

THE DEPARTMENT OF  
CONSERVATION  
STATE OF MICHIGAN



Geological Survey Division

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NINETEENTH BIENNIAL REPORT  
1957-1958



GEOLOGICAL SURVEY DIVISION

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Procedures for obtaining data on the mineral resources of the State, processes of interpreting the information and finally making the determination of the best uses of the minerals available for public use, were expanded and improved during the biennium.

Distinct progress was made in learning about the general geology of the Northern Peninsula. Field and editorial work on the study, "The Cambrian Sandstones of Northern Michigan, a cooperative project with the Geology Department, University of Michigan, were completed and the publication is now in press. Participation in department and other educational programs were continued and expanded.

A reconnaissance study, by county, of the ground water possibilities of the Northern Peninsula was in progress, with the field and editorial work completed on Chippewa, Mackinac, Luce, and Schoolcraft counties. The Chippewa County report was well received and found to be very useful in providing new water supplies. The work is in cooperation with the Ground Water Branch of the U. S. Geological Survey and should be of wide use in helping to solve water problems in the areas studied. The geologic data have been helpful in answering basic, long-standing questions.

Establishment of an office at Escanaba during the previous biennium has permitted closer work with all groups actively engaged in conservation. Assistance or participation in most of the education and information programs of the Department was improved in many areas of the Northern Peninsula.

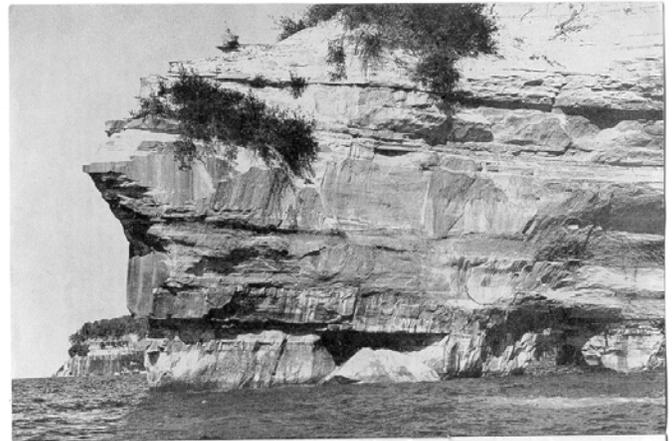
Maps and reports from the Iron Ore Investigation cooperative with the U. S. Geological Survey have resulted in improved general information and several areas of possible exploration have been opened to the mining companies. The investigations in areas where

the mineral rights are held by both public and private owners could be conducted only by public agencies such as represented by this project.

Data supplied in the Division's, annual summaries were expanded and improved by adding new and more comprehensive types of information giving the users a better understanding of the possibilities of the State's minerals. The summaries are not only more informative but were released earlier in the year.

Relationships with the petroleum industry continued at a level where mutual understanding of problems is usually possible. Compliance with the statutes and regulations has become the order rather than the exception. Distinct progress was made in having several troublesome old wells repaired, sealed or completely plugged. The Interstate Oil Compact Commission, in which Michigan has participated for almost 20 years, continued to assist in petroleum regulatory problems and in relationships with similar agencies in other oil and gas producing states. Several significant reports prepared by committees from the states in cooperation with staff members were published by the Compact.

The metal mining industries were showing effects of the expansion and depression of business. Projects for upgrading of less desirable ores increased and processes were improved. Research endeavors of the mining companies, working independently and in cooperation with Ores Research Laboratory of Michigan College of Mining and Technology should help to keep the state industry in a healthy competitive position.



*The Pictured Rocks of Lake Superior were the subject of the latest research report of the Geological Survey Division.*

Hydrologic studies reached the point where further expansion of efforts are dependent upon having a state-wide plan of submitting authentic subsurface water well data. Several reports published proved to be most helpful in answering perplexing questions. Expanded water uses make it expedient that complete data be obtained and made available for use as promptly as possible.

Cooperative projects with universities and colleges were continued when funds for such work were provided. Work with organized conservation groups continued,

with much time spent in lecture and field trip guidance. Teachers and students were assisted and encouraged by exploring and identifying minerals in the Division's offices and in the field. Sets of rocks and minerals of the State were prepared, with accompanying explanatory booklets, and made available to collectors at a nominal fee.

Staff geologists served both as official and informal consultants to other divisions of the Department, to other state agencies, to Federal agencies, to colleges and universities. Considerable consultation and cooperation were carried on with the Dominion of Canada, several of the provinces, and with many neighboring states. Petroleum data was supplied in complete and comprehensive forms to many states, agencies and industry committees for model uses.

## **GENERAL GEOLOGY, RESEARCH, EDUCATION**

Work continued in studies in surface (glacial or Pleistocene) geology of Michigan, in public education in geology, and in assistance in stratigraphic studies and interpretations. The Centennial Geologic Map of Michigan issued in 1937 was revised. Maintenance of the divisional library and clipping service continued.

The map of the Surface Formations of the Northern Peninsula was completed, and published early in 1958. It is companion to the map of the Surface Formations of the Southern Peninsula published in 1956. Both maps comprise Publication 49. Soils and land use maps and topographic maps were used in the revision study. In much of the Northern Peninsula the glacial drift is thin and bedrock is at or near the surface. The new map is valuable to agriculturists as indicative of soil and land use types. It also is of value in search for good water supplies in indicating areas of accumulation and recharge; it shows (with the topographic map) terrain suitable for airports and military installations and terrain which highways must traverse. Like the map of the Southern Peninsula, it is used by teachers, tourists, youth-camp groups, industrialists, chambers of commerce, and the general public. These maps have an overprint of the topography of the State, but as it is difficult to follow the contours, the contour map on the same scale as the surface geology map has been issued separately in blue line print. The contour-topographic map was compiled from elevations shown on U. S. Geological Survey topographic maps as well as oil well elevations and highway profile data.

An interesting development in glacial studies was the carbon dating on long buried wood. Wood from a buried peat bog near Lansing was dated by the U. S. Geological Survey and the University of Michigan radiocarbon laboratories. Such data are valuable in determining the time of advance and retreat of the last pulsations of the continental glacier during the last Ice

Age, and in dating and study of recent stages of the Great Lakes levels.

Public education in geology, and educational and public relations projects were carried on independently and in cooperation with the Office of Information and Education. The work consisted of participation in extension and field courses in conservation of Michigan State University, Central Michigan College Munuscong Conservation Laboratory of Northern College of Education, and Flint Junior College. Also, personnel participated in programs of the Michigan Educational Association teacher institutes, county teacher institutes and field trips, and in programs of service clubs, boy and girl scouts, science clubs, farm bureaus, garden and other women's clubs engaged in conservation, and of civic groups. In addition to the usual visual aids, prepared for such participation (maps, charts, slides, mineral collections, field trip guides and others), brochure outlines of the geologic history of 13 counties were prepared and distributed. Many of the county outlines of geology were prepared at the request of teachers, county planning groups, and soil conservation directors. Overprints of the glacial geology of 18 counties were prepared for publication on departmental county maps. To carry public education in geology further, invitations to assist in programs of other civic, social, and service groups not carrying a definite conservation program were honored as time permitted. Assistance and direction was given in establishing mineral displays at the Michigan Historical Museum, Lansing, and the Bay City State Park. Much time was spent in interdivisional and interdepartmental discussions and conferences on matters of geologic and mineralogic import affecting other divisions, state agencies, county and civic planning boards and agencies, and in consultations and correspondence with industry and the general public on geologic and mineralogic problems and interests.

The Centennial Geological Map of Michigan has been in continuous revision since publication in 1937 as new data were derived from borings into bedrock. Late in 1957 a small black and white map with revision to date was printed.

Cooperative work with the Office of Information and Education continued in the field, with the regional offices, and at the Conservation Training School with lectures on the geology and mineral resources of Michigan. All of these activities meant additions to an unpublished library of visual aids — maps, charts, brochures and other teaching material. More active cooperation was extended to the Department's TV program. Articles of geologic import were contributed to MICHIGAN CONSERVATION.

Conferences were held relating to stratigraphic studies of surface outcrop rocks, of subsurface formations (mainly oil bearing) and of the geology of mineral resources.

As reported in the 1955-1956 Biennial Report the Division cooperated with the Geology Department of the

University of Michigan in a study of the Lake Superior sandstones. The work was completed in the fall of 1957. The report of it was written and accepted by the University as a doctoral thesis and submitted to the Department for publication. Editorial work was completed and the book issued as Publication 51, "The Cambrian Sandstones of Northern Michigan." To complete the study of the Lake Superior sandstones, a similar study on the older Freda sandstones of western Keweenaw Peninsula is in progress. The report of this study with Publication 51 will fill a long-discussed gap in the study of the Cambrian geology of the Northern United States and of the rocks along the Lake Superior shore.

Personnel cooperated with the American Geological Institute and the Geological Society of America in the revision of the Michigan section of the areal geology and surface, glacial (Pleistocene) maps of the United States.

Teachers and others have asked for a book on the geology of Michigan similar in character-of-presentation to the lectures they have heard. The book is now in progress — maps drawn, fossils and other illustrative material photographed and drafted. The book will supplant the popular "Outline of the Geologic History of Michigan" — which is a synopsis of the book to be entitled "How Michigan Got This Way."

## HYDROLOGY

Basic data must be gathered and processed if any water rights legislation is to be successfully administered. The term "basic data" means the information derived by the measurement of rainfall, stream discharge, lake levels, and ground water levels. Also included are measurement of ground water temperatures and chemical analyses of surface and ground waters, and the geology as shown in the drilling records of water wells.

Lack of well records is particularly distressing because, although an estimated 30,000 wells are drilled in the State each year, there are only 24,000 well logs in the files of the Water Resources Section of the Division. This number is double that at the start of the biennium, due in large part to the reconnaissance survey of the eastern counties in the Northern Peninsula.

The time, effort, and material spent in the construction of 30,000 wells a year represents a considerable amount of money, and the information if preserved would help not only to define our water resources but also to eliminate many unsuccessful wells.

Stabilization of levels of inland lakes, and development of ground water supplies for domestic needs of riparian owners are matters of concern.

Field studies, letters, and conferences regarding artificial lakes and flooding projects were part of the activities of this Section. As consultants to the State Health Department, staff members recalculated aquifer

performance tests made by private consultants and advised the Health Department on the reliable capacity of subdivision water supplies.

Information regarding Michigan's water resources were given by talks before a variety of organizations. Information was furnished through correspondence and published material. Conferences were held with newspaper feature writers. A television program was presented. A quarterly newsletter entitled "Water Views" was distributed as a regular quarterly bulletin.

Water Supply Report No. 1, "Summary of Ground-Water Conditions in Michigan in 1956," was published. Water Supply Report No. 2, "Summary of Ground-Water Conditions in Michigan, 1957," is in press. The Water Supply reports are prepared in cooperation with the U. S. Geological Survey and give data on pumpage, precipitation, and ground water levels in selected key areas of the State.

U. S. Geological Survey Water Supply Paper No. 1387, "Surface Water Supply of the United States, St. Lawrence River Basin Part 4, 1955", was published. It contains the report of the stream discharges in Michigan during 1955, measured and recorded under a cooperative agreement with the U. S. Geological Survey.

The cooperative reconnaissance survey of ground water supplies in the Northern Peninsula, begun in the last biennium, is progressing very satisfactorily. The first, Geological Survey Division Progress Report No. 17, "Reconnaissance of the Ground-Water Resources of Chippewa County, Michigan," is being distributed. "Reconnaissance of the Ground-Water Resources of Mackinac County, Michigan," as Progress Report No. 19 of the Geological Survey Division, is in press. Field work has been completed on the next two reports, Luce and Schoolcraft counties.

The Water Section assisted the Water Resources Commission by investigating geological aspects of disposal of waste products through recharge wells, and by completing information on ground water resources in the Huron River Basin.

Besides recalculating aquifer performance tests, a proposed site for a sanitary land fill in the Ann Arbor area to replace a dumping ground was investigated in the field for the State Health Department.

A field investigation was made of lake levels of inland lakes on the property of the Kalamazoo State Hospital and a recommendation sent to the State Department of Administration. Studies of the water available at hospital sites and the other state institutions were also made.

Section personnel acted as owner's representative during construction of wells for Conservation Department projects.

Advice was given on watershed improvements on Little Black River in Cheboygan County, the Sanborn Watershed in Alpena County, and Misteguay Creek in

Genesee and Saginaw counties at the request of the U. S. Soil Conservation Service.

Information was compiled from the Section's log and geological libraries and advice and instruction given with or without field investigations to enable industries, municipalities, farmers, water well drillers, and individuals to develop new water supplies, repair and maintain old ones.

## **MINES AND MINING**

Valuation of iron and copper mines for tax purposes continued to be a major function of the Mines and Mining Section. The State Geologist, or his authorized deputy, annually determines the valuation of metallic mineral properties. These valuations are certified to local assessors for entry on the tax rolls. The work involves a review of the drill hole records, maps, cross-sections and ore estimates, as well as surface and underground examination of the physical properties of the mining companies. Approximately 140 mining properties, including 35 active iron ore and 15 active copper operations, were valued during each of the years of the biennium.

Three iron ore mines were closed because of physical or economic exhaustion of reserves. These included an underground direct-shipping mine and two open pit siliceous properties. During the last quarter of the biennium almost all of the mines in the State operated on a curtailed schedule. Some were closed due to lack of market for the ore.

Although the slow-down in iron ore mining activity was in large measure due to the general business recession, another factor, which to all indications will become more serious in the future, also has a part. This is the increasing demand for an available supply of higher grade ore, both domestic and foreign.

In an effort to make ore of underground mines competitive, more selective mining methods were adopted at many of the mines. In addition, some of the mine product was treated to reduce impurities and increase the iron content. Treatment ranged from simple screening on the Gogebic Range to a combination of drying, screening and heavy-media separation on the Marquette Range.

Construction of the fifth beneficiation plant in the State was begun. This plant, near Felch, Dickinson County, will be the State's largest. Low grade iron-bearing material will be processed into a high grade ore. The product of this operation as well as those in Marquette County should aid in maintaining the iron ore industry of the State.

The recognized need for a resurvey and comprehensive study of the iron-bearing regions of Michigan was met by a continuance of the cooperative magnetic and geological mapping program in cooperation with the U. S. Geological Survey. Field work was essentially

completed in Iron and Dickinson counties, and preparation of a comprehensive report on this area is in progress. Mapping of the Marquette Range was begun, and it is hoped that the work will be accelerated.

To permit earlier release of information for exploration purposes, it has been the policy of the United States and Michigan surveys to issue preliminary reports as the survey is completed in a unit area. The geological report of an area in Iron County was published, as well as a professional paper on the stratigraphy of the Menominee Range. In addition a preliminary geological report of another area in Iron County and five geological maps of the Menominee Range from Iron Mountain area, to Waucedah were placed in open file. Thus far, the cooperative program has resulted in the publication of 11 geological, 3 geophysical and 13 open file reports or maps, primarily in Iron and Dickinson counties. Considerable work remains to be done on the Marquette and Gogebic ranges to bring up-to-date the geological information on all iron-bearing districts in the State.

The cooperative program provides basic geological data on all lands in the potential iron ore area. Because of access to the various properties and records, it is a function that can best be carried on by a governmental agency. The results of the work will undoubtedly prove of value in pointing the way for exploration which may well lead to new deposits of ore. The program has already been instrumental in the discovery of new ore, the value of which, and the resultant effect upon the economy of the district by way of taxes and payroll, has far exceeded the cost of the effort.

Drastic decreases in the price of copper resulted in an over-all reduction of activity in copper mining during the last half of the biennium. Three mines and one reclamation were closed and operations were curtailed at other mines. Exploration continued throughout the district, however. The most interesting development was the discovery of a potential orebody in the vicinity of the Presque Isle River, Gogebic County.

Interest in the leasing of state-owned lands for copper was at a high level. This resulted in active intradepartmental cooperation with the Lands Division in the drafting of a new lease form. Annual reports of the exploratory work done on state lands held under copper, iron ore or uranium leases were reviewed for conformance with lease requirements. Annual inspections were made of the Warner Mine, an iron mine in Iron County on leased state land.

## NONMETALLIC MINERAL RESOURCES

Annual collections of mineral statistics were made for 1956 and 1957. In replying to questionnaires, mineral operators supplied the Division with data on quantity and value of rocks or minerals produced, labor and business conditions and trends and uses of the raw materials. Compilation of this data shows that the value of Michigan's mineral production for 1957 increased approximately \$250,000 over 1956 and reached an all time high. Iron ore continued to rank first in value, followed by cement, salt, sand and gravel, stone, copper, and petroleum.

VALUE OF MINERAL PRODUCTS, 1956-1957

Mineral (nonmetallic)	1956	1957
Cement	\$ 67,798,262	\$ 71,605,137
Salt (common)	35,643,860	41,072,497
Natural salines (bromine, magnesium, compounds, calcium-magnesium chloride and potash)	37,873,042	37,664,914
Sand and gravel	35,145,953	35,144,352
Stone*	24,135,997	30,008,637
Clay products	6,951,866	6,851,113
Gypsum (crude)	5,861,152	4,822,810
Miscellaneous (lime, marl, peat, clay, mineral pigments, gem stones)	3,396,072	3,620,175
<b>Mineral (metallic)</b>		
Iron ore	105,688,087	110,605,689
Copper	51,531,138	33,629,326
<b>Mineral (fuels)</b>		
Petroleum (crude)	30,607,137	30,505,806
Natural gas	1,556,575	929,574
Natural gasoline	374,092	349,570
<b>Total mineral value</b>	<b>\$ 406,563,233</b>	<b>\$ 406,809,600</b>

\*Limestone used in the manufacture of Portland Cement and lime not included.

Two reports, "Michigan's Mineral Industries," 1955 and 1956, were published and compilation of data for the 1957 edition was begun. The reports present summaries of the mineral industries, with tables on production and value of each, a breakdown of production and value on a county basis, directory of mineral producers, and a review of recent developments. These reports representing the official status of our mineral industry are used regularly by teachers, students, people in industry, and the general public.

Expansion and developments continued in the mineral industries of the State. Maps on bedrock, data on outcrop localities, records of rock borings, physical and chemical analyses, and other general geological information supplied by the Division were of aid to several new mineral developments. A large cement firm purchased property in Monroe County and began construction of a 5,000,000-barrel cement plant north of Dundee. It is expected to be in operation by 1960. Michigan's gypsum industry, already number one in the nation, expanded through the opening of a new gypsum deposit north of National City. Shipment from the new quarry, presently being stripped of its glacial lake clay overburden, is scheduled for 1959. Increased aggregate demands in Detroit and southeastern Michigan resulted in the opening of a new stone quarry along the Huron River at Flat Rock and the reopening of the old Woolmirth quarry at Scofield. Four gravel plants making use of new methods of beneficiation were put into production to meet demands for aggregate for use in highway construction.

Data were obtained by field visits to quarries and outcrops, study and logging of rock cores, and examination and sampling of rock sections to permit the Section to satisfy frequent requests for geological assistance and information on the undeveloped and established mineral deposits. Information so obtained not only assists in answering the requests but supplements work of similar earlier surveys. Reports in preparation include: Clays and Shales of Michigan, Michigan's Sandstones, Geology of Jackson County and Geology of Calhoun County. Examination and interpretive assistance was given in the collection and tabulation of geological data for a report on the Cambrian sandstone.

Typical duties performed included: 1) Maintaining an inventory of economic mineral deposits of Michigan. 2) Gathering data through surveys for the preparation of maps on mineral deposits of the State. 3) Gathering data on composition of rocks in the State. 4) Compiling a record of the mineral industries, their production, and methods of processing mineral raw materials to finished products. 5) Providing the public with information on the geology and mineralogy of the State, its mineral resources, mining activities, and usefulness of its mineral industries. 6) Acting as geological consultant for other divisions and departments on mineral resource matters. 7) Making mineral valuations of state-owned lands containing deposits of nonmetallic minerals for land exchanges or leases.

## OIL AND GAS

The decline in oil and gas operations evident during the previous biennium continued into the 1956-1957 biennium. The rate of decline, however, decreased from the rather rapid decline which was evident during the early 1950's. There appears now to be a levelling off of oil and gas activity at or near current levels and there are indications that such activity may not decline appreciably during the late 1950's.

The accompanying table reflects the slow decline in oil and gas activity which carried into the 1956-1957 fiscal years:

	1954 and 1955 Fiscal years	1956 and 1957 Fiscal years
Permits to drill .....	1,019	918
Well completions .....	1,012	882
Oil wells .....	406	342
Gas wells .....	19	53
Geological test permits .....	135	12
Gas storage wells .....	12	60
LPG storage wells .....	1	4
Exploratory wells .....	401	308
Oil discoveries .....	24	14
Gas discoveries .....	2	4
Oil production .....	22,610,960 bbls.	20,126,977 bbls.
Gas production .....	17,533,662 MCF	16,148,206 MCF
Producible oil wells .....	4,239	4,233
Producible gas wells .....	314	335
Cumulative oil production .....	390,519,766 bbls.	410,646,743 bbls.
Cumulative gas production .....	306,372,291 MCF	322,520,497 MCF
Producing oil fields .....	178	177
Producing gas fields .....	76	74

Permits issued declined from 1,019 during the 1954-1955 fiscal years to 918 during the 1956-1957 fiscal years. This was a decrease of 101 permits as compared with a decrease of 411 during the previous biennium.

Well completions decreased in the same ratio.

Geological test permits decreased from 135 to 12 during the biennium. This was caused by the greatly increased use of gravity meter and seismic methods of geophysical prospecting rather than the drilling of geological test wells. Oil production declined 2,483,983 barrels during the 1956-1957 fiscal years. This decline is due to declining production from older oil fields, and the failure to find new producing fields. Prospecting for oil in Michigan has reached the point where it is necessary to drill deeper wells and prospect in older formations. Such prospecting is more costly and development is much slower. Recent developments in these deeper and older formations, however, give promise that Michigan may continue to have a significant oil and gas industry.

Despite conversion of many Michigan gas fields to gas storage, there was only a small decline in gas production. Sixty gas storage wells were drilled during the 1956-1957 biennium as compared with 12 in the previous biennium. Storage of liquid petroleum gas in cavities developed in salt formations has become a significant industry in Michigan. Four such storage wells were drilled during the 1956-1957 biennium. Five of these storage reservoirs were in operation or in the process of development at the end of the 1957 fiscal year.

Oil operators continued their highly satisfactory disposal of production brine to approved subsurface formations. They were producing 195,630 barrels of brine per day at

the end of 1957. Of this 98.77 per cent was being returned underground.

Sixteen oil fields were producing in excess of 2,000 barrels of brine per day. This brine was being returned to the Marshall, Traverse, Dundee, and Detroit River formations. This method of subsurface brine disposal has eliminated waste which would result in damage to property and pollution to surface and underground water resources.

The Division participated in 11 general hearings before the Supervisor of Wells and The Advisory Board. These hearings resulted in the promulgation of 10 oil and gas well spacing orders, the amendment of three such spacing orders, and the abrogation of six such spacing orders. Three amendments to Proration Order No. 23 were placed in effect and the order affecting two fields was abrogated. An order was established governing the casing and sealing on wells in southern Michigan. The Division and staff members acted for the Supervisor of Wells in 11 hearings to determine advisability of issuing drilling permits for locations as exceptions to established spacing orders.

Scrubber-booster gas plants were processing oil well gas for industrial sales or return to reservoirs for pressure maintenance. The plants processed 10,621,420 MCF's of gas, of which 3,913,043 MCF's were returned to reservoirs for pressure maintenance and 4,191,485 MCF's were sold. Seven of the plants accounted for sales of 7,156,993 gallons of liquid petroleum gas as an important byproduct of their operations.

Pilot water flood projects were operating in four of the major reservoirs in a continuing study of the problems and economic feasibility of increasing ultimate recovery from these Michigan carbonate reservoirs. The quantity of water injected into each reservoir to the end of the biennium was:

Kawkawlin Field, Bay County, Dundee formation, four input wells. . . . 384,000 bbls.

Walker Field, Kent County, Traverse formation, two input wells. . . . 246,000 bbls.

East Norwich Field, Missaukee County, Detroit River formation, two input wells. . . . 325,000 bbls.

Rose City Field, Ogemaw County, Detroit River pool, one input well. . . . 40,500 bbls.

Produced and extraneous waters were being injected into the Eden Dundee Pool in Mason County and the Reynolds Dundee Pool in Montcalm County for pressure maintenance purposes to augment limited natural water drives and increase recovery efficiency.

At the close of the biennium, the eight prorated oil fields were producing 7,459 barrels per day. They averaged almost 30 percent of the State's production, with per well allowables ranging from 50 to 200 barrels daily.

Fifteen refineries on stream at the end of the biennium had a daily capacity of 168,000 barrels with actual runs averaging 117,258 barrels daily. Michigan crude production was supplying approximately 20 percent of refinery runs. The remaining 80 percent consists of approximately 90,000 barrels daily of outstate crude of which 3,000 barrels daily is Canadian crude delivered via the Lakehead Division of the Interprovincial Pipeline.

## **PETROLEUM GEOLOGY**

During the biennium, 795 new well logs were published and distributed. Of this number, approximately 200 were logs prepared from actual well cuttings and the remaining 595 were drillers' logs. In addition to the above new records, more than 400 old logs were revised. About 19,231 logs were distributed to regular log subscribers. Another 16,000 logs were distributed as special orders from members of the petroleum industry. Well log sales added some \$4,110 to the State's General Fund.

Thirty-four new oil and gas field and county oil and gas maps were made. This brings the total number of such maps available for distribution to 218. These maps are kept posted to date as additional wells are drilled or depleted wells plugged. Approximately 7,967 regular maps and topographic sheets were sold or distributed. Revenue from these maps amounted to \$3,356.25, which was also added to the General Fund.

The Geological Survey Division has maintained an active sample library of the wells drilled in the state. Limited storage space allows only samples from deep tests and wildcat wells. Constant expansion of the library has made it necessary to discard some sets. During the biennium, 319 new sample sets were added. As of July 1, 1958, about 6,202 sample sets were on file. The samples are used for research by universities, the Division, and company geologists. They are in constant demand, and in excess of 700 sets were placed on loan. Many other sets were examined in the library.

Operators directed efforts toward the search for oil and gas in the Salina and Trenton formations. These formations are relatively unexplored in Michigan. Developments in Allegan and St. Clair counties with respect to Salina gas and/or oil and in Hillsdale County for Trenton oil have greatly increased their potential as oil or gas producing formations. It is believed that future increases in petroleum reserves will depend directly on the results of the exploration and development of these formations.

Additional encouragement was also given to other areas in the State. Mason, Oceana, Montcalm, and Isabella counties recorded significant discoveries in the Traverse and Dundee formations. Although potentials recorded in these western and central Michigan areas were not great, they will help maintain activities in those areas which may lead to more important developments.

Approximately 1,450 persons came to the Petroleum Geology Section with problems related to petroleum geology. They included members of the petroleum industry, students and professors from universities, property owners, and the general public. In addition, services were frequently utilized by persons from other states and countries. Also, studies were made on problems with other divisions of the Department, the Corporation and Securities Commission, Michigan Public Service Commission, Water Resources Commission, and Economic Development Department.

The Petroleum Geology Section prepared and published summaries and reports of findings in problems of the petroleum geology of the State. Progress Report Number 18, which represents two years of study and research on the Salina sediments in the southwestern part of the State contributes materially to the knowledge of the stratigraphy of the area studied.

## PUBLICATIONS

Publications prepared included:

Publication 49, Map of the Surface Formations of the Northern Peninsula.

Publication 50, Index of Michigan Geology.

Revision of the areal geologic map of Michigan.  
Black and white outline—1957.

Outline of the geology of the Grand Traverse Region.

Outlines of the geology of Branch, Hillsdale, Kalamazoo, Midland, Mecosta, Oceana, Ogemaw, and Shiawassee counties.

Glacial geology overprints on Departmental county maps for 12 counties.

Something About Caves in Michigan.

Mineralogical Guide 1958.

Michigan Iron Mines 1957.

Reconnaissance of the Groundwater Resources of Chippewa County, Michigan, in cooperation with the U. S. Geological Survey.

Summary of Groundwater Conditions in Michigan in 1956, in cooperation with the U. S. Geological Survey.

Water Views, Volumes II and III.

Open File (In cooperation with the U. S. Geological Survey, Ground Water Branch):

Groundwater Conditions in the Alma Area

Groundwater Resources of the Holland Area

Progress Report on Groundwater Conditions at the Cayla Mine Near Crystal Falls, Michigan.

Probable Effect on Groundwater Resources from Construction of the Proposed Grand River Cut-off Channel West of Lansing, Michigan.

Interpretation of the Pre-Pleistocene Geomorphology of a Portion of the Saginaw Lowland.

Geology of the Lake Mary Quadrangle, Iron County.

Preliminary Geological Map, North Half of Iron Mountain Quadrangle.

Preliminary Geological Map, South Half Iron Mountain Quadrangle.

Preliminary Geological Map, North Half Norway Quadrangle.

Preliminary Geological Map, South Half Norway Quadrangle.

Preliminary Geological Map, South Half Vulcan Quadrangle.

In cooperation with U. S. Geological Survey:

Geology of the Kiernan Quadrangle, Iron County, Michigan.  
Stratigraphy of Pre-Keweenaw Rocks in Parts of Northern Michigan.

Progress Report 18, Notes on the Devonian-Silurian in the Subsurface of Southwest Michigan, April 1958.

Miscellaneous Reports:

Developments in Michigan, 1956-1957 (American Association of Petroleum Geologists).

Summary of United States Oil and Gas Development and Production in 1956, 1957 (American Institute of Mining, Metallurgical and Petroleum Engineers).

Proved Reserves of Crude Oil, Natural Gas Liquids and Natural Gas, 1956-1957 (American Petroleum Institute-American Gas Association).

Petroleum Production and Estimated Ultimate Recovery for Oil Fields in Michigan, 1956-1957 (National Stripper Well Survey in cooperation with Interstate

Oil Compact Commission).  
Statistics Covering Costs and Production of Michigan Iron Mines, 1956.

Statistics Covering Costs and Production of Michigan Iron Mines, 1957.

Summary of Operations Oil and Gas Fields, 1956.

Summary of Operations Oil and Gas Fields, 1957.

Monthly Schedule of Allowable Oil Production for Prorated Fields of Michigan

Monthly Summary of Crude Oil Production, Pipe Line Runs and Refinery Data

Monthly Tabulation of Oil and Gas Production by Designated Fields.

Weekly Numerical List of Oil and Gas Permits with Exact Well Locations.

Oil and Gas Well Log Records Distributed to the Public as Requested.

Miscellaneous Reports and Summaries for Interstate Oil Compact Commission.

Oil and Gas Field Well Location Maps by Fields, Townships and Counties.

Oil and Gas Industry Summary, Michigan Manufacturers and Financial Record 1956-1957.

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