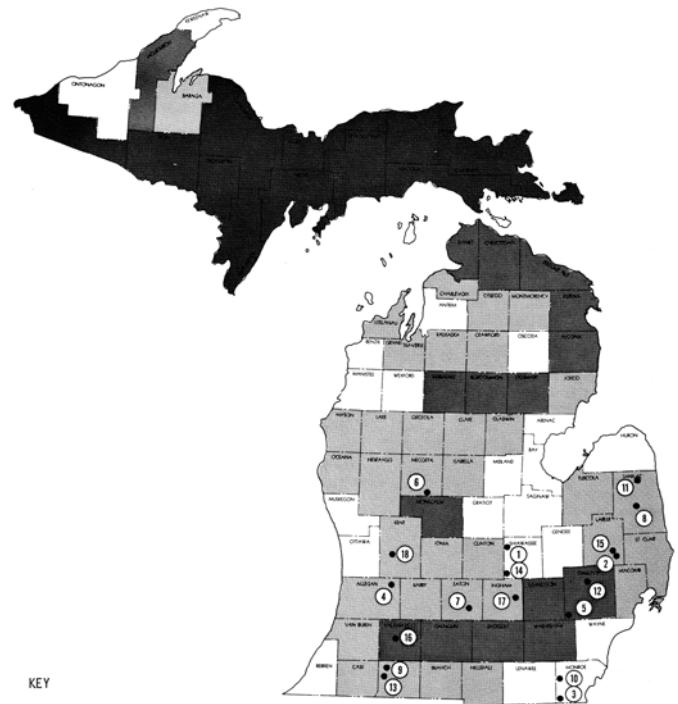
and new uses, compounds, and combinations are constantly being developed.

The source beds of the commercial natural brines of Michigan are commonly the Filer and Sylvania sandstones of middle Devonian Age (Detroit River Group). The more concentrated of these brines are available only to moderately deep drilled wells which must be pumped to bring the raw product to the surface for settling, treating, and processing.

Michigan presently ranks first among the states in the production of natural salines and indications are that this position will be maintained for many years to come.

PEAT

MICHIGAN ORGANIC SOIL RESOURCES AND OPERATIONS



KEY

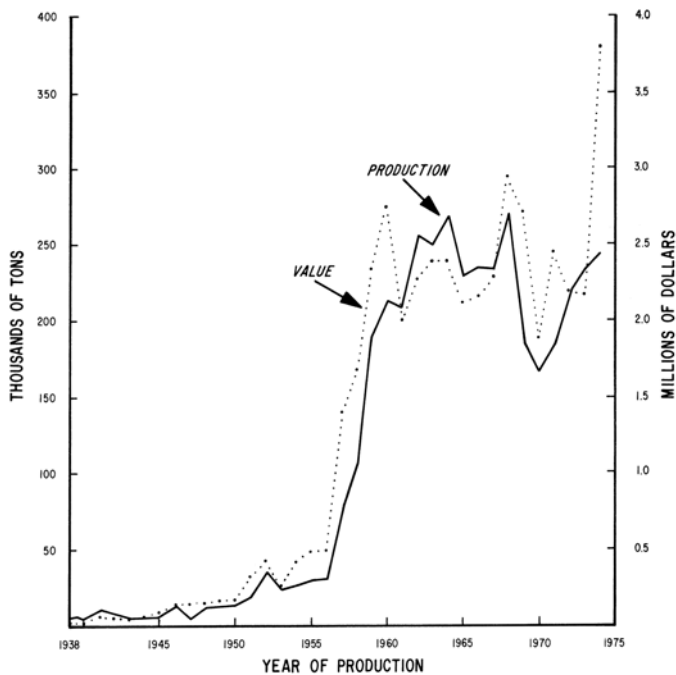
COUNTY ACREAGE OF ORGANIC SOILS

- Up to 25,000
- 25,000 to 50,000
- 50,000 to 100,000
- 100,000 and Greater

Organic soil contains 20% to 30% or more organic matter one foot or more in depth.

Source: "Organic Soils" Special Bulletin 425, 1959
Dept. Soil Science, Agri. Exper. Sta., Michigan State University

PRODUCTION AND VALUE OF MICHIGAN PEAT



Sand and gravel is produced mostly from glacial deposits which cover much of the state. Commercial deposits are generally confined to glacial outwash, eskers and glacial lake shore lines. Other deposits of local importance are river terraces, kames and deltas.

Leading sand and gravel producing counties during the year (over 2 million tons) were Oakland, Kalamazoo, Ottawa, Livingston, Kent and Washtenaw. Together these counties contributed 50 percent of the state total sand and gravel output. Michigan continues to rank second among the contiguous states in the production of sand and gravel. Production during 1974 was 60,073,000 short tons or about 6 percent of the national total.

CONSTRUCTION SAND AND GRAVEL

Perhaps the most widespread mineral commodity that exists in Michigan is construction sand and gravel. In addition to being the most widespread commodity, it is by far the most easily accessible. Michigan received her last shipment of sand and gravel nearly 15,000 years ago when the last glaciers began to melt and retreat. This huge ice sheet left behind millions of tons of sand and gravel which were locked up within it.

Construction sand and gravel is used largely for fill material, concrete aggregate and road use. It is probably obvious to the reader that construction sand and gravel is not used in the variety of ways as are natural salines, nor does it stir one's imagination as does the mining of gold or copper. It is interesting to note, however, that the 1974 value of Michigan's construction sand and gravel deposits exceeded 70 million dollars.

The construction sand and gravel business had a relatively meager beginning. Small operators in the early 1900's extracted only a few hundred thousand tons per year. As the demand increased sand and gravel operations expanded and eventually grew into a relatively large industry.

Considering the vast amounts of construction sand and gravel known to exist on Federal, State and private lands, Michigan shall continue to have an abundant supply of construction sand and gravel for generations to come.

INDUSTRIAL SAND

Michigan leads the nation in the production of industrial sand. Nine sand mining companies produce more than 40% of the sand used by the foundry industry. In Michigan alone, more than 90% of the sand produced is used by the automotive and associated industries. During 1974 Michigan produced nearly 4.6 million tons of industrial sand with a value over \$12 million.

Most of the industrial sand production is from the sand dunes found along the Lake Michigan shoreline. Secondary production comes from other sources found in Wexford County and the Saginaw Bay area. These

SALT

MICHIGAN SALT PLANTS AND MINE

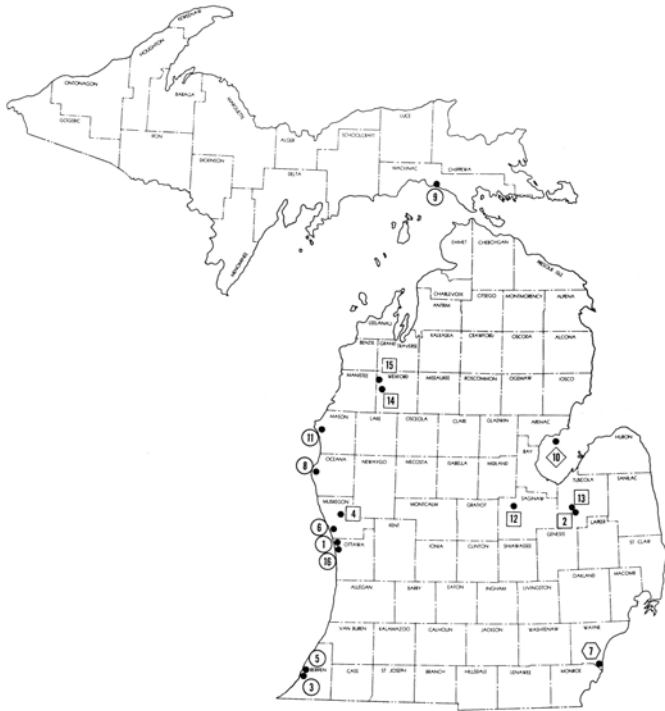


SAND AND GRAVEL

Geographically the sand and gravel industry is concentrated around expanding urban areas, in areas of highway, bridge, dam and other large scale public and private construction projects.

sands generally have similar grain sizes ranging from .5 mm to 1 mm in size. The grains are well rounded and composed mostly (95+ percent) of silica. Sand mining companies prefer to mine this type of sand because of the large volumes available, the economic cost of mining and processing, and the nearness to major transportation facilities. The sand is in demand by the foundry and other minor industries because of its physical and chemical properties, and low purchase price.

MICHIGAN INDUSTRIAL SAND OPERATIONS



- KEY
- ◇ Dredging Operations
 - Dune Sand Operations
 - Inland Sand Operations
 - ◻ Sandstone Operations

STONE

Stone is an important Michigan product consisting mostly of limestone and dolomite with lesser amounts of sandstone, basalt and marble.

The principle limestone and dolomite quarry operations are located at Rogers City and Presque Isle in the northern Lower Peninsula and near Gulliver, Cedarville and on Drummond Island in the eastern half of the Upper Peninsula. Several steel companies own quarries which are mined mainly for flux stone in the manufacture of steel at down-lake steel centers. Other stone shipped include stone for lime burning, the manufacture of Portland cement, stone aggregate and for chemical use.

Quarries operated solely for the manufacture of Portland Cement are at Alpena, Charlevoix and Petoskey in the

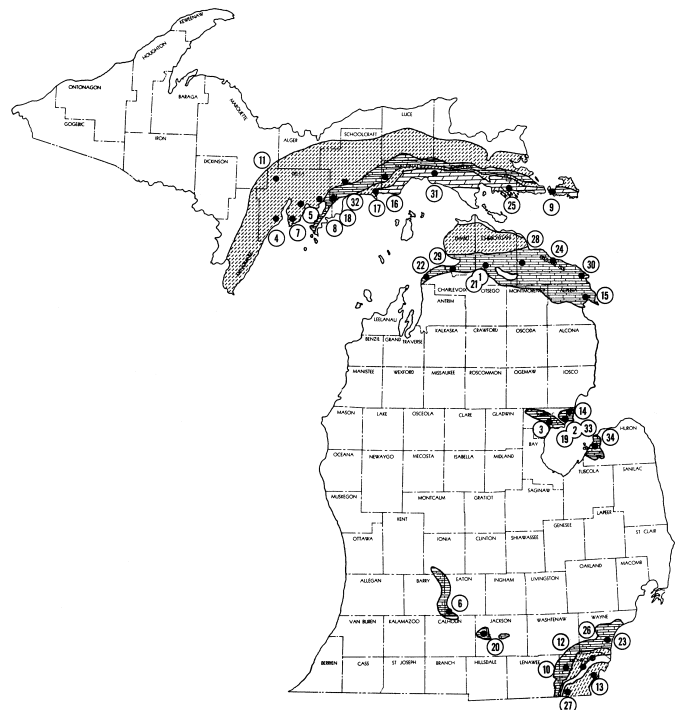
northern portion of the Lower Peninsula and at Dundee in the southeast part of the Lower Peninsula. Numerous smaller limestone and dolomite operations are present locally throughout much of the state where the rock is at or near enough to the surface to permit quarrying. The stone aggregate produced is largely for construction and maintenance of state and county roads.

In addition to limestone and dolomite, sandstone is quarried at Napoleon and sold for a number of uses including building front construction, flagstone and stone for retaining walls. At Rockwood a very white pure silica sandstone is quarried and sold for glass manufacture and foundry use. Other stone quarried include white marble, pink feldspar and black amphibolite. Deposits of these rocks are in Dickinson County in the Upper Peninsula. Much of the stone produced is used for landscaping purposes, with smaller quantities also being sold for terrazzo and ornamental concrete use. Basalt and waste mine rock is processed for stone aggregate material in Marquette and Ontonagon Counties in the Upper Peninsula.

Michigan ranks 7th among the states in stone production. Production during 1974 amounted to nearly 48 million tons or about 5 percent of the nations total.

LIMESTONE AND DOLOMITE

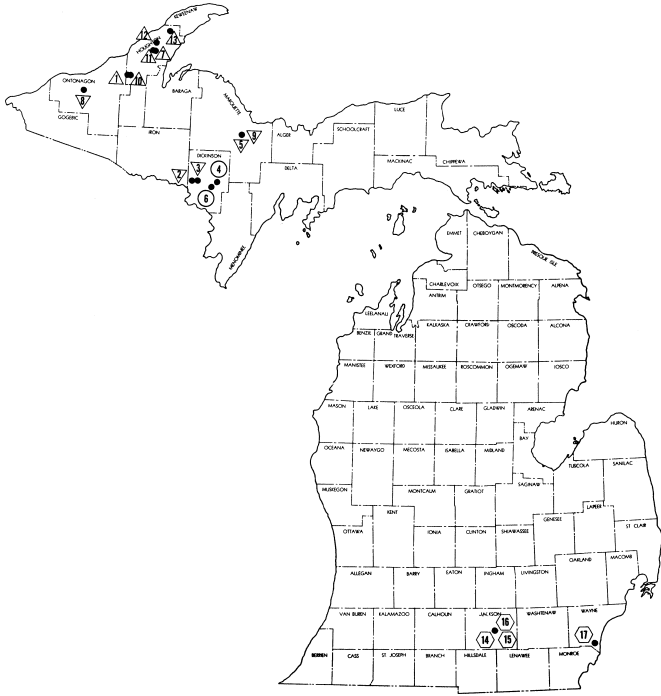
MICHIGAN LIMESTONE AND DOLOMITE RESOURCES AND QUARRIES



- KEY
- ▨ Areas of Industrial quality dolomites
 - ▩ Areas of Industrial quality limestones
 - ▧ Areas of other limestones and dolomites

MISCELLANEOUS STONE

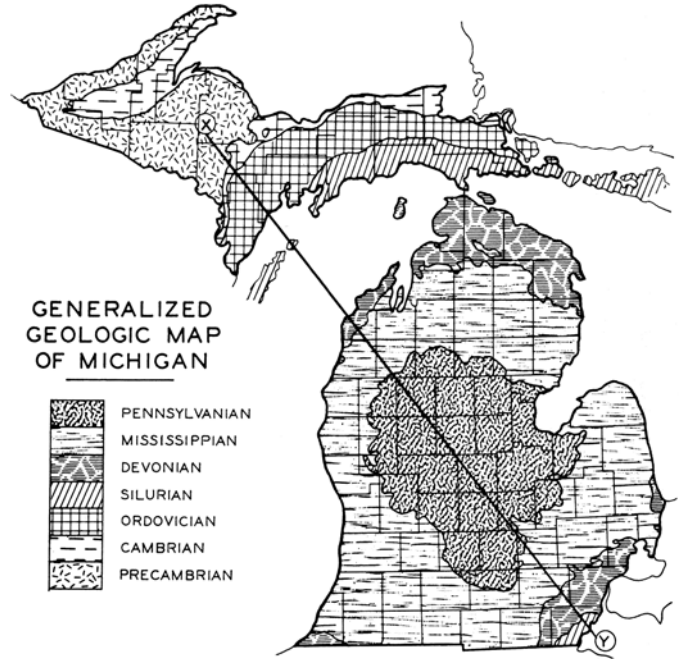
MICHIGAN MISCELLANEOUS STONE AND SANDSTONE OPERATIONS



- KEY
- MISCELLANEOUS STONE
- ▽ Granite or rhyolite
 - Marble
 - △ Trap rock (basalt)
- SANDSTONE
- ⬡ Sandstone operations

GENERALIZED GEOLOGIC MAP OF MICHIGAN

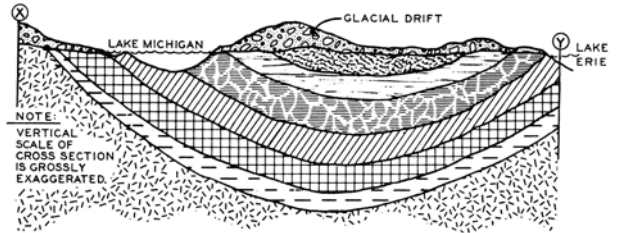
Selected Minerals By Geological Formation



GENERALIZED GEOLOGIC MAP OF MICHIGAN

- PENNSYLVANIAN
- MISSISSIPPIAN
- DEVONIAN
- SILURIAN
- ORDOVICIAN
- CAMBRIAN
- PRECAMBRIAN

CROSS SECTION X-Y



MICHIGAN DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY DIVISION
TECHNICAL STAFF

Arthur E. Slaughter, *State Geologist & Chief*

ECONOMIC AND ENVIRONMENTAL GEOLOGY SECTION

Robert C. Reed, *Section Chief*

MINING AND ECONOMIC GEOLOGY UNIT

Harry O. Sorensen, *Geologist in Charge*

ECONOMIC GEOLOGY

Wm. A. Walden, *Supervisor-Geologist*

Milton A. Gere, *Geologist*

MINE RECLAMATION

R. Thomas Segall, *Supervisor-Geologist*

GEOLOGY AND MINERALS RESEARCH UNIT

Jerry D. Lewis, *Geologist*

David W. Snider, *Geologist*

MINERAL WELLS UNIT

Robert E. Ives, *Geologist in Charge*

Raymond Ellison, *Geological Engineer*

Elmore E. Eltzroth, *Test Wells Geologist*

Alford Rarick, *Mineral Wells Geologist*

GENERAL GEOLOGY UNIT

Irvin V. Kuehner, *Geologist in Charge*

GROUNDWATER GEOLOGY UNIT

Richard P. Bissell, *Geologist in Charge*

GEOHYDROLOGY

Wm. M. Iversen, *Supervisor-Geologist*

Innaiah Pothacamury, *Geologist*

James Heinzman, *Geologist*

Richard E. Kimmel, *Geologist*

GLACIAL AND ENVIRONMENTAL

Dorothy Skillings, *Supervisor-Geologist*

Christine Iversen, *Geologist*

OIL AND GAS SECTION

Robert M. Acker, *Section Chief*

HEARINGS UNIT

Wm. C. Fulkerson, *Hearings Examiner*

PETROLEUM GEOLOGY UNIT

Garland D. Ells, *Geologist in Charge*

Beverly L. Champion, *Petroleum Geologist*

D. Michael Bricker, *Petroleum Geologist*

Richard Lilienthal, *Petroleum Geologist*

Darrell D. Hodge, *Cartographic Draftsman*

Gregory A. Wilson, *Cartographic Draftsman*

PRODUCTION AND PRORATION UNIT

James Lorenz, *Geologist in Charge*

Floyd Layton, *Geologist, Field Operations
Coordinator*

Arthur D. Matzkanin, *Proration Engineer*

Ronald J. Pollom, *Proration Geologist*

Steven E. Wilson, *Proration Geologist*

REGULATORY CONTROL UNIT

V. F. Sargent, *Geologist in Charge*

Samuel Alguire, *Geologist, Field Operations
Coordinator*

FIELD OFFICES

REGION I - MARQUETTE

Jack VanAlstine, *Regional Geologist*

ESCANABA FIELD OFFICE

Kenneth Gravelle, *Supervisor-Geologist*

Donald Brackenbury, *Geologist*

REGION II - ROSCOMMON

Sydney Dyer, *Regional Geologist*

Paul Daniels, *Mineral Wells Geologist*

CADILLAC FIELD OFFICE

Russell Wiles, *Supervisor, Field Investigator*

John Snider, *Regulatory Geologist*

Derek, Stadler, *Field Investigator*

GAYLORD FIELD OFFICE

Billy G. Ellis, *Supervisor-Geologist*

Joseph Davis, *Regulatory Geologist*

Jerry Wendel, *Regulatory Geologist*

GRAYLING FIELD OFFICE

Daniel Bertalan, *Supervisor-Geologist*

MOUNT PLEASANT FIELD OFFICE

Benjamin Gunning, *Supervisor-Geologist*

Wm. E. Booker, *Regulatory Geologist*

Melvin Greenwald, *Field Investigator*

G. Ervin Lamb, *Regulatory Geologist*

Michael Moss, *Regulatory Geologist*

Robert Pinaire, *Regulatory Geologist*

REGION III - LANSING

John Byerlay, *Regional Geologist*

LANSING FIELD OFFICE

Allan B. Collins, *Supervisor-Geologist*

James Duszynski, *Regulatory Geologist*

Harold R. Fitch, *Regulatory Geologist*

Thomas A. Godbold, *Regulatory Geologist*

PLAINWELL FIELD OFFICE

Harold Rickard, *Supervisor, Field Investigator*

Max Crego, *Field Investigator*

Alfred C. Medendorp, *Regulatory Geologist*

IMLAY CITY FIELD OFFICE

John Manners, *Supervisor-Geologist*

Michael Cote, *Regulatory Geologist*

Bruce J. Waldo, *Regulatory Geologist*

