Michigan
State Department of
Conservation

Geology Division

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GEOLOGICAL SURVEY DIVISION

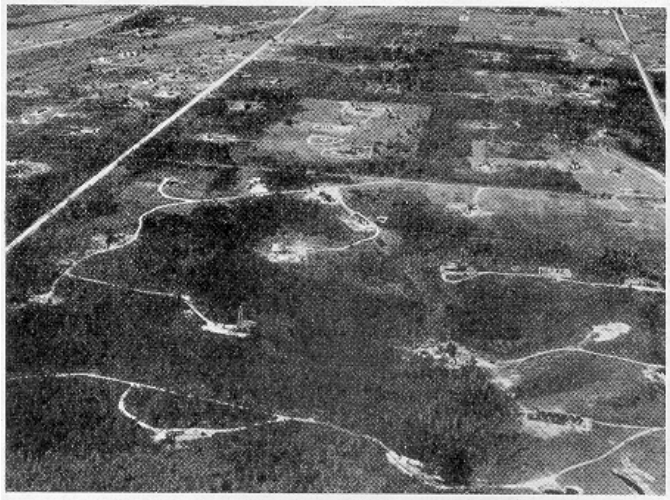
R. A. SMITH, State Geologist

Wartime mineral needs and ability of the Geological Survey to give aid to some of the demands show the wisdom of the clause in the basic act creating the present survey. That clause, among other provisions, authorizes a thorough geological and mineralogical survey, an investigation of all mineral and rock deposits, and, just to be sure the inclusiveness of the act shall be clear, "all other productions of the geological world within the limits of the State capable of being converted to the uses of man." Through the decades since the passage of the Act of 1869 the Geological Survey, complying with the law, has collected data, mapped and studied the metallic and non-metallic minerals, rock formations, water resources. Some of the information has been published in 75 or more formal reports, some informal reports to other State and Federal agencies and scientific and commercial interests, and much remains unpublished in the files of the Survey, available to the public on request.

Technological developments and advances, depletion of resources in Michigan and other states occasion search for new resources, resurvey of certain formations, and detailed study and survey of areas formerly covered only by reconnaissance. For example: Need for metallic magnesium caused a detailed survey of our dolomitic limestones to be made; new uses for rocks and minerals, as in the manufacture of rock wool, made necessary a resurvey of our limestones and shales to detail those suitable for the new use. Impossibility of importing peat from Europe turned attention to Michigan peat bogs and led to search of data on peat in the files, and to some field work. Depletion of Michigan iron ore reserves and improved metallurgical and ore dressing practices making low grade ores usable are among the causes that gave further impetus to the resurvey of the iron regions. Critical conditions of inland lake levels affecting the tourist industry made a study of ground water and lake level control imperative.

After Pearl Harbor, despite losses of personnel to the armed forces, the tempo of routine work of the Survey was stepped up. Michigan's minerals are needed in the war effort, especially our copper, iron, and petroleum, the magnesium of our brines and dolomites. Requests for assistance in locating mineral deposits come from the Federal and State governments, various governmental agencies and from industrialists. Of vital importance became the search for water supplies. Where formerly a problem had been to find adequate supplies of ground water for air-conditioning stores, theatres, apartment houses, in areas of low water resources, now the problem is to find adequate water supplies for the war factories and housing projects of those areas. Michigan's favorable location on transportation routes has increased the importance of Michigan oil. A somewhat lagging interest in the State has been rekindled and exploration is going on as rapidly as priorities will permit—not, of course, directly by the Geological Survey but with its enthusiastic assistance. War-induced interest in strategic minerals has increased the requests from the general public for information about them—either through correspondence or by program speakers.

In fact during the entire biennium the work of the Survey, routine and otherwise, has been influenced in a considerable degree by the global war,—in the first three quarters of the biennium by the National Defense program and in the last quarter by our entry into the war. A decreasing personnel has carried a heavier load, particularly in the field offices. Eight men have left the Survey staff for better jobs with the Federal Government and private industry. Six are in the armed forces. Franklin Pardee, Mining Engineer and State Mine Appraiser, was on leave for 14 months in Brazil as foreign mineral specialist and technical adviser to the United States Embassy, assisting in the search for and development of strategic mineral deposits of Brazil needed by the United States—our contribution to the Good Neighbor policy.



A Michigan oil field. North Buckeye Field, Gladwin County.

Cooperation in the study of geologic problems has been maintained with various bureaus of the United States Geological Survey and the Bureau of Mines. Inter-departmental cooperative services continued with the Public Service Commission, the Tax Commission, and the Department of Health. Completion of the laboratories of the Department of Health gives promise of closer cooperation in the matter of examination and analyses of limestone, coal, and particularly of water supplies. Cooperation with The Michigan College of Mines, University of Michigan, and Michigan State College has continued. Because of its proximity to the office of the Survey closer relations are maintained with the College than with the other institutions. The College continues to make available storage space for the Survey's well over half million rock samples taken from drilled wells. The arrangement by which part time student assistants prepare rock samples for study, work on certain research problems, and prepare and file certain rock material and data not only relieves the Survey staff of time-consuming necessary routine, but also enables the Survey to direct the preparatory work of, and, in a measure, train possible future employees. As in the past, the College laboratories have been opened to the Survey for limestone analyses. A field trip through one of the oil fields was conducted by one of the field geologists for students of the College studying petroleum geology.

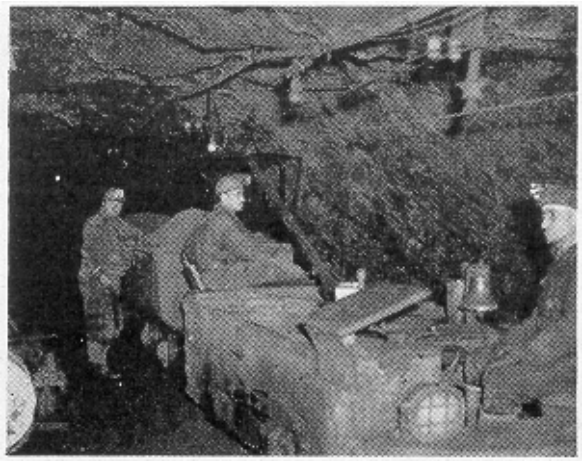
A very considerable part of the time of the Survey personnel is consumed in public relations maintained by correspondence and discussions in the office, with the general public; with State, Federal, municipal, and educational agencies; with the mineral and mineral-using industries; recreation activities; journalists and others on various matters in which the geologist can assist.

Public interest in the geologic basis of conservation is shown by the continued requests for divisional geologists to appear on the programs of educational, conservation, scientific, service, business, garden, social, and other clubs and federations, to assist in field institutes of such clubs, and to contribute articles on geology to their journals. Several of the colleges of education plan their science courses to include lectures given by Survey personnel. Survey geologists also assist the Education Division by lectures and conducted field trips in the work of the Training School carried on in cooperation with the Colleges of Education, the 4-H Clubs, and the summer "School on Wheels" through the Northern Peninsula, and have contributed to and edited the Departmental bulletin on conservation—"They Need Not Vanish."

The entire personnel of the Geological Survey Division both field and office force met early in June at the Higgins Lake training school for a "refresher course" in what practically each member of the staff is doing, what problems are involved in different fields of work, and the plan of past, current, and future work of the Division. The Geological Survey Division staff greatly appreciate the plans of the Department for such refresher training and the cordial cooperation and hospitality of the directors and superintendent of the Training School.

MINES AND MINING

The annual routine work of appraising the iron and copper mines of Michigan for the State Tax Commission was continued as usual, although beset with some difficulties. Appraisal of mines requires an intimate knowledge of the geology of the iron and copper formations and of ore concentrations, in addition to a knowledge of the engineering problems involved in getting the ores out. It requires a knowledge of details needed in the estimation of ore reserves developed and prospective in mines and partially explored properties. It demands ability to make surface and underground investigations of the physical properties of the mining companies. It necessitates also examination of all records, maps, cross sections, and estimates of the mines and ore reserves. For the purposes of the Tax Commission an appraisal further requires a report on the condition of the iron and copper mines of the State and recommended valuations for taxation purposes.



Ore train underground—James Mine.

Mine appraisal work with the State Tax Commission is an outgrowth of the dissatisfaction of the State Grange in 1905-10 with the proportion of taxes paid by the agricultural and mining interests. The Grange wanted to raise the admittedly low valuation of the mines and add a tonnage tax. The outgrowth of Grange agitation was the so-called "Finlay appraisal," following which the State Tax Commissioners decided on an annual appraisal of the iron mines with the cooperation of the Geological Survey by a modification of the Finlay method devised by the State Geologist, R. C. Allen, and the Tax Commission—a system which recognized the geological and other factors involved in the estimation of reserves. This "Michigan system" was the first strictly scientific system of mine appraisal for taxation purposes, and was pronounced by the National Tax Association as "the most admirable system that could be devised." It has been in use in Michigan since 1913.

Normally appraisal work is done by a mining engineer and a mining geologist working together and checking each other, but with the absence of the State Mining Engineer in Brazil as Technical Advisor to the American Embassy, practically all the work and attendance on routine and protest hearings before the State Tax Commission had to be done by the mining geologist.

Dissatisfaction with valuations again arose in 1941. Some citizens of Gogebic County protested that mine valuations were too low. The citizens' protests led the Governor to appoint a commission of seven to investigate the matter. The appointment of the committee during the time the appraisal was being made was confusing, but the Geological Survey Division and Conservation Commission agreed it wise to complete the work of the appraisal. The report of the committee of investigation was a general approval of the method of taxation, with added recommendations for unimportant changes in procedure, which would add to the work of the appraisal and of the Tax Commission, but would not lessen the work of the Division.

Miners at the Surface. Homer Mine.

In October of 1941 by accepting the report of Mr. Warren Roberts of Western Reserve University, the National Tax Association reaffirmed its views regarding the "Michigan" system of mine appraisal. Said Mr. Roberts, who was paid by the Guggenheim Foundation to make a study of all mines, taxation methods, and procedure throughout the United States in his paper on "The Theory of Ad Valorem Taxation of Mines:"

> "For thirty years the geologists in Michigan's Department of Conservation have set a standard for other important mining states, and in mine tax administration Michigan still appears to lead the way. With some security of tenure and relative freedom from direct political pressure, this office has been a constructive influence in the economic and political development of the State. Its history furnishes one of the bright spots of mine valuation."

Depletion of iron ores, and a belief that more ore bodies awaited discovery, led to the initiation of a more detailed survey of the iron regions. The work was started in 1937 and field parties have worked in the iron ranges each summer field season since. Results of the field work, reported in Progress Reports 5, 6, and 8, gave new ideas on the geology of the area surveyed and lent credence to the belief that discoveries of more iron ore-bodies may be expected. The need of the United Nations for more iron and steel at this time proves the wisdom of the resurvey as the necessary information for scientific prospecting is in part available. The results of each summer's field work have been reported in a mimeographed pamphlet with detail maps available to the public shortly after the close of the field season.

Geologic and magnetic surveys were continued in the southern end of the Copper range, completing the survey from Painesdale to Mass City. The results of that work are published in Progress Report No. 7. Conclusions drawn from these surveys enabled the Division to assist exploration and exploitation of copper lands. Work for the summer of 1942 was planned with special effort on locating workable copper deposits of sufficient promise to warrant thorough detailed exploration.

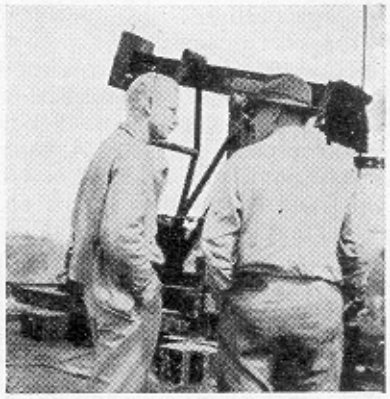
At the close of the biennium a survey was initiated of the graphitic slates of Baraga County and a search made for commercial graphites.

As usual, each year, investigations were made of reported discoveries of gold and other supposed valuable ores.

Several reports have been made to the War Production Board on copper and iron resources.

A member of the staff served on the Governor's Committee looking into the matter of war time emergency movement of iron ores through the port of Escanaba to Great Lakes ports.

Mimeographed reports on the Michigan System of Mine Appraisal and on general statistics covering costs and production of the Michigan iron mines have been made.



A survey geologist-engineer talks it over with a pumper.

NON-METALLIC MINERAL RESOURCES

Act 7 of the Public Acts of 1911 abolished the office of Commissioner of Mineral Statistics and transferred the duties to the Board of Geological Survey; thus the Conservation Department inherited those duties. Work of collecting mineral statistics is in cooperation with the United States Bureau of Mines, Department of Interior. Sources of information are the individual mineral operators, State Tax Commission, the Bureau of the Census, and the Department of Labor and Industry. Statistics on copper and iron are collected directly by this Division, as a part of the mines tax appraisal work; figures on petroleum and natural gas production are supplied by the State Tax Commission; information on coal production is obtained from, the State Department of Labor and Industry; and statistics for bromine, calcium chloride, cement, coke, gypsum, lime, limestone, magnesium, marl, peat, pig iron, salt, sand and gravel, sandstone, trap rock, are obtained from questionnaires sent to the operators by the Bureau of Mines. Replies are returned to this Division, recorded, and sent on to the Bureau. The report on Mineral Resources statistics for the years 1938-42 is in preparation.

The restudy and detailed mapping of the dolomitic or heavy magnesium limestones initiated at the close of the last biennium was completed. The study was made to determine the availability of Michigan's dolomites as a source for metallic magnesium. A field party of two men,—senior majors in geology from Michigan State College—mapped Mackinac and Chippewa counties, but concentrated on quarryable areas of Engadine dolomite. Representative samples were collected and later analyses were made by Michigan State College. Analyses show that the magnesium content of the dolomites is very high. A limestone survey was made of Jackson County, a part of the plan to make a complete supplementary resurvey of all the limestone areas. Samples collected from Jackson, Schoolcraft, and Alpena counties were also analyzed in the College laboratories, some 80 analyses in all.

Work of directing industrialists to mineral resources, assisting manufacturers in locating supplies of minerals no longer obtainable from foreign sources, and minerals needed for defense, identifying mineral samples, supplying schools with mineral and rock samples, is a large part of the Division's routine.

Limestone and Dolomite

The Michigan Geological Survey apparently is the first State Survey to recognize and call public attention to the probable role of dolomite as an ore for magnesium metal. About two years before the United States' entry into the war the Geological Survey made plans for a detailed survey of the dolomite resources of the State, and the Survey was completed in 1940. At that time public notice was given through the press that dolomite was expected to become of major importance as a source for magnesium, and attention was called to the extensive deposits of high grade dolomite in Michigan convenient to water transportation. As a result of the surveys and accompanying publicity the Geological Survey has had many requests for complete information from the War Production Board, Defense Plant Corporation, U. S. Bureau of Mines, and many individuals and firms interested in magnesium production. Special field examinations have been made to locate deposits specifically adapted to the needs of certain companies. Such examinations are of a cooperative nature, a representative of the Survey and the company meeting in the field to look over deposits and select samples, which are later tested or analyzed by the company.

Brine Analyses

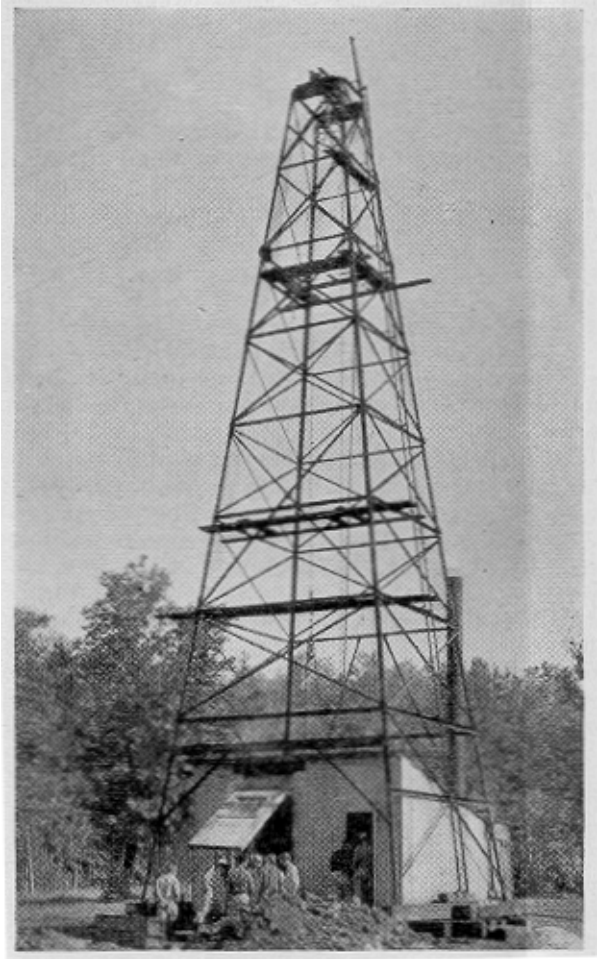
For many years Michigan has led the nation in the utilization of deposits of natural brines for the manufacture of salt and valuable chemicals. One of the products of the brines is metallic magnesium, of which, prior to the war, Michigan was the only producer in this country. Tremendous expansion in the war requirements of this important metal has stimulated interest in Michigan brine. The Survey has in its files hundreds of analyses of brines collected from various parts of the State, in the search for salt, water, and chemical bitterns. Prospecting for oil and gas has made possible the collection of many brine samples from other areas, and from deeper rock formations. The Survey is continuing the collection of brine samples from oil and gas wells and thus making a more complete and systematic coverage of the State. Analyses have shown that some areas and geological structures contain a much higher concentration of magnesium chloride than other sections. The State Health laboratories cooperate by making the analyses of the samples obtained through the Geological Survey field representatives.

OIL AND GAS

The oil and gas industry continued to expand, but at a fluctuating rate. In February 1941 production declined to the lowest level since March 1937. Late in May 1941 the prolific "Monroe" pay underlying the Reed City field was discovered. Late in June the Headquarters Field in the Traverse formation of Roscommon and Clare counties came in, and by the end of 1941 production was climbing at the highest rate of the two years previous.

However, total pool production for 1941 was 16,358,717 barrels compared with the 1940 production of 19,753,103 barrels. Production during the first six months of 1942 was 10,356,729 barrels. Permits for 1044 wells were issued in 1941, but only 392 permits were issued in the first seven months of 1942. This decrease was due to restrictions imposed by the War Production Board on the recommendation of the Office of Petroleum Coordinator. From September 1927 to July 31, 1942, 9,720 oil well drilling permits were issued. At

the end of the biennium we had 3,200 producing oil wells.



Diamond Drill Rig. Cleveland Cliffs Iron Company.

During the biennium exploration has been carried to deeper levels and to older rock formations. The deepest well ever drilled east of the Mississippi was completed near Kawkawlin, Bay County, at a depth of 10,447 feet. The formation was not productive at that depth so the well was plugged back to about 7,800 feet, where it has a rated capacity of about 7,000,000 cubic feet of gas at a pressure above 4,600 pounds. The well cost over $550,000. In other deep wells in widely separated areas commercial production has been found in the Sylvania formation and the underlying Bass Island or "Lower Monroe" of the drillers, using a formation name abandoned on the State geological map. These discoveries show the possibilities of production from the older deeper formations, although war time priorities will probably prevent extensive deep exploration. Experience in drilling the deep Reed City field definitely proved that wells can be successfully drilled by rotary tools to the deep producing formations.

Production of natural gas in 1941 was the highest on record—15,092,-464,000 cubic feet. For the first half of 1942 production was 8,973,055,000 cubic feet, indicating a record production for the year. From 1929 to July 1942 a little over 90 billion cubic feet of commercial gas had been reported produced in Michigan.

More gas wells were drilled in 1941 than in any year since 1936, but drilling slowed up in the first half of 1942. Over 600 wells are in production.

Engineering and geological studies of the various prorated fields have continued. Continuous engineering studies to control physical waste of oil and gas are made in the Temple and Winterfield fields of Clare County, Reed City field of Osceola County, Headquarters field of Roscommon County, and North Adams field of Arenac County. Results of the studies are compiled monthly, and with data on refinery and pipeline operations and forecasts of future demands guiding the Supervisor of Wells and the Oil Advisory Board in making adjustments in the per well allowables. Plans are being made to expand this work in order to produce all the oil possible without waste.

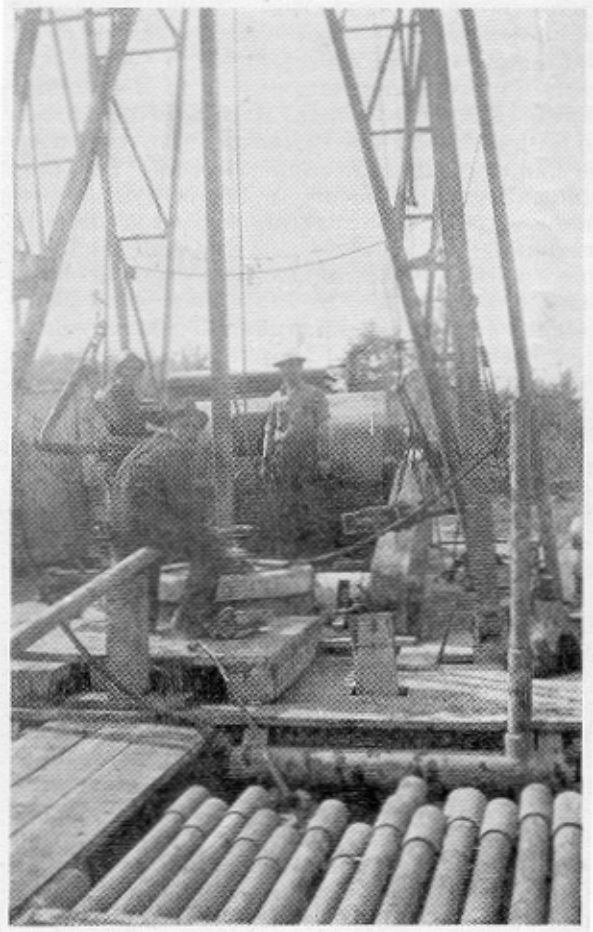
Control of brine produced with the oil continues to be a problem. Locally the problem, becomes acute, but for the State as a whole brine disposal is a difficult job almost conquered. More than 75,000 barrels of brine are produced each day but more than 95 percent is returned to barren underground formations and stored there for possible future development by the chemical or other brine-using industries.

Routine work has continued in keeping progress structural maps of the Southern Peninsula to date, drafting new base maps of counties and townships and new oil fields, keeping maps of new oil fields posted, revising old maps as new data accumulate. New base maps on a scale of one mile to an inch have been made for Lake, Missaukee, Newaygo, Tuscola, and Saginaw counties, and for Trowbridge township, Allegan County; Deep River township, Arenac County; Riverside township, Missaukee County; Richfield township, Roscommon County; Bangor township, Van Buren County; and for the Headquarters oil field in Roscommon and Clare counties.

Samples of rock from drilling wells have been collected. They are washed, bottled, labeled, stored by part time student assistants at Michigan State College. All wildcat well samples are microscopically studied as soon as possible to keep abreast or ahead in knowledge of possible developments. Likewise all important interesting wells in developed fields—"extensioners" and deepened wells receive prompt attention. Samples from all other wells are being studied as rapidly as possible. "Sample" logs are prepared for all. Graphic strip logs are prepared whenever necessary to show and/or study structural relations or position of rock strata in a field, or to prepare graphic cross sections, showing the geology from well to well, pool to pool, or county to county. Either driller's or sample logs are available on practically all the oil and gas wells drilled in the State since the permit system went into effect. Many logs of older wells and of water wells are also in use.

A map showing the topography of the bed rock is nearly completed. This map, with a map showing the thickness of the glacial drift mantle covering the bed rock is of value not only to the petroleum industry, but to the water resources and all other mineral industries east of the meridian of Marquette.

Data are being assembled and maps are being prepared showing the thickness of all the sedimentary rock strata of the State younger than the copper and iron bearing series. All these data made available by wells drilled for oil, gas, water, and other exploration are filed not only for the petroleum but for all other industries using our mineral resources brines, coal, gypsum, limestone, or exploring for them. A considerable library is being built up on subsurface data.



Pulling up "kelly." Smith Petroleum Co. Fork Township, Mecosta County.

Field men, geologists and engineers, working out from the division field offices in Mount Pleasant, Allegan, and Cadillac, collecting samples; watching critical wells, aiding in oil field proration, engineering, law enforcement, and brine disposal problems, are on almost 24-hour duty. Conferences with land owners, petroleum operators, geologists, and the general public are a daily routine in the field and Lansing offices. Maps are prepared for the Public Service Commission and hearings attended on gas and oil matters. Examinations are made for the Michigan Corporation and Securities Commission of the status of operators who wish to explore or drill in Michigan. Reports are made to the Lands Division regarding the geology of State-owned lands.

An annual report on the oil and gas developments in Michigan was published in the bulletin of the American Association of Petroleum Geologists.

The "oil and gas" control laws, Act 326, P. A. 1937, and Act 61, P. A. 1939, (discussed in the Tenth Biennial Report) continue to work well. In the main the industry and the Department are satisfied, the laws are found workable. Accumulated experience of both operator and enforcing authorities prove that only a few minor amendments to the law may be necessary. Producers have cooperated with the Department in fine spirit and deserve much credit for the successful operation of the laws.

Our entry into the war has brought many new problems. Mid year of 1941 President Roosevelt established the Office of Petroleum Coordinator for National Defense, which is now the Office of Petroleum Coordinator for War. The OPC works with the petroleum industry and the state regulatory officials in the endeavor to produce the most oil and gas with use of the least amount of critical material—mainly that equipment made of steel. Therefore drilling of new wells has materially decreased, as drilling of wells for oil is now limited to one well for forty acres, and for gas to one well for 640 acres, excepting specific exemptions granted by the WPB on recommendation of the OPC. The Geological Survey Division, as the representative of the Supervisor of Wells, is continually working with the oil and gas operators to obtain exceptions to the spacing rule in areas where study of all geological and physical conditions is convincing that different spacing is in the public interest to promote the war effort.

PUBLICATIONS

No formal publications have been issued by the Division during the past two years, but several mimeographed pamphlets have been issued:

Progress Report No. 6—Geology of the Menominee Range in the vicinity of Iron Mountain. With maps.

Progress Report No. 7—Dip Needle Survey of the Wyandotte-Winona Area, Houghton County, and the Cherokee Area of Ontonagon County. With maps.

Progress Report No. 8—Geology of the Menominee Range, Norway to Waucedah. With maps.

General Statistics on Costs and Production, Michigan Iron Mines.

Michigan System of Mine Appraisal.

Annual Summary of Oil and Gas Operations.

Guide Book for Geological Field Trip to Mackinac and Vicinity. With maps.

Papers on geology, mineral industries, oil and gas operations, and water supplies of Michigan, written by staff geologists and engineers, have been published in various scientific journals, U. S. Geological Survey Water Supply Papers and bulletins of the Inter-State Oil Compact Commission.

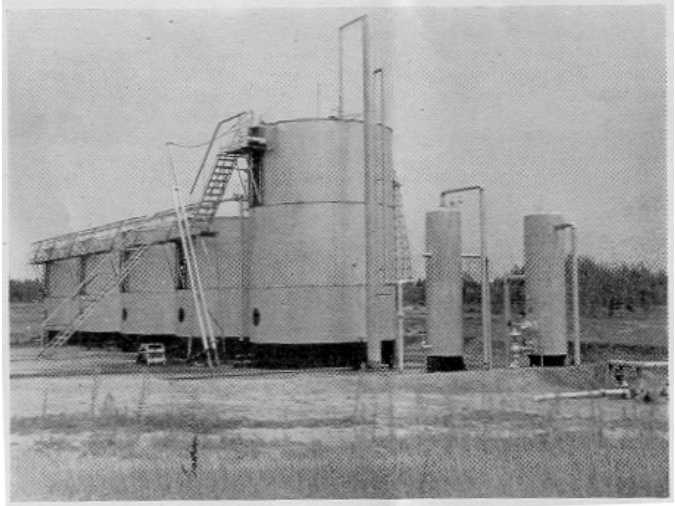
Several hundred mimeographed well logs have been added to the well log library and prepared for sale. A variety of county and township base maps have been drafted and issued in blue line prints.

SURFACE GEOLOGY

Work has continued on the revision of the map of the surface formations of the State ("soil map") in cooperation with Dr. Frank Leverett, the University of Michigan and Michigan State College Departments of Geology.

In cooperation with the Geology Department of Michigan State College the glacial formations and limestone outcrops of Charlevoix, Emmet, Cheboygan, Presque Isle, and Alpena counties were mapped.

In cooperation with the University of Michigan a survey was made of Mackinac Island and a report written. In the early summer of 1942, at the suggestion of the Survey, a detailed survey of the rock formations of St. Ignace and Mackinac and Bois Blanc Islands was initiated, and a study made of the rock exposures in the new canal excavation at the Soo Field work on the dune studies was completed in the southern Lake Michigan area, and reports are in preparation.



Model oil tank battery with gas separator.

WATER SUPPLIES AND LAKE LEVELS

The need for information on the availability of ground water for forest fire suppression resulted in the development in Michigan of a new type of underground water study in which this State pioneered. The method and technique have been described in previous reports. Several thousand wells were put down to the ground water table as CCC projects, and maps were compiled that showed the depth to underground water over a large area in the northern part of the State. The United States Geological Survey cooperated in supervision of this work. Approximately 200 wells were selected as observation wells for periodic measurement of the fluctuation of the water table. This program was begun in 1934 and continued with the aid of the Michigan State CCC until 1938, when CCC aid was curtailed, and as a consequence the number of observation wells was reduced during the next several years to 75. Complete discontinuance of CCC aid in 1941 required that the work be taken over by the Geological Survey, but lack of personnel to make so many observations necessitated reducing the number of wells regularly measured to 45. The intervals of measurement were also changed from twice monthly to monthly. It is believed, however, that the value of information obtained is not greatly decreased by this change. An automatic recording well was constructed at Roscommon Forest Fire Experiment Station in 1934, and a continuous record of the variation of the water table there is available since that date. The U. S. Geological Survey continued supervisory cooperation and publication of the data in its Water Supply Papers. The latest report, United States Water Supply Paper No. 906, contains data for 1940.

Originally begun as a forest fire suppression measure, the ground water well program, in the northern part of the State was later found to be of great value in a study of the fluctuations of the levels of inland lakes. Because of a ten-year period of subnormal rainfall, hundreds of the State's lakes dropped to alarmingly low levels, to the great concern of cottage and resort owners and associations. Several hundred complaints and requests for aid on problems of low water have been received by the Conservation Department in the past several years. Although Act 194 of the Public Acts of 1939 gave the Department authority to commence proceedings for the determination of normal levels of lakes, and to apply such corrective measures as were feasible, no funds were appropriated by the legislature to administer the act. Consequently the only aid the Department could give was of an advisory or consulting nature until additional funds and cooperation were made available by the Fish Division. One geologist was available for part time work, and some engineering service was also available. In October 1941 another geologist if was added, and in November a cooperative program of stream gauging with the U. S. Geological Survey was expanded to include studies of inland lake levels. As a result of this cooperation, gauges have been established

on 65 of the larger lakes of the State, and on 25 streams, which are either inlets or outlets of those lakes. A number of urgent problems on larger lakes have been the reason for special detailed hydrologic study by Survey geologists and engineers of the Conservation Department and United States Geological Survey. These studies were made Black, Mullett, Burt, Manistique, Otsego, and Missaukee lakes. Expansion of the program is planned to study additional lakes as cooperative funds become available because the data obtained are essential to the solution of certain problems affecting the tourist industry, owners of lakeside property, public lands bordering lakes, building of dams, flooding of farm lands and others.

Another important outgrowth of the forest fire ground water surveys is the application of the information gained from observation wells to the calculation of increase or decrease in ground water storage, and the effect of this storage on flow of streams. Regulation of stream flow is important from several standpoints: removal of industrial and municipal wastes, preservation of fish and wild fowl, provision of a constant supply of water for hydro-electric power development. Michigan has no large reservoirs for storage of surface waters. Surface water storage is not needed for hydro-electric purposes in Michigan because, unlike many other states, Michigan, particularly in the northern part, has extensive sandy forested plains and swamps which soak up rainfall like a sponge and give out the water gradually. Ground water storage tends to prevent or reduce the severity of floods. Monthly summaries of ground water conditions in Northern Michigan are supplied to companies producing hydro-electric power from waters heading in that part of the State. This information has been found of considerable value to the companies. The war time value of these studies is shown by their use in complying with the orders of the War Production Board that all water reservoirs be kept full to conserve fuel; thus information on water storage as reflected in the height of ground water becomes increasingly important, especially as Michigan lacks large reservoirs for surface storage of water.

Studies are being started in the translation of ground water levels to water storage and stream flow. In such a study Michigan is a pioneer.

Water level studies have been made and data collected on municipal wells in seven cities in the southern part of the State. These observation well studies are for a different purpose than in Northern Michigan. Municipal wells supply important information on the continuing adequacy of the water supply in cities. The latest reports on the study of municipal wells is published in U. S. Water Supply Paper No. 906.

With the advent of war, municipal and industrial water supplies have not only increased in economic importance, but have become of strategic and in some places of critical importance. This fact has been recognized by the War Department, the War Production Board, by the executives of various plants producing war materials, and by cities of major importance in war production. Survey geologists have made a number of water supply investigations on the direct request of the War Department, War Production Board, and other Federal agencies.

Routine work in securing potable waters for hospitals, parks, municipalities, and individuals continued through the biennium, but was increased and specialized with wartime need of water for defense plants, housing projects, army camps and cantonments. Rock samples from and logs of wells drilled for water are added to the Survey data on subsurface conditions in the State.

In addition to the lake level program, which includes measurement of inflow and outflow of lakes, the Conservation Department in 1941 entered into a cooperative agreement with the State Stream Control Commission, the State Highway Department, and the Water Resources Branch of the U. S. Geological Survey for continuing records of stream flow at 32 stations in the southern part of the State. This work is carried on by the same engineers conducting the cooperative lake level work. Funds for this Department's participation are derived largely from the 40-cent fund from fishing licenses. The U. S. Geological Survey also publishes the data on stream flow. The latest report for Michigan is in U. S. Water Supply Paper No. 894, with data for 1940.

Ontonagon Project

In addition to measurement of inflow and outflow of lakes and the regular stream gauging program, the Conservation Department, the U. S. Geological Survey, and the Copper Range Power Company commenced cooperation on a study of the Water Resources of the Ontonagon River Basin. The Conservation Department is interested mainly in requisite amounts of flow to support fish life, and, with the Power Company, is interested in the water resources of the system for production of power vital to the copper mining industry. Ten stations established on the main stream and tributaries give complete information on the water resources of this river basin.

The U. S. Geological Survey established an office in Lansing as headquarters for cooperative work in Michigan on lake level stabilization and stream flow work in the State. Field offices have been established at Grayling with a hydro-geologist from this Division in charge to conduct the work in the northern part of the Southern Peninsula, and at the College of Mines in Houghton for work in the Northern Peninsula. Two U. S. Geological Survey engineers work from the Houghton office.

WAR WORK

The Geological Survey Division's contribution to the war effort:

Six men in the armed forces.

Leave of absence of the Mining Engineer to act as technical advisor to the United States Embassy in Brazil on strategic minerals of Brazil.

Investigations and surveys of deposits, with reports, maps, analyses, geological and geographic relationships (shipping facilities), of copper, iron, manganese, dolomite, brines, strontium (for tracer bullets), feldspar (for "putting out" incendiary bombs), graphite and water, for the War Production Board, Defense Plant Corporation, Bureau of Mines, Public Health Service, and industrialists holding government contracts.

Cooperation with War Production Board, and the Office of Petroleum Coordinator, and the National Conference of Petroleum Regulating Officials in matters relating to oil and gas production and conservation, and the conservation of steel. Desiring to clear the files of records of inactive wells, foreseeing the shortage in steel, and as a corrective measure to prevent waste under our oil and gas laws, a list was made late in the biennium of all abandoned and inactive wells which might have possible recoverable casing. Therefore when the shortage of steel became critical, yet steel is needed to produce the strategic mineral, oil, and the WPB and OPC salvage committees came into Michigan to investigate the situation here, they found a salvage program already functioning. Michigan is the first state to complete such a survey and to set up an active program of recovery of oil field steel. Results of the survey and program are to be watched and applied on a National scale to expedite recovery from other oil fields in other states. Petroleum engineers serve on several industrial committees with the OPC to sustain and increase oil and gas production to meet war needs, and serve for the Supervisor of Wells representing Michigan in the National Conference of Petroleum Regulatory Officials, which meets quarterly with the directing officials of the OPC to work out oil production problems of mutual interest.

Located adequate water supplies for the Willow Run Bomber Plant, which, by August 1942 needed live million gallons per day. At the request of the War Production Board a reconnaissance survey was made of the southeastern section of the State to determine the sources and adequacy of the water supply in that highly industrialized area. Later a staff geologist assisted the U. S. G. S. Division of Ground Water in a more detailed reconnaissance of the same area. Location of war plants and their efficiency depends on the immediate water supply; therefore special surveys, investigations, and/or reports have been made for Flint, Owosso, Plymouth, and Saginaw, where plants are to be located. Water supplies for housing projects connected with the war plants, for camp and cantonments, and for evacuation areas have been investigated and reported to Federal authorities, as well as water resources of several interior counties where large scale war developments or uses are contemplated.

Wartime need for magnesium stepped up from a pre-war annual use of 6,000,000 pounds in the United States to a war need of 400,000,000 pounds annually, made Michigan's enormous reserves of dolomite strategic. The Survey's suggested use of the rock as a source of magnesium resulted in numerous requests for reports from governmental and industrial resources. Several reports on the dolomites, as well as on the magnesium-bearing brines of the State have been made.

The survey of the iron regions was planned for areas where later diamond drill exploration might open war-needed reserves of ore.

Miscellaneous reports to various agencies have been made on useful minerals for the war need.