OIL AND GAS DEVELOPMENT IN MICHIGAN

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INTRODUCTION

Michigan has never held a significant position in petroleum production, although for many years the occurrence of oil and gas in the state has been fully appreciated. Various attempts at discovery have been made and these have received considerable impetus from both within and without the borders of the state because of known remunerative oil fields in districts close by. Attention has been called at various times to the oil and gas possibilities of Michigan both in survey* publications, and other sources.

The growing importance of Michigan in petroleum development in the past few years has been influenced largely by the discovery of the Saginaw Oil Field and the condition of the oil industry. The opening up of the Saginaw field proved conclusively that right structural and geological conditions may result in the occurrence of a commercially important pool of oil. The position of the industry was such that many of the large companies could release members of their departmental staffs for work in new territory. Unexpected flush production from new pools in the Mid-continent fields and California created such large stocks on hand and so depressed the prices for crude in these districts, that a great deal of expansion and new development was curtailed. Arising out of this condition, Michigan, because of its advantageous location in respect to market and greater possibilities for high priced oil, received added attention. Wildcat drilling activity which resulted from these causes points to a more promising future, for although the percentage of dry holes has been great the more recent results have been decidedly attractive. During October, 1927 the Diamond Crystal Salt Company at St. Clair, St. Clair County, drilled in a gas well which had an open flow of over 500,000 cubic feet and gauged 1200 pounds closed in rock pressure. Late in December of 1927 an oil well was brought in near Muskegon, Muskegon County, which flowed over 300 barrels initial daily production. This was followed closely by reports from Ashley, Gratiot County, that a 50-barrel well had been struck in the same general vicinity where a shallow gas well showing about a million cubic feet open flow capacity was discovered earlier in the summer preceding.

The haphazard nature of the wildcat operations and prospecting by even some of the larger companies has had mute testimony in the number of dry holes drilled. It is true that a great many factors enter into the prospecting for oil and gas besides those of geological significance, but evidence so far would indicate that the only accumulations of any size in Michigan are governed by structural conditions. Prospecting and the delimitation of structure should precede deep drilling in any systematic wildcat venture. In Michigan where the glacial drift sheet veils the surface rocks, this can only be done by scattered shallow test hole drilling to an identifiable key formation. To follow such a procedure

*Smith, R. A., Oil and Gas in Michigan Pub. 8. Geol. Series Mineral Resources, Michigan Geol. and Biol. Surv. 1910. pp. 366-397.
Smith, R. A., The Occurrence of Oil and Gas in Michigan. Pub. 14, Geol. Series 11, Michigan Geol. and Biol. Surv. 1912.
Robinson, W. I., Possibilities of Oil and Gas in Michigan. Pub. 32, Geol. Series 26, Michigan Geol. and Biol. Survey 1922. pp. 103-118.
Emmons, W. H., Geology of Petroleum, Michigan Field. p. 254, McGraw Hill Co., 1921.
Robinson, W. I., Geological Factors Affecting Oil Exploration in Michigan. Nat. Pet. News, Sept. 6, 1922.

requires a large expenditure and a careful study of geological conditions and is time consuming as well. However, the points in its favor are that for the same amount of money many points of control are obtained instead of only one, and the results are either to sanction or condemn a territory and thus cut down lease holding expense. The sum total effect is to reduce the gambling chances and assure a greater return upon the investment involved. The oil man will contend that the only ultimate test is for the drill to penetrate a possible formation and to that we must agree. He also knows, however, that the use of geological knowledge and interpretation of structure has been an important factor in elimination of dry hole loss. At the present time one large company operating in the state has adopted the shallow test program for its prospecting activity. Future results should bear out its practicability and prove its value in comparison to deep tests drilled upon mere suggestions of structure.

ACKNOWLEDGMENTS

In compiling the data for this report frequent recurrence has been made to previous writings of former members of the Michigan State Geological Survey. The works of A. C. Lane, R. A. Smith, and W. I. Robinson have been often consulted and a few excerpts are included in certain sections. The writer has adhered rather closely to the classification of Lane in the statement of stratigraphy and the discussion of unconformities largely embodies his ideas of Michigan Paleo-geography. Those modifications added to description and thickness limits of formations have been derived from the results of later well drilling and the more detailed examination of certain areas.

The very brief outline of the ideas relative to origin and accumulation of petroleum has been derived from different sources. The most important of these are the Geology of Petroleum by W. H. Emmons and the Lectures of C. W. Cook. The method for determining reserves has been that of C. H. Beal as outlined by R. W. Brown.

An unusual amount of thanks is due to the various operators who have furnished well records and production statistics. Among these are included the Saginaw Prospecting Company, the Sun Oil Company, and the Ohio Oil Company for the Saginaw Field; the Muskegon Oil Corporation and the Dixie Oil Company for the Muskegon Oil Field; and the Pure Oil Company, Norris and Smith, and the Grayling Development for Central Michigan. The great number of other operators which can not be listed gave splendid co-operation and it was only through their careful collection of well cutting samples that much of the information included in this report was obtained.

The writer is also indebted to the other geologists operating in the state under major oil company direction. Many helpful suggestions have been offered by W. A. Thomas, H. D. Crider, R. L. Melhorn, and R. E. Gore. Much personal assistance has also been rendered by James C. Graves, President of the Saginaw Prospecting Company and George Myers, Supt. of the Sun Oil Company.

The newspapers of cities in which oil development has been centered have contributed materially to current information. Especial commendation is due to the Saginaw Daily News and the Muskegon Chronicle for the careful manner in which their staffs have handled the oil news. Further data has also been gleaned from summary reports in such trade

publications as the Oil and Gas Journal and the National Petroleum News.

Acknowledgment is given to the great number of others who have added directly or indirectly to the material of this report. Wells drilled for salt, water supplies, and other purposes besides oil and gas have given points of control in many areas. For these many records and the various sources not included individually a final recognition is included.

HISTORY

EARLY DISCOVERIES.

Probably the first knowledge of the presence of any petroliferous substances in the Michigan rocks came from observations of exuding oil upon surface outcrops. Shallow well drilling for water showed traces of oil and often considerable gas was found where the geological formations immediately underlying the drift were of a bituminous nature. Later borings for salt proved that there were deeper occurrences of oil and gas in the rocks. Influences of the finding of large quantities of petroleum in Canada and in the Lima-Indiana field prompted drilling activity around Port Huron and in the Southern part of the state. The result was that four small fields or districts were outlined, although only one of them ever made any regular production.

PORT HURON.

At one time the production of the Port Huron area was some 70 barrels of heavy oil per week from a group of 22 wells situated on the west and the northwest side of the city. The structure is a low anticline which trends westward across the St. Clair River from Sarnia and turns sharply northward along the course of the Black River. It has a very gentle pitch and there are no evidences of marked cross folding. The initial yield of the wells amounted to from three to seven barrels per day, but after a very rapid decrease the yield amounted to about one-half barrel per day. Most of the wells yielded sufficient gas for motive power in pumping operations and the drilling of new ones. The only company operating was the G. B. Stock Zylite & Grease Company, who used the oil in the manufacture of lubricants. The wells are shallow, being from 500 to 650 feet deep and the oil is a heavy black variety. Production was insignificant after 1920 and wells were plugged in 1924(?).

ALLEGAN.

Nearly a dozen wells from 1300 to 1400 feet in depth were drilled in the immediate vicinity of Allegan, Allegan County. The first of these was drilled about thirty years ago by the Allegan Gas, Oil and Mining Company and they were reported to have yielded at the outset from three to five barrels per day. More recently in 1912 drilling was carried on by the Northern Oil and Gas Company and small wells were obtained from a split pay separated by a few feet of gritty limestone. The oil was dark reddish brown in color with a sulphur odor and tested about 36 degrees Be gravity. There was very little gas associated with the oil, and the depth made the commercial pumping of such small wells quite prohibitive. Although some of the data appears to be inaccurate, the structure is considered to be a terrace with abrupt northward dip and the oil was found on the lower part of the terrace and on the steeper slopes to the north.

SAGINAW.

In the winter of 1912 a group of enterprising Saginaw business men formed the Saginaw Development Company for the purpose of testing out the oil and gas possibilities of the Saginaw Valley region. Prior to this time the wells drilled for salt brine at Saginaw and Bay City had furnished sufficient data to outline a pronounced anticlinal fold in the vicinity of Saginaw. Development had been previously encouraged by Dr. A. C. Lane when State Geologist and upon the basis of this knowledge ten wells were drilled. The results of these tests were to define three well represented and accessible oil or gas formations in the Berea, Traverse and Dundee with the possibility of three oil horizons in the Dundee. Eight wells reached the Dundee and the Traverse was reached by two, and all seemed to verify the presence of the anticline both from depth figures and presence of oil or gas. Of the six wells appearing to be on the fold, four yielded oil and gas in significant if not commercial quantities. One difficulty was the close spacing of most of the wells in a limited area beyond the supposed high places on the flexure. Five of the wells were located within a radius of 1200 feet and the remaining five were at considerable distances from the supposed anticlinal crest, which greatly minimized the structural information derived from them. What was later found to be the more exact location and trend of the Saginaw anticline, was but slightly missed in these early explorations. The oil found in 1912 came principally from the "Saginaw" Sand, a cherty or sandy phase in the top of the Traverse limestone, and from about 35 feet below the top of the Dundee formation. The Berea was practically barren, containing only brine or small shows of gas. Although no production of note resulted from these operations, several of the wells gave promise and the Garey-Casamer No. 1 started at from 25 to 30 barrels and in spite of trouble from water, yielded 3 to 4 barrels daily for some time. "The "Saginaw" Oil which was light green in color by reflected light and dark red by transmitted light, tested 47 degrees Be. gravity and an analysis at the Paragon Refining Co., Toledo, Ohio, yielded 28.16 per cent naptha and 34.5 per cent burning oil. The oil from the Dundee tested 36 degrees Baume gravity, was dark green in color, and had a distinct sulphur odor.

DEERFIELD.

Near Deerfield, Lenawee County, in the vicinity of the Monroe County line five wells were completed in 1921 by the Deerfield Oil and Gas Company and its successor, the W. K. Development Company. Some production was obtained on the Roe and Gaertner farms. The first well was drilled to 2235 feet and finished in the Trenton limestone. It was shot with 300 quarts of nitroglycerine, and pumped about 70 barrels of oil the first month. According to reports the Gaertner well made 3 to 4 barrels a day for some time. It is still pumped at intervals and gives considerable oil. Two pays were encountered in this well at 20 and 60 feet in the Trenton formation, and the depth to the Trenton in the general area is from 2000 to 3000 feet. The oil is of high grade, showing light green in color and has a gravity of 40 degrees Baume. The structures outlined by a number of wells scattered throughout Monroe and Lenawee Counties is a broad nose-pitching northwest with steep dips on its west flank and much flatter on the east flank.

OTHER AREAS OF INTEREST.

Numerous other showings have been obtained in Monroe County, the oldest of importance being the Potter well drilled in 1899 in NW¼ of NW¼ of Sec. 22, Erie township. Up to 1912 about 15 wells had been drilled in this county, and more recently the Bedford-Erie Oil and Gas Co. completed two wells to the Trenton near Temperance and found a showing of oil. At Osseo, Hillsdale County, some gas was obtained from the Dundee limestone at about 1400 feet. The history of prospecting for oil in Lenawee County offers about the same sort of picture as Monroe County, various light shows being found from the Trenton. Jackson County was tested in 1922 to a depth of 1876 feet by a well sunk near Napoleon by the Jackson County Oil and Gas Company but no very important showing of oil or gas resulted from this well.

At about the same time a deep well was completed near Chesterfield, Macomb County, by the Macomb Oil and Gas Syndicate, which penetrated the Trenton at 3500 feet and finished at 3558 feet. There were small and unimportant showings of oil from 2610 and 2710 feet, but the Trenton did not prove productive. A later well was drilled by the Thumb Oil and Gas Developing Trust near Brown City, Sanilac County, under the management of Col. J. C. Gaines. This boring located in Burnside township, Lapeer County, obtained no important showings of oil and was completed in the Detroit River formation at 2627 feet.

Various shallow wells have encountered small quantities of gas from time to time where the drift material is underlain by the black bituminous Antrim shale. These offer a source for local farmhouse consumption and may last for several years. The expense is hardly more than for drilling a water well with additional cost of laying a small pipe. The most important localities for such wells have been in Manistee, Alcona, Montmorency, Macomb, Oakland and St. Clair Counties. Similar gas wells have been found in Livingston County either in the drift or the shallow occurrence of Berea which immediately underlies.

Western Michigan has a history bearing on oil and gas which dates from the beginning of the salt industry. Four wells at Muskegon, the first of which was drilled in the early seventies, showed the presence of oil at about 1200 feet, with smaller indications locally in the Coldwater shale and the Devonian limestones. At Ludington, Mason County, similar conditions were found in the wells drilled by the Pere Marquette Lumber Co., Stearns Lumber Co., and the Anchor Salt Co. (Morton Salt Co.) where oil was encountered in local sand phases of the Coldwater formation from about 700 to 1200 feet and in the upper part of the Traverse limestone at approximately 2100 feet. The horizon at about 1200 feet may be equivalent or correlative to the Berea of the eastern part of the state, as it occurs at nearly the same local position in the column of rock succession. Of the 35 or more salt wells drilled around Manistee Lake in Manistee County, the most notable amount of oil was found in the R. G. Peters Salt and Lumber Co. well drilled in 1886. It is reported that water and oil shot up 150 feet above the derrick, and the oil flowed for some time from part of the Monroe Series. Some oil was also recorded at about 960 feet in the Antrim formation. More recently the Manistee Oil and Gas Company reported a show at about 900 and 1100 feet in their well across the river from East Lake and Ruggles and Rademacker record gas at 800 feet on the west shore of Manistee Lake.

STRATIGRAPHY

DESCRIPTION OF FORMATIONS.

The sedimentary strata of Michigan, with the exception of the Quaternary which is largely unconsolidated, are entirely included within the Paleozic Era. The section represented is one from the base of the Upper Cambrian to near the top of the Pennsylvanian. In many parts of the state exposures are frequent, especially along both the north and south shores of the Upper Peninsula. The Lower Peninsula is more or less mantled by a layer of glacial drift material which with a few exceptions hides the bed rock from exposure. The only areas where it outcrops to any considerable extent in the Southern Peninsula are in Alpena and Presque Isle Counties to the north and Hillsdale, Jackson and Calhoun Counties to the south. Limited but commercially important outcrops occur along the south shore of Little Traverse Bay in Charlevoix County and in Monroe and Wayne Counties. Rock is occasionally uncovered in Cheboygan, Emmet, and Antrim Counties and outcrops exist in the Central Michigan Counties of Ingham, Eaton, Ionia, Shiawassee, Genesee, and Saginaw. A few scattered exposures are available in the counties surrounding Saginaw Bay, the northern and eastern parts of the "Thumb" district, and Ottawa and Kent Counties. The thickness of the drift cover throughout the major part of the State varies from 100 to over 700 feet, which makes it impossible to gain any knowledge of rock character, distribution, or structure excepting from the records of deep wells. Thickest glacial material is located in the north central part of the Southern Peninsula, and therefore information pertaining to the rocks of this section is most meager. A brief summary description of the Michigan sedimentary rocks will suffice to give some idea of their extent and thickness.

CAMBRIAN

Cambrian age is represented by the *Lake Superior* sandstone sometimes called Possdam, Jacobsville, or Eastern in limited or adjoining areas. This formation is the upper member of the Cambrian and probably underlies the entire Michigan basin. Outcrops occur along the Lake Superior shore from Marquette eastward and it has been encountered in various bore holes in the southern part of the Northern Peninsula. Because of the great depth it has not yet been penetrated in the Southern Peninsula. The characteristics of the formation are a red lower portion and a white or less colored upper portion. Grains are both quartsose and felsitic and often irregular in shape and variable in size. Thickness ranges from about 200 and 300 feet at Rapid River and Neebish Island to 1500 feet at Grand Marais.

The formation contains fresh water, especially in the lower part.

ORDOVICIAN

Outcrops of this age are limited to the Northern Peninsula and include the Hermansville limestone, the Trenton limestone, and the Cincinnatian shales.

Beekmantown (Lower Magnesian, Calciferous or Prairie du Chien) is represented by the Hermansville limestone which is probably equivalent to the lower part. It is mainly limestone, sandy limestone, and white

sandstone and this latter phase makes identification difficult from the St. Peters and Potsdam where encountered in well samples. The color is sometimes buff to red, the lithologic character is usually dolomitic and the formation contains fresh water. There is a thickness of from 200 to 250 feet represented.

St. Peters sandstone, is absent in outcrop throughout Northern Michigan, but is about 75 feet thick near Marinette, Wis. The formation is a white sandstone with grains well rounded and loosely cemented and shows a variable thickness caused from filling irregular hollows in the eroded surface of the Beekmantown. The St. Peters is also fresh water bearing where encountered at shallow depths.

Trenton (Black River—Lowville) limestone outcrops in the Northern Peninsula and has been penetrated by deep wells in the southern part of the Southern Peninsula. In the exposed beds the formation is from 250 to about 270 feet thick and includes three phases (1) an upper granular, crystalline, dolomitic limestone of alternating blue and brown layers terminating at the base in a dark bituminous limestone, (2) a middle portion of cherty layers or lenses alternating with thick beds of limestone and, (3) a basal member of blue shales and limestone, a part of the latter being black or dark. Some of the outcrops near Rapid and Whitefish rivers show oil impregnating the rock and asphalt filling fissures and cavities. The total thickness of Trenton found in the Ford well at Dearborn, Wayne County, was 875 feet and it very likely underlies the entire Southern Peninsula.

Cincinnatian Series include the shales and gradational limestones of Utica, Lorraine and Richmond members. The Utica (Eden of Ohio) shale is brown to black and bituminous with a thickness varying from 50 feet in the Northern Peninsula to about a maximum of 300 feet in the Southern Peninsula. The Lorraine or Maysville shales are soft blue calcareous beds with some streaks of black near the base. It is difficult to distinguish from the Richmond above which is a red and blue shale, locally sandy, and often fossiliferous. Hussey* gives a thickness of 158 feet to the Richmond of the Stonington region in Northern Michigan which does not include several covered intervals. The color is largely gray and brown often weathering blue and the beds grade upward into limestones. The total maximum thickness of the Lorraine—Richmond in the Southern Peninsula has thus far been found to be about 595 feet.

SILURIAN

The Silurian formations include the Medina-Clinton interval, the Rochester shale, the Niagaran Series, the Salina formation, and the Lower Monroe or Bass Island.

The Medina-Clinton interval is usually considered under the heading of the Cataract formation with the two sub-divisions of Manitoulin and Cabot Head members. Occasionally the Clinton is recognized as a clayey dolomite with more or less iron ore and red shale and varies in thickness from nothing to 130 feet. The presence of water and gas is characteristic of the top of the formation. The Manitoulin member of the Cataract formation may be mistaken in part in well logs for Richmond, but it is correlated as gray dolomitic limestone reaching a maxi-

*Hussey, R. C.—The Richmond Formation of Michigan Cont., from Mus. of Geology, Univ. of Mich. Vol. II, No. 8, pp. 113-187, July 15, 1926.

mum thickness of 150 feet. The Cabot Head Member as correlated may often contain the Clinton and Rochester formations in part. It consists of red, blue and greenish blue shales and the maximum thickness recorded is 205 feet.

The *Rochester* shale where identified is a persistent blue shale horizon from 30 to 80 feet in thickness. This shale has been correlated with the Rochester formation of New York but may be a part of the Clinton.

The *Niagaran Series* including the Guelph and Lockport limestones and dolomites forms a belt of outcrop in the form of an escarpment extending from the southern part of Garden Peninsula along the Lake Michigan and Lake Huron shores to the eastern point of Drummond Island. This series as subdivided by *Ehlers includes the Clinton Group below and the Lockport Group above. Locally in the Upper Peninsula the Clinton Group is Middle Clinton in age, and is called the Mayville Dolomite. The Lockport Group is divided into the Burnt Bluff Manistique, and Racine Dolomites. Of these the Racine is the same as that previously called Engadine and equivalent to the Guelph of Ontario.

The Niagaran formation is made up of massive white to blue, gray, and buff dolomites and limestones. The Guelph is white to bluish white in color and is easily recognized by this characteristic, whereas the Lockport, although somewhat uniform, has a variable color. The Niagaran is rather free from such impurities as iron and clayey material and consists largely of carbonates of calcium and magnesium with the exception of thin lenses, and nodules of chert and occasional sandy beds. Limestone prevails through the lower part but the formation as a whole is dolomitic. Thickness of the series varies throughout the State from 270 to 790 feet. Usually one or more water bearing horizons occur in the formation and the water is fresh near the surface and becomes but slightly mineralized with depth. This is a striking contrast with the strong sulphate brines occurring in the Monroe above.

The *Salina* formation is extremely variable and is difficultly separated from the overlying Monroe dolomites when beds of salt are absent. It consists of brown to drab dolomite, anhydrite, gypsum, and salt beds with lesser amounts of red, green, and rarely blue to black shales, and dolomitic marls or oozes. If no salt beds are present, the first gypsum bed is taken as the dividing line, which is wholly abitrary because more or less gypsum occurs in the lower Monroe as well. The thickness of the formation varies from 370 to 1600 feet with the thickest part yet known located north of Port Huron.

The *"Monroe Formation"* is divided into three members, the Bass Island, Sylvania, and Detroit River, which divisions can be clearly differentiated only in the southeastern part of the state. The Lower Monroe or Bass Island is Silurian in age and is exposed in Monroe County. It varies from 365 to 522 feet in thickness and consists of oolite, sandy dolomite, dolomite and anhydrite, and acicular or gashed dolomite. The water flows are fresh when shallow and mineralized and sometimes sulphuretted at depth.

DEVONIAN

The Devonian consists of the Sylvania sandstone and Detroit River Series of the Monroe formation, the Dundee limestone, the Traverse limestone, and the Antrim shale.

*Ehlers, G. M. Unpublished Manuscript.

The *Sylvania* sandstone is locally present in southeastern Michigan since it is found only along the flanks of the Cincinnati anticline. The character of the formation is pure white, well rounded, incoherent sandstone from 5 to 300 feet thick and sandy limestone or dolomite from 30 to 165 feet thick. It is thickest along a line from Milan, Monroe County, to Royal Oak, Oakland County, and thins west of this and east toward the outcrop where there is from 50 to 100 feet represented. The gradation is to a sandy dolomite where found northward along the St. Clair River. Water found in the formation when it occurs at any depth contains large amounts of hydrogen sulphide gas, and free sulphur and celestite are frequent in zones of the rock.

The *Detroit River Series* or *"Upper Monroe"* consists of gray to buff oily dolomites and one pure limestone called the Anderdon. The thickness varies from 0 to 435 feet and the formation is best exposed on both sides of Detroit River and on the islands in it.

The *Dundee* limestone is equivalent to the Corniferous of the Canadian Ontario Section, the Onondaga of New York, the Jeffersonville of Indiana, and the Columbus of Ohio. It underlies the most of the Southern Peninsula and outcrops in large exposures near Sibley, Wayne County, Dundee, Monroe County, and Rogers City, Presque Isle County. The thickness varies considerably from about 100 feet in southeastern and southwestern parts of the State to over 250 feet in central part and the Saginaw Bay region. In Northern Michigan it is about 200 feet thick. The character of the Dundee is usually a very pure, gray to buff limestone with local nodules and seams of chert. Fossils are abundant and in many localities the rock gives a strong odor of oil and contains cavities filled with black bituminous matter. Waters from the Dundee occur at some distance from the top and are highly mineralized with large percentages of sulfate and often free hydrogen sulfide. This water high in sulphur content is usually termed by drillers the "black water" and is so recorded in various well records.

The *Traverse* formation is much thicker group than the Dundee and can be correlated with the Hamilton and Marcellus of New York and the Delaware of Ohio. Exposures are numerous in Alpena and Presque Isle Counties and on the South side of Little Traverse Bay. The formation is largely a limestone featured by coral reef structure, but it contains local beds of gray blue to black shale. One of these near the base is more persistent and continuous and is given the name of Bell Shale. Its maximum thickness has been found to be about 80 feet and where present it is a valuable marker in separating the Traverse from the Dundee. The limestones are mostly gray in color with some showing buff and even dark brownish cast. The thickness of the formation is on the average about 600 feet in the northern and eastern parts of the Southern Peninsula. A thinning takes place to the south and southeast and there is a decided thinning to the southwest where the Traverse is represented by as small as 60 to 70 feet of strata. Many of the beds show high purity in calcium carbonate and are very fossiliferous but essentially they are of a transitional nature from heavy limestones of the Dundee below to the thick unctuous black shale of the Antrim above. The Traverse according to depth may contain fresh or mineralized flows of water, and these may occur at various intervals from top. A water bearing porous zone is usually found from 85 to 100 feet in the formation

and this is probably near the contact of the Thunder Bay and Alpena Members.

The *Antrim* shale is an equivalent formation at least in part to the Ohio, Huron, Chagrin, Cleveland, and Bedford of Ohio; the Genesee, Portage and Chemung of New York; and the New Albany of Indiana. This shale is one of the most persistent in Michigan and varies in thickness from 140 to 466 feet. The color is black to brownish black with some blue shale members, and balls of ironstone and pyrite are often found. Spherical to ellipsoidal calcareous concretions with a radial concentric columnar structure and a diameter of six feet occur in some localities. The distinctly black shale is usually confined to the lower part of the formation and in places it contains so much bituminous matter that it is inflammable and attempts have been made at distillation tests. In the western part of the state where the Antrim passes into the horizon of the Berea, elsewhere represented by a sandstone, it is generally red, gritty, or interstratified with thin sandstone lenses.

MISSISSIPPIAN

The Mississippian in Michigan definitely includes the Berea sandstone, the Coldwater shale, the Marshall sandstone, the Michigan series, and the Bayport limestone. Since the base of the Mississippian is a mooted question, Lane* tentatively fixed it at the base of the Berea, stating that to place the base of the Carboniferous at the base of Bedford would split the Antrim in a very impractical way. The latter division is largely backed by paleontologists, although Ulrich suggests that it be placed still lower in the column. *Robinson has proposed to use the term Bedford to cover both a red shale phase sometimes present and the series of gray grits which sometimes shade upward into the Berea. In such a correlation the greenish gray shales and grits which are found in the interval between the Antrim and Coldwater in the western part of the state might also be called Bedford.

The *Berea* sandstone is regarded as equivalent to the Berea of Ohio and is found at the base of the Coldwater where sometimes it is difficultly recognized with certainty because of similarity to stray sandstones in the base of that formation. If the Sunbury (sometimes called Berea) shale occurs above the sandstone it may be definitely determined as Berea, as this fissile black to brown shale is quite easily determined. The Sunbury shale is sometimes termed a definite formation and although its common occurence is about 20 feet it has attained a major thickness where penetrated in wells of as much as 103 feet. The Berea occurs only throughout the eastern part of the Southern Peninsula where it is generally a fine grained white to gray sandstone. Coarser phases are found in southeastern Michigan and fresh water is present where it approaches the surface. At depth the brines contained in the Berea are largely devoid of sulphates and usually heavy containing a high percentage of salt. The average thickness is about 100 feet in southeastern Michigan and the Saginaw Bay Regions with a maximum thickness yet found of 273 feet. The formation thins northward in Iosco and Alcona counties and disappears entirely westward as a definite sandstone. At Alma, Mt. Pleasant and Grayling it is either represented by red shales,

*A. C. Lane and A. E. Seaman,—Notes on the Geological Section of Michigan. Annual Rept. Mich. Geol. Survey for 1908. pp. 73 and 75.
*Robinson, W. I. Unpublished Manuscript.

locally sandy, or it is absent. Near Charlotte, Eaton County, about 40 feet of broken sandstone was found in about the right place for the Berea but farther west its position is only marked by a thin red shale.

The *Coldwater* shale is one of the thickest formations in the state and its equivalent in Ohio includes part of the Waverly, Sunbury shale, together with Cuyahoga and Raccoon and perhaps the Black Hand. It is a soft blue and gray shale including large balls of ironstone near the top, lenses of fine grained sandstone (lenses of limestone in the western part of the State) and streaks of red shale. The thickness usually aggregates from 800 to 1100 feet, the base being separated by the black Sunbury and the top by the red micaceous sandstone of the lower Marshall. A local sandstone of considerable extent in the northern "thumb" and Saginaw Bay region occurs in the Coldwater at some distance above the Berea. This has been an important source of brine and when finally determined as distinct from the Berea was given the name of Richmondville. The Coldwater outcrops principally in Branch County and along the Lake Huron shore north of Port Huron.

The *Marshall* sandstone is made up of two divisions, the Lower Marshall and the Upper Marshall or Napoleon. The correlating formations in adjoining states are the Raccoon, possibly, Black Hand and Logan of Ohio in part, and the Kinderhook of Illinois. The Marshall outcrops occur in a belted arrangement extending from the "thumb" region southwest into Jackson, Hillsdale and Calhoun Counties and then northwestward into Ottawa County. The largest exposures are along the Lake Huron shore near Port Austin, Huron County and between Marshall and Battle Creek, Calhoun County. The lower division of the Marshall in the eastern part of the state is a white, red and gray micaceous and fossiliferous sandstone containing greenish gray gritstones with small peanut sized pebbles and red and blue shale. In the central part of the State it consists of red and blue shales usually sandy and containing ironstone. The demarcation both at top and bottom is generally a red sandstone or sandy shale which is popularly termed "paint rock." The division line between the lower Marshall and Coldwater is not a sharp one, but aside from the red color it is usually determined to be where the micaceous sandy shales leave off and the distinct blue gray shale begins. The Lower Marshall is locally water bearing.

The *Napoleon* sandstone is coarse and non-fossiliferous, often cross bedded, and shows a color from white to gray and grayish green. It contains pyrite, locally gypsum, aluminous minerals, and coaly material. The formation offers an abundant source of fresh water near its margin and contains brines strong in bromine and salts of the alkaline earth metals near the center of the basin. The thickness of the Marshall formation as a whole varies from 260 to 485 feet and roughly the Napoleon is usually about 100 feet thick.

The *Michigan Series* is extremely variable in thickness and character and is marked by the local thick beds of gypsum in Kent and Iosco Counties. As a whole it consists of blue to gray shaley limestone and dolomite, blue, black and light green shale, gypsum, anhydrite, and red sandstone. The sandstones are thin and irregular, and dark limestones occur near the base of the formation. Near the margin of the basin the thickness is about 200 feet, but toward the center it mounts to as much as 460 feet. Along the southeastern margin from Tuscola

County into Jackson County the formation is absent in whole or in part. Waters of the formation are noted for their permanent hardness, being salty and bitter at depth because of the high content of calcium and magnesium sulphates.

The *Bayport* formation which occurs at the top of the Mississippian is about equivalent to the Maxville of Ohio and the Upper St. Louis, Middle Kaskaskia of the Mississippi valley. It is a white bluish, gray limestone, often cherty or fossiliferous and occasionally weathers green. Because of its position as an erosion surface at the close of the Mississippian the Bayport is very irregular in thickness and distribution. On the southeastern margin from Tuscola into Livingston County, it seems either to have been completely removed by erosion or was never deposited. From the presence of remnants of the formation between Jackson and Grand Rapids the former hypothesis seems to hold. Generally the formation is not over 50 to 75 feet thick but occurrences of 100 feet are known. White sandstone lenses which are locally limy, are often present, and water is usually high in sulphates.

PENNSYLVANIAN

The Pennsylvanian includes the Parma sandstone or conglomerate, the Saginaw formation, and the Woodville formation.

The *Parma* which is supposed to be about equivalent to the Pottsville is a white to gray sandstone with conglomerates near the base containing small pebbles of white quartz. It is rather persistent but varies considerably in thickness because of being deposited in the eroded surfaces of the Mississippian below. The thickness varies from 0 to 220 feet and the waters encountered around the outcrop are fresh the brines near the center of the basin are high in sulphates. Local coals are found in the formation but none are known of importance.

The *Saginaw* formation contains the productive coal measures of Michigan and is considered to be Upper Pottsville in age. Underneath the drift cover of the Southern Peninsula it is the most widespread formation and underlies the entire central portion. It partakes very little of the basin-like major structure and is found to be nearly a level plain of shifting deposition. The formation is extremely variable in section and changes rapidly within short distances, but there is a curious persistence of local character. In one locality sandstone may predominate, in another shales prevail, and where the coal seams occur they are similarly concentrated. The Saginaw series consists of white and gray sandstone, white, gray, blue, and black shale, coal and thin limestone lenses with concretions of ironstone and pyrite. The average thickness is about 400 feet but the maximum observed is 535 feet. The waters are fresh except in the Saginaw Valley and some are of the chalybeate variety.

The *Woodville* formation is known locally, the type locality being at Woodville, Jackson County, and occurrences have been reported from wells at Maple Rapids, St. Johns, Ionia, and Gladwin. It is tentatively placed in the Pennsylvanian, questionably correlated with the Conemaugh, but may possibly be Permian in age or later. The basis for this last contention is the presence of red color and the occasional local occurrence of gypsum above it but there is no fossil evidence to support the supposition. The color is buff to reddish and there are some shale

beds with the sandstone. Thickness has been found thus far from 80 to 95 feet, and since the formation is near the top of the coal measures it has been eroded to a large extent. Fresh water is usually prsent in the sandstone.

PLEISTOCENE.

The *Pleistocene* is made up of irregularly distributed, loosely or partly consolidated material which was brought in by ice and water from glacial invasions and retreats. This consists of sand, gravel, and clay, which varies in thickness from a thin veneer to 1,000 feet or more, but the common thickness is less than 200 feet. The area of heavy drift extends in a belt northeastward from Mason, Oceana, and Newaygo counties through Otsego, Montmorency, and Alcona Counties. In this district the depth to bed rock varies from 300 to 1,000 feet and over with an average of 600 feet. There is also a thick drift area caused by a preglacial channel which extends southwest from Saginaw Bay to Alma and then northwestward through Mason and Manistee counties. Due to this cause, drift is from 400 to 500 feet thick in Isabella County and 500 to over 700 feet thick in Manistee County. Localities of thin drift of any extent in the Southern Peninsula are in Presque Isle and Alpena Counties to the north and Monroe, Hillsdale, Calhoun, and Jackson Counties to the south. Other places of rock exposure are around the margin of the Coal Basin and near the lake shore. Water is encountered in the glacial drift material in the various porous lenses of sand and gravel, and occasionally artesian conditions prevail if sufficient head is created by impervious clay capping.

FORMATIONS CONTAINING OIL AND GAS

The formations which may possess oil and gas in the Michigan rock section can be delimited only in broad way, the only basis for such classification being the findings in wells drilled and a comparison with other regions. Certain physical characteristics of rocks either from age or manner of formation are prohibitive to their containing any quantity of petroleum products. The prevalence of these characteristics over any large area under cover is something we can not postulate, as countless changes may have taken place of which there is no knowledge. Those formations known to contain oil and gas in any quantity may be enumerated and include the following:

1. The Saginaw Formation, the Michigan Coal bearing series, is made up in some cases of a large thickness of bituminous shales and often the coals are high in bituminous matter. At Fowlerville a water well boring showed some quantity of oil and gas from these beds. Since this formation occurs only at shallow depths, has but little cover, is deeply eroded, and is composed of lens shaped beds of small lateral extent, it has never been considered promising. Some question also exists as to the identity of the known productive horizons.
2. The Parma Formation had never been considered as an important reservoir until a large gas well was discovered near Ashley in rock which was very similar to the Parma. The porosity and the position of this sandstone below the Saginaw Series might be considered favorable, but the shallow depth at which it occurs and the uncertain position which it occupies in filling erosion channels in the Michigan Series, makes it a very indefinite goal for prospecting.

3. The Marshall Formation has recently been found to be a possible producer of oil and gas near the center of the basin where is occurs at sufficient depth and structure is favorable. In Midland County near the Isabella County line, wells have found a quantity of heavy black oil in a stray sandstone which comes but slightly above the horizon of the Marshall brines. Some have considered this to be Lower Michigan Series rather than Marshall but the concensus of opinion seems to favor the latter age.

4. The Coldwater Formation is distinctly a shale member, but it does contain sandy phases in which certain showings have been reported on the west side of the State. These may have been in gritty parts of the Bedford formation which take the place of the Berea and are difficultly distiguished from the Coldwater when the Sunbury black shale is lacking. The Richmondville which is a rather well defined sandstone occurring in the lower part of the Coldwater in the "thumb" region may show future development providing conditions are favorable.

5. The Sunbury Formation, a black to brown bituminous shale containing a great deal of volatile matter, is of too fine texture to be considered important as a producer of any large amount of free oil and gas.

6. The Berea Formation is in the most favored position to be an important reservoir rock for oil and gas and it is in this strata that Michigan's first significant oil field was discovered. The white to gray sandstone is usually very fine grained and requires a heavy shot of nitroglycerine to bring it into maximum production. It is bounded above and below by bituminous shales (the Sunbury and Antrim formations) and contains a heavy salt brine. The limited occurrence on the eastern side of the state is an unfortunate circumstance for structures in central and western Michigan.

7. The Antrim shale formation often shows puffs of gas while drilling and where it occurs directly under the glacial drift the gas has been found in sufficient quantities to supply single homes for several years. The local nature of these gas reservoirs is revealed by their rapid depletion. Because of the irregular distribution of the drift, prospecting is more a question of trial and error than of intelligent search.

8. The Traverse Formation which first showed oil in the Saginaw district and to the top of which the name "Saginaw Sand" was given, has proven to be a significant producer. The principal obstacle thus far has been the fact that aside from structure, the local physical rock conditions may be decidedly adverse. The Traverse is usually composed of hard limestones and dense shales and only when locally the limestones are porous, dolomitic, or sandy, may oil and gas be present in any quantity. These pay streaks may occur anywhere throughout the formation. At Owosso and Bannister the oil was near the top, near Ashley it was about ninety feet in, and between Mt. Pleasant and Midland, six zones of possible production were found in the first 120 feet. Recent large wells at Muskegon find the oil from 80 to 100 feet in the Traverse, and near Ludington a pay was encountered at 90 feet from the top. These results have lent considerable encouragement for prospecting in this formation.

9. The Dundee Formation, a limestone, nearly always has an odor of petroleum and has produced free oil in noteworthy quantities at Allegan, Saginaw and Port Huron. It is a producer of oil in Ontario but up to 1926 no steady production has been obtained from it within the State with the exception of a group of small wells which operated for a number of years near Port Huron. As this formation occurs near the surface in southeastern Michigan, testing it is not expensive and a number of wells have been drilled with this intention. Recently some small production has come from Birch Run, Saginaw, and Decatur. Early in 1928 the best well yet found in the Dundee came in near Mt. Pleasant with a flow of about thirty barrels daily. Thus far the pay streaks in the Dundee have occurred from the top to about 90 feet in with a most favorable zone at about 35 feet from the top.

10. The Detroit River Formation (Upper Monroe) yielded free oil at Kalamazoo and East Lake (Manistee) but only in small quantities. Near Blaine, St. Clair County, production was obtained in the Monroe Series probably near the bottom of the Detroit River, although this age has not been definitely established. Some oil and gas was found in the lower Detroit River Formation close to Mt. Clemens, Macomb County.

11. The barren Salina may prove to be an important formation as a very strong flow of gas obtained at St. Clair is thought to be coming from that horizon. Oil also was found in a well near Mt. Clemens at a short interval below the last salt bed.

12. The Niagaran or more specifically the Guelph Formation has produced oil and gas in Canada, but only a very few wells in Michigan have penetrated to that depth. At Blaine a small amount of gas was reported from this formation, and there is a small possibility of the gas at St. Clair being from the Niagaran although lithologic character of the rock does not seem to confirm such a contention. A show of oil was found in the Guelph dolomite near Mt. Clemens.

13. The Richmond has never yielded oil or gas except for oil showings provisionally referred to this formation at Chesterfield, Macomb County. The Medina or Clinton might become a producer if lithologic conditions were favorable.

14. The Lowville and Black River Formations (the Trenton Formation) have yielded oil showings in several points in Monroe County and signs of oil have been noted at their outcrop near Rapid River in the Upper Peninsula. The only well now making any oil from the Trenton is reported to have encountered two pay streaks at 20 and 60 feet in the formation.

Of these formations mentioned the Berea, Traverse, Dundee, Monroe, Lower Salina (possibly Guelph), and Trenton offer the best possibilities as a source of production. Other valuable horizons may be found as time goes on.

COMPARISON OF WELL SECTIONS

A comparison of well sections across the State serves to bring out many relationships of correlation and unconformable condition. They also show in general the character and extent of the basin with its deepest part in the geographical center of the Southern Peninsula. In making such comparisons, they indicate the various possibilities for oil and gas and the depths at which petroliferous formations are likely to be encountered in different localities.

FIGURE 2.

Map Showing Orientation of Sections across Southern and Central Michigan with Location of Wells Involved.

The lines on the map in Fig. 2 represent the directional orientation of these sections, one of which is taken across the central part of the basin and the other across the more southern margin. The correlation of sections across Central Michigan is included in Figure 3 and the correlation of sections across Southern Michigan is shown on Figure 4.

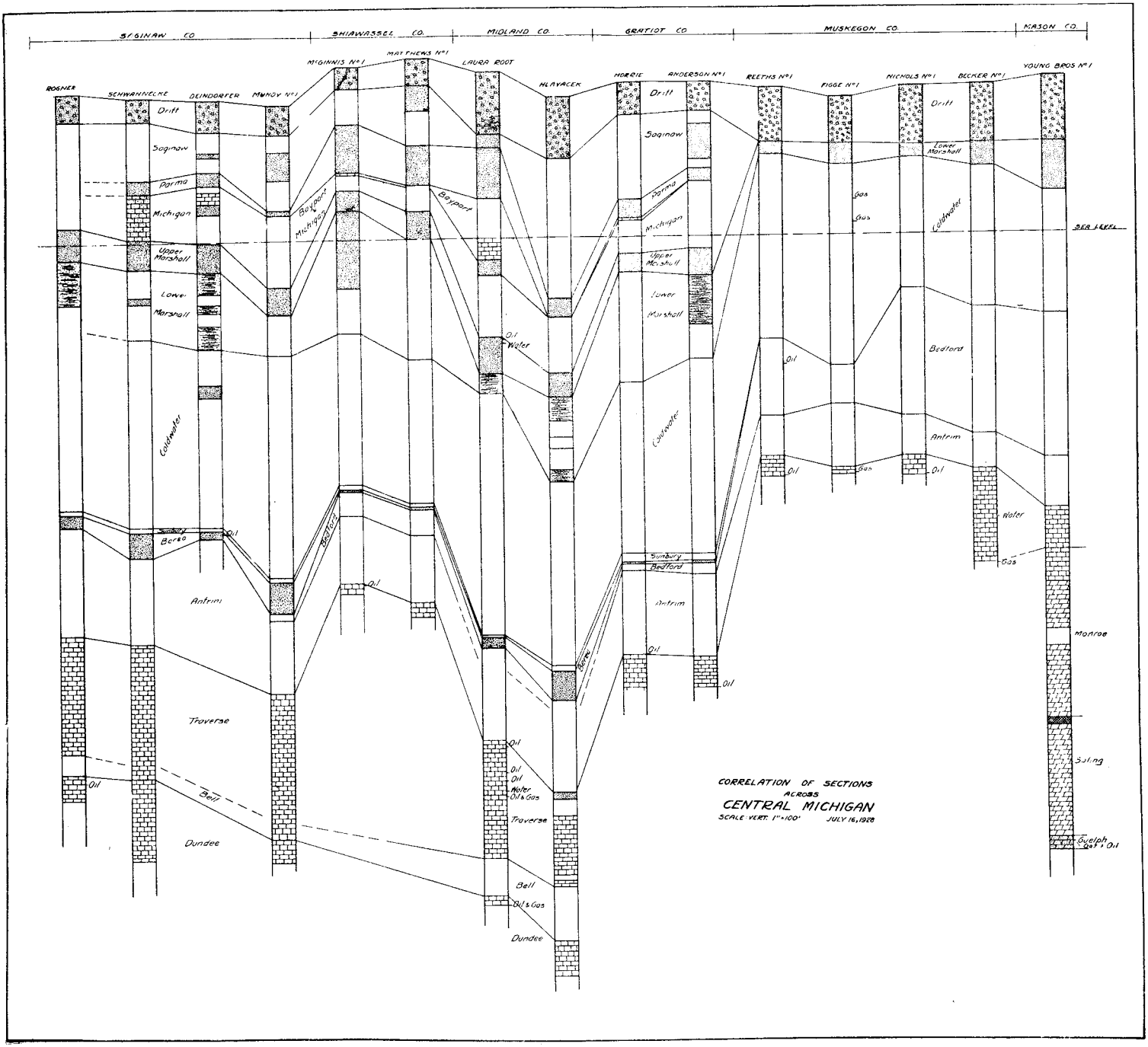

FIGURE 3.

Correlation of Well Sections across Central Michigan.

Map Showing

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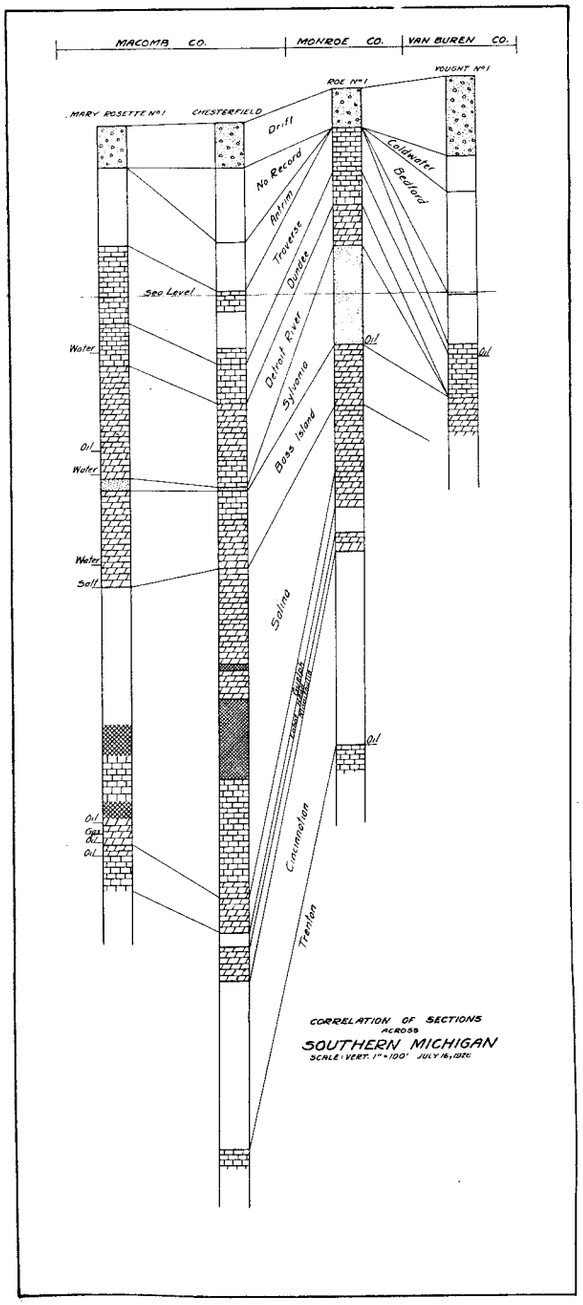


FIGURE 4.
Correlation of Well Sections across Southern Michigan.

In Figure 3 of Central Michigan a north-south section is also involved from Shiawassee through Gratiot to Midland County and from Muskegon to Mason County.

Several of the salient features illustrated in these sections might be pointed out. In the south part of the State the Traverse thins and the Detroit River practically disappears to the west. The Sylvania is thickest in the southeastern part and is present in only remnant form to the southwest. The Salina is decidedly variable and salt beds disappear entirely in the southwestern part of the State.

Across the central part of the State the Parma and Bayport because of their position at an unconformable contact change considerably in thickness and lithologic character. The Napoleon or Upper Marshall is constant as a prominent water bearing sandstone member and its thickness is more or less uniform. The lower Marshall does not possess this uniformity and the line of demarcation at the top and bottom is rather indefinite. From east to west the Coldwater thins somewhat and changes from a sandy shale with definite sandstone members to a calcareous shale with limestone facies coming in. The Sunbury black shale and Berea disappear as recognizable formations in about the center of the state and are not present in the western part. The Berea interval is replaced by the gray and greenish gray shales of the Bedford Formation. Rather constant thickness conditions exist in the Antrim shale, but a slight thinning takes place on the western side of the State. The limestones of the Traverse and Dundee thin to the west and southwest and the separating bed of Bell shale is absent.

A sufficient number of wells have not been carried to the lower formations to make similar comparisons. The great depths at which other possible pay horizons exist in the center of the state has prohibited further explorations. As time goes on additional drilling should add materially to the knowledge of this region.

STRUCTURE

In every study dealing with regional possibilities for oil and gas both the major and minor structural features must be considered. The major structures are those great upwarpings or downwarpings of the earth's crust which furnish the gathering area for any quantity of petroliferous substances which may be concentrated locally. Of these in general there are three types, the great broad anticlines of the eastern and middle western states, those affected by the various mountain uplifts of the southwest, and the great inter-montaine basins of the far west. This division is by no means all conclusive, for there are many minor differences but in general it brings out the nature of the major structure. In comparison, the minor structures are those folds of but limited extent which act as the trap for commercial pools of oil. They are usually only a few miles in extent and are characteristed by comparatively steeper dips than the major structures. It is for this type of fold that diligent search is constantly being made by those interested in the development of oil and gas.

MAJOR STRUCTURE.

The structure of the Paleozoic rocks of Michigan has always been termed as that of a great basin. The shape and size of the basin is

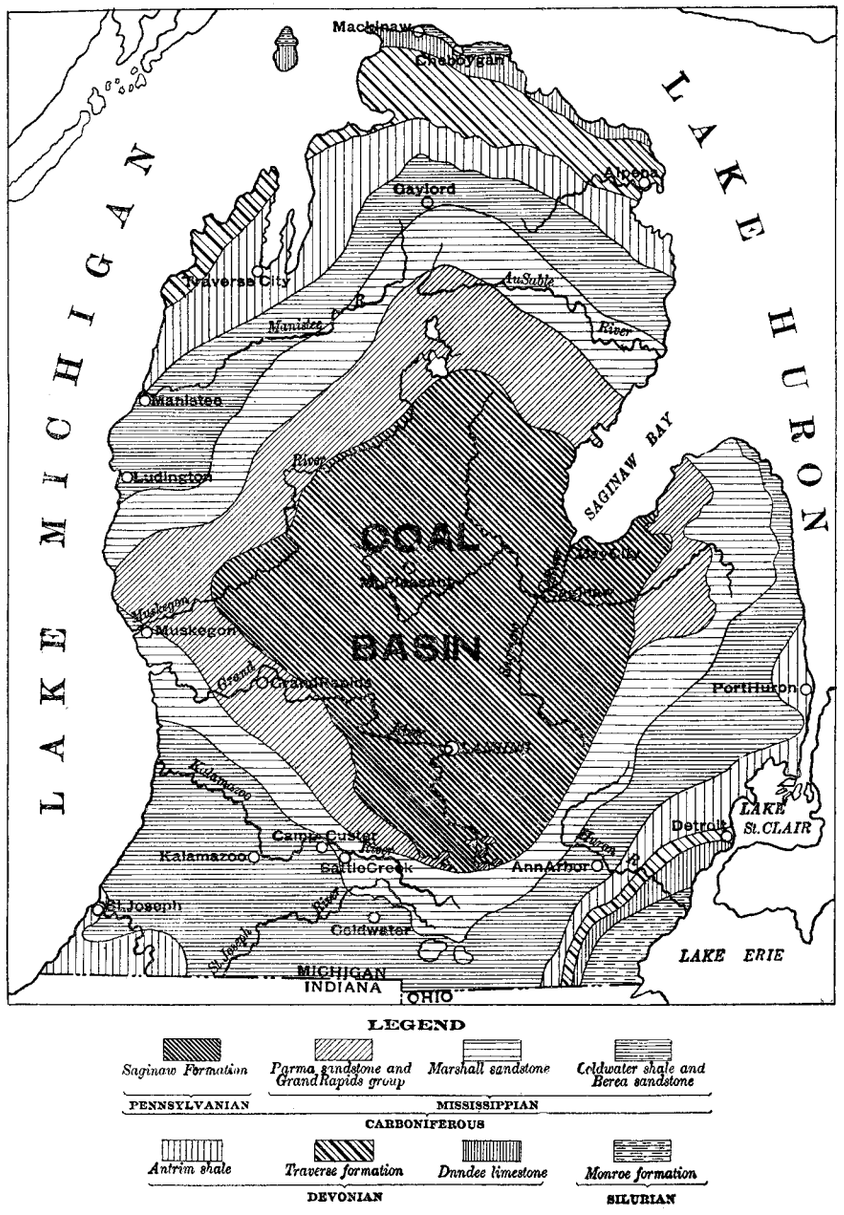


FIGURE 5.

Outline Areal Geological Map of the Southern Peninsula of Michigan.

illustrated in the outline Areal Geological Map in Figure 5. The geographical center of the basin is in Isabella, Midland, Gladwin, and Clare Counties and the width is some 500 miles. Although the greater part of this structure is confined to the Southern Peninsula of Michigan, it laps up into portions of the adjoining states of Wisconsin, Illinois, Indiana, and Illinois together with Ontario and the eastern part of the Northern Peninsula. Regional dips in the basin are very moderate and barring local structures are no greater than those to be observed in near shore deposits now forming. This structural basin in which the dips of successive older formations are very closely conformable, has also been considered a more or less isolated basin of deposition since late Ordovician time. It is to be noted also that the structure is true basin shape, for around the central portion it is relatively flat and dips steepen somewhat as the borders are reached. The depth of the basin has been estimated as close to 7,000 feet but even at that it is so small in comparison to diameter that the inclination of its beds is ordinarily between 25 and 50 feet to the mile. Although the dips of various formations are largely conformable and do not differ in a great degree from the original slope on which they were laid down some folding took place between the Monroe and Dundee as well as prior to the Coal Measures.

MINOR STRUCTURES.

The minor structures of the state are very slightly known. Those which have been found thus far have been largely discovered by the detection of minor irregularities in dip from plotting well records and outcrop observations. These have been limited by the regions of outcrop, the local centers of well drilling for salt and brines, and those communities where wells must penetrate the bed rock in order to obtain drinking water supply. It is logical from the nature of the state that this would cover a very small territory.

The anticlines or upward folds of which there is some indication seem to all have their axes trending more or less toward the center of the basin. Of these, the ones which have been known for some time exist in the vicinity of Saginaw, Saginaw County; Port Huron, St. Clair County; Stony Island (Detroit River); Wyandotte, Wayne County; Khagashewing Point (Little Traverse Bay); and Seul Choix Point, Schoolcraft County. The largest fold yet outlined extends from near Ann Arbor, Washtenaw County, northwestward through Livingston County, southwestern Shiawassee and northeastern Ingham counties, and into Gratiot County. Two other broad anticlines occur east of Niles, Cass County, and in the western part of Monroe County. Other structures yet poorly defined exist in the vicinity of New Baltimore, Macomb County, near Manistee, Manistee County, and north of Muskegon, Muskegon County. The latter is rapidly being outlined by drilling in progress. Sharp local folds are known to exist in the northern part of the "thumb" region and a "high" extends through Midland and Isabella Counties. Folds adjacent to the Saginaw Anticlines have been traced southeastward through Birch Run and into Genesee County and will probably be found to join across Lapeer County with disturbances in the vicinity of Port Huron. Lane has mentioned anticlines south and west of Tawas City of which there is very scanty information.

Robinson* has advanced the theory that these small folds in Michigan

*Robinson, W. I., Possibilities of Oil and Gas in Michigan. Pub. 32, Geol. Series 26. Michigan Geol. & Biol. Survey, 1922, p. 106.

are not the usual type caused by lateral pressures but are more of the nature of wrinkles in the border of the basin and are primarily due to vertical forces involved in the stress of relations of the larger feature. He points out that this arrangement suggests† at once either folds due to a difference in compressibility of the materials involved which would result in low undulations along the strike or folds due to a settling of the central area and an accommodation of the overlying layers to the new shape of their formation. Although this is doubtless a very plausible explanation for many of the folds existing in Michigan, its use as a generalization might readily be questioned. It is now known that there are intensified lines of folding of considerable length and that minor structures of significant magnitude exist within the center of the basin. In conjunction with this we know practically nothing whatever of the north central and western parts of the state. Factors which must be considered very seriously are the dying out marginal effects of the movement which formed the Cincinnati Anticline, the presence of the supposed old land mass Kankakeeia extending northeastward from Indiana, the possible extension of effects from the La Salle anticline of Illinois and unknown parts of the "Wisconsin Island" extending at depth underneath the Michigan Paleozoic. Ablation of the salt beds, deeply buried faults, and tiltings from glacial retreats are other structural causes to be brought under consideration.

Discordant dips, terrace structure, and small faults are prevalent in localities where data is available. High dips and reversals have been observed in several places in southeastern Michigan, in Huron, Alpena, and Presque Isle Counties, and along the Lake Michigan and Lake Huron shores of the Northern Peninsula. Some of these may be ascribed to coral reef formation. There is a sudden change in the general northeastward dip near Allegan indicating the presence of structural terrace or "bench." A great many small faults have been observed in the Coal Measures and two faults showing displacements of over 50 feet have been reported in the Saginaw Valley and near Rogers City, Presque Isle County. Brecciated dolomites are found in the Monroe Series of Southeastern Michigan and the Northern Peninsula, and widespread shattering in the rocks of the Manistee-Ludington salt district and Presque Isle County has been attributed to ablation. Wherever rock outcrops are to be found, the extensive systems of jointing present may give evidence to the source and direction of movement and possible orientation of nearby folds.

THEORY OF ORIGIN AND ACCUMULATION

Many ideas have been advanced concerning the theory of origin and accumulation of petroleum. The two great schools of thought divided on the question of origin into advocates of chemical origin and of an organic origin. Some approached a possibility of a combination of the two theories. Geologists were the chief supporters of an organic origin and chemists were the principal backers of the chemical origin, which was no more than to be expected in the limited light of their individual knowledge and experience. At the present time the generally accepted theory is that petroleum or rock oil originated from organic matter either vegetable, animal, or perhaps both in some cases. Conditions

†Robinson, W. I., Geological Factors Affecting Oil Exploration in Michigan. Nat. Pet. News., Sept. 6, 1922.

varied in different regions and periods of rock formation, and thus arose the different types of crude oils from various sources of origin. Later rock forces of distillation and polmarization also entered into the formation of the final product. Whether these organic sources were microscopic, megascopic, or both is another matter of conjecture and again we may answer, all three.

The fundamental theory of oil accumulation is the "Anticlinal Theory" of concentration, although many modifications and ramifications have entered into the original conception. The idea is that an anticline or arching up of rock strata will be the localization of any large quantity of petroliferous substances. Oil and gas being lighter than the water contained in the rock pores, will be buoyed upward by the force of differences in specific gravity to the highest points. Three conditions are necessary for this to occur (1) a source rock from which the oily substances may originate (2) a reservoir rock possessing sufficient pore space to hold the oil (3) and a barrier of sufficiently dense rock above to prevent further upward migration. The source is usually a black or brown bituminous shale, the reservoir either a sandstone or porous limestone, and the barrier may be any impervious shale or heavy dense limestone. Types of structures have been thoroughly classified by Clapp* and include anticlines, domes, terraces, and noses. Other influences on accumulation are faults, changes in porosity, and unconformities which can best be accurately determined at depth by actual drilling operations.

The use of this theory has been the localization of structural features by accurate mapping as an aid to the discovery of oil pools. This has been done by running the levels on actual rock outcrops, and a comparison of depths of similar formations in well records in instances where exposures were not available. From such data maps have been compiled showing the configuration of the rock surface by means of contour lines in like manner to a topographic sketch of the ground surface. In nearly every case a close correspondence between oil pool locations and the structurally high spots has been demonstrated. Mapping of this type has come to be vital in systematic and intelligent oil field development.

SAGINAW OIL FIELD

HISTORY.

Ever since the unsuccessful attempts to develop the oil possibilities at Saginaw in 1912, a feeling prevailed in the minds of many that the chances were by no means exhausted. In fact these explorations proved conclusively that a definite anticline was present; that it contained oil and gas in noteworthy if not commercial amounts; and that the anticlinal structure controlled the distribution of the oil and gas. In August, 1925, a group of Saginaw business men organized as the Saginaw Prospecting Company with an original capitalization of $52,000 for the purpose of further testing the structure. The officers of the company were Jas. C. Graves, Pres.; Geo. L. Burrows, Vice-Pres., and Stuart G. Morley, Sec'y, and Messrs. Reber, Meyers, and Goff located the first well on the basis of 1/8 overriding royalty in the case production was found. The discovery well located on property owned by the City of Saginaw just north of the city limits in the NW¼ of Section 14, T. 12 N., R. 4 E.

*Clapp, F. G. Revision of the Structural Classification of Petroleum and Natural Gas, Geol. Soc. America, Bull., Vol. 28, 1917.
Also in Emmons, W. H., Geology of Petroleum, McGraw, Hill & Co., p. 123.

was commenced in July, 1925, and completed on August 28th. The Berea was encountered at 1,838 feet and the hole was drilled to a depth of 1,873 feet. After shooting with 60 quarts of nitroglycerin the well came in with a small flow and averaged 23 barrels daily for the first three weeks. Casing was set at the bottom with a packer at the top of the sand and the two bottom joints were perforated. The oil was of high grade, testing about 46 degree Be. gravity, and the decline of production was comparatively slow.

The second well was located three-eights of a mile west of the first, found the Berea at 1,825 feet and drilled in 28 feet. It was shot with 80 quarts of nitroglycerin on Oct. 22nd and made 35 to 40 barrels a day until the latter part of November. This well showed a little more water than No. 1 and was structurally on the Berea about 9 feet higher.

After the successful completion of the third well at 1,834 feet which was seven feet in the Berea, other companies and individuals became interested and the real development of the field bgan. The Saginaw Prospecting Company continued their successful operations and the average cost of the first 17 wells was about 10,600 dollars each with a maximum of about 15,000 dollars and a minimum of 7,000 dollars. By December 1st, 1926, the original capitalization had been increased to $312,000 and the Saginaw Prospecting Company became an active operating concern.

SCOPE OF FIELD.

The Saginaw Oil Field is approximately three miles long and two miles wide east and west. It extends in a northwest-southeast direction from the NW¼ of Section 10, T. 12 N., R. 4 E., to the Saginaw River where development has been checked by the hazards of drilling in the business district. On this account the limits of the field have been well outlined except to the southeast. Unfortunately a large part of the proven area lies within the city of Saginaw, and a great deal of town-lot drilling has been the outcome. In some cases wells have been drilled on small leases of only two ordinary sized lots. Certain small development companies adopted the plan of community leases which alleviated some of the ill effects due to close in drilling. The larger companies at once realized the situation and took up no leases within the city proper.

The Saginaw Prospecting Company is the largest operator in the field and the Sun Oil Company is second in the scope of its operations. Their properties are almost entirely in the northern part of the productive area. Other companies are restricted to only a few leases each and are listed below:

PRODUCING PROPERTIES IN THE SAGINAW OIL FIELD.

(Revised to March 24, 1927.)

ATLAS OIL COMPANY
1. **Osborn et al.—on Reed Street.**
2. Pelkey at Hermansau and Reed.
3. **Black, Rosemeyer et al., Oak and Schaefer.**
4. **Palmer, Davenport St. and M. C. R. R.**

BACON PETROLEUM COMPANY
1. **Leamon (or Lehman) on Reed and Cecelia Sts.**
2. **On property of Wm. Huegel, east of Baker well on Shattuck road.**

BARKER OIL AND GAS CO.
1. **No. 1, C. Phillips—250 ft. S and 250 ft. W of N¼ 15.**

W. D. BERGHERON
1. No. 1 Winter—50 ft. N and 1220 ft. W of S¼ 12.

BLISS PETROLEUM CO.
1. No. 1 C. Ulrich—1,200 ft. W and 1,150 ft. S of NE 14.
2. Fred Engel—800 ft. W and 1,220 ft. S of Center 10.
3. No. 3 C. Ulrich—650 ft. W and 1,300 ft. S of NE 14.
4. No. 2 C. Ulrich—150 ft. W and 1,330 ft. S. of NE 14.
5. No. 4 C. Ulrich—660 ft. W and 1,060 ft. S of NE 14.
6. No. 5 C. Ulrich—250 ft. E and 1,500 N of W¼ 13.
7. Oehring, Cor. Madison and Monroe Sts.

WM. BOURDOW, et al.
1. Mich. Ave. and Clark St. (back of Bourdow's store).

Wm. BRADLEY & SON
1. Gile Bourdow, at Clark and Hermansau.
2. Pleasant and Stone Streets.

CHAS. P. BRANT
1. Thos. Walker, on Deindorfer, between Clinton and Madison.

JAMES COOPER & JOHN O. NEWBERRY
1. Woelsein on Hermansau between Pleasant and Ash.
2. Jones, near Hermansau and Ash.
3. Wm. Wedding, on Harrison St., M. of Madison Carrolton.
4. Foot of Ash Street.

CRESCENT OIL COMPANY (Bourdow).
1. Neumeyer at Harrison and Shattuck.
2. Cheesebrough at Clark and Hill Sts.

CROSS PETROLEUM COMPANY
1. Kline (or Klein) well at Oak and Hermansau.
2. Hansen on Hermansau Road north of C. Ulrich.
3. Arthur A. Bouwler et al. at Hermansau and Ash.

S. R. DIETRICH, et al.
1. No. 1 Lodge—Hermansau Road.
2. Oak and Schaefer.

FORDNEY PETROLEUM COMPANY
1. Schultz-Carrollton—824 ft. E and 1,184 ft. S of N¼ 13.
2. No. 1 Bisner—near corner N. Charles and Weiss Sts.
3. Branon—on Starck, between Ash and Pleasant.
4. Arthur Ladow, at Clinton and Deindorfer.
5. Courtney Schraeder et al.—near Michigan avenue and Oak St.
6. Patterson-Schartow, on Benjamin near Ash.
7. No. 1 Ace Park—300 ft. E and 450 ft. N of S¼ 13.
8. No. 1 Weiss St. and Michigan.
9. Nelson Nowack—1,500 ft. S and 1,100 ft. W of E¼ 14.
10. No. 2 Ace Park—250 ft. E and 50 ft. N of S¼ 13.
11. Oakley and Reed Sts.
12. Property of Polin and Madison at Clark and Eddy Sts.

THOS. J. GILGIRAS
1. Carrollton road near Weiss St.

GREAT LAKES OIL COMPANY
1. Tomfordes—Harrison St. Carrollton.
2. Carrollton on Harrison St., across from No. 1.
3. Pleasant St. near Hermansau.

G & W OIL COMPANY
1. Ash and Schafer (Meyers well).

MATTHEW HOEGGLER
1. On Shattuck road west of Hermansau.
2. On Hermansau Road.

J & S DEVELOPMENT COMPANY
1. Near Hermansau and Ash.
2. At Clark and Schaefer.

K & M OIL COMPANY
1. Reed well on Reed Street.

KIPP OIL COMPANY
1. Carrollton—Harrison and Madison Sts.

MYRON E. LEE
1. No. 1 J. Conrad Brechtelsbauer—750 ft. E and 140 ft. S of NW 13.
2. No. 2 J. Conrad Brectelsbauer—1,020 ft. S and 90 ft. W of N¼ 13.

LOCAL PETROLEUM COMPANY
1. Graham Sparling on N. Oakley St.
2. At foot of State St.

MICHIGAN OIL AND GAS CO.
1. Carrollton on Nickles and Mertz property.

RALPH E. MILLS
1. Osborn et al., N. Michigan Ave. and P. M. tracks.
2. N. Michigan Ave.—940 W and 300 ft. N of center 13.

OHIO FUEL GAS CO.
1. No. 1 Fisher—1,130 ft. E and 480 ft. S of W¼ 11.
2. No. 2 Fisher—200 ft. E and 100 ft. S of W¼ 11.
3. No. 3 Fisher—300 ft. W and 230 ft. S of E¼ 10.
4. No. 1 Laundra—1,020 ft. W and 1,120 ft. N of center 10.
5. No. 4 Fisher.

OHIO OIL COMPANY
1. No. 1 Mershon—Eddy and Parker.
2. No. 2 Mershon—Eddy and Parker.
3. No. 3 Mershon—Eddy and Parker.
4. No. 4 Mershon—Eddy and Parker.
5. Oakley Street.

SAGINAW PROSPECTING COMPANY
1. No. 1 Deindorfer Woods (city property).
2. No. 2 J. Edgerer No. 1—1,150 ft. S and 650 ft. N of center 14.
3. No. 3 M. Spatz No. 1.—1,450 ft W and 600 ft. N of center 14.
4. No. 4 G. Deindorfer—225 ft. E and 250 ft. N of W¼ 13.
5. No. 5 Kunitzer—430 ft. N. and 760 ft. S of N¼ 14.
6. No. 6 Northmoor No. 1—800 ft. E and 330 ft. S of center 14.
7. No. 7 Pavlas—1,120 ft. E and 1,480 N of center 14.
8. No. 8 City Waterworks—330 E and 1,140 N of center 14.
9. No. 11 Martin Hanson—1,200 W and 820 E of NE 14.
10. No. 12 Waterworks Park—1,000 W and 200 S of center 14.
11. No. 9 Bremer—400 E and 160 N of N¼ 14.
12. No. 10 Aug. Kruscke—900 N and 500 W of N¼ 14.
13. No. 15 Fred Remer—1,090 W and 460 S of NE 14.
14. No. 14 Waterworks Park—440 W and 1,050 N of center 14.
15. No. 16 Periard-Bixby—50 W and 350 S of E¼ 14.
16. No. 19 Brechtelsbauer—510 E and 675 S of NW 13.
17. No. 18 Pickert—450 E and 820 N of W¼ 13.
18. No. 17 Scherzer on ¼ line road east of Bay St.
19. No. 25 Geo. Diendorfer—800 E and 20 N of W¼ 13.
20. No. 23 Koepke, O—280 W and 920 S of center 14.
21. No. 24 Mershon—Vineyard.
22. No. 27 Fred Remer—130 S and 1,220 W of NE 14.
23. No. 28 Christian Scherzer No. 2—550 W and 780 S of center 11.
24. No. 26 Chesser (or Chesler) Shattuck road.
25. No. 33 Geo. Deindorfer No. 3—1,120 E and 820 N of W¼ 13.
26. C. Scherzer.
27. No. 22 Edwin Neuchterlein—340 W and 90 S of E ¼ 14.
28. Sax No. 30 Bechtelsbauer—830 S and 20 E of NW 13.
29. No. 31 Kline Fox.
30. No. 29 Pappoa on Shattuck Road.
31. No. 35 Northmoor.
32. No. 32 City (Deindorfer Woods)—1,200 E and 150 N of center 14.
33. No. 37 Grieble on Shattuck road.
34. No. 36 Draper estate foot of State Street.

SAVAL DEVELOPMENT COMPANY
1. J. A. Weiss—near Weiss and Hermansau.
2. No. 1 Geo. Spatz—712 E and 616 S of W¼ 13.
3. Geo. Nentwig at Weiss and Eddy.
4. Russell—1,080 E and 856 S of W¼ 13.

H. W. & W. H. SCHAIBERGER BROS.
1. Carrollton well—620 E and 1,320 N of center 13.

JOHN SCHWINCK
1. Packing house property, foot of Weiss on Carrollton Road.
2. No. 2 Packing house.

SAMUEL SCHWINCK
1. Gager—Hermansau road, just north of P. M. tracks.
2. Sparling property on N. Michigan Ave.

J. H. SHALTRY, et al.
1. Brechtelsbauer on Michigan Ave.

STAR OIL COMPANY
1. Benjamin Street at Weiss.

SUN OIL COMPANY
1. No. 1 Neurminger—250 E and 1,190 N of S¼ 11.
2. No. 1 Weiss—250 E and 860 N of S¼ 11.
3. No. 1 Schoenheit—250 E and 520 N of S¼ 11
4. No. 2 Schoenheit—250 E and 1,220 S of center 11.
5.
6. No. 1 Bagshaw—250 N and 250 W of E¼ 10.
7. No. 1 Scherzer—1,120 S and 200 W of center 11.
8. No. 1 Rabe—1,120 W and 530 S of center 11.
9. No. 3 Schoenheit—720 E and 520 N of S¼ 11.
10. No. 4 Schoenheit—250 E and 360 S of center 11.
11. No. 2 Weiss—720 E and 860 N of S¼ 11.
12. No. 1 Jno. Strelzriede—1,150 W and 50 S of center 11.
13. No. 5 Schoenheit—520 N and 560 W of SE 11.
14. No. 1 L. Voight—250 S and 790 E of center 10.
15. No. 2 Scherzer—1,120 S and 1,120 W of center 11.
16. No. 2 Bagshaw—990 W and 250 N of E ¼ 10.
17. No. 6 Schoenheit—705 E of No. 3 Schoenheit—165 ft. from N and S line.
18. No. 2 Jno. Stelzreide.
19. No. 2 Neurminger.

SUPERIOR OIL COMPANY
1. No. 1 Spatz—160 S and 50 E of W¼ 13.
2. No. 2 Spatz—512 E and 256 S of W¼ 13.
3. No. 3 Spatz—328 S and 744 E of W¼ 13.
4. No. 1 Wall near Hermansau and P. M. R. R.
5. Wehen & Berz at Weiss and Hermansau.

WM. SUTHERLAND, Trustee
1. For Nieman on N. Michigan Ave.

VALLEY OIL AND GAS CO.
1. Mertz & Grahem, 1st well—670 W and 288 S of E¼ 14.
2. Chas. Priess at Madison St. and Mich. Road. Carrollton.
3. No. 2 Priess—1,100 S and 890 W of N¼ 13.

VOORHEES AND McNALLY (Pine Oil Co.)
1. Chas. Ulrich at Hermansau and Shattuck roads.

WANIGAS OIL COMPANY
1. Rudolph Kunitzer at Hermansau and Oak.

WAYCO OIL PRODUCING CO.
1. No. 1 Braun, near Weiss & Eddy—480 W and 80 N of center 13.
2. Kaleyter—Eddy St. and P. M. Tracks.
3. Chas. H. Spiekerman on Weiss just east of Eddy.

WELLS SCHMIDT OIL CO.
1. Near Oak and Pine Sts.
2. Whittier on Ash Street at foot of Pine.
3. No. 3 Whittier near Mershon—Whittier Natatorium.

WESTERN DRILLING & OIL
1. No. 1 Nentwig—1,280 W and 200 N of center 13.
2. Reed Street well, between Berg and Cecelia.
3. Dan McGuire—Pleasant and Durand.

WILLEX OIL COMPANY
1. No. 2 Reinholdt on Hermansau road.
2. Reinholdt No. 1 on Hermansau road
3. Weise corner Hermansau and Shattuck.

The size of the wells is not large and of those from the Berea formation the range is from about 10 to 90 barrels initial daily production. In one case the "Saginaw Sand," a deeper pay formation at the top of the Traverse limestone yielded an initial production of about 500 barrels of light oil the first 24 hours. This well soon declined and is now after a year's time a very steady producer of about 8 barrels daily. No other large flush production wells were found and this was evidently a pocket accumulation in a locally porous phase of the formation. In nearly all

the wells the amount of gas was small but in some cases it was of sufficient rock pressure to cause them to flow. A few wells were drilled with the gas found in those adjacent.

PRODUCTION.

The highest production of the field was reached sometime in the early summer of 1927. On June 1st more than 190 wells were giving an output of about 1400 barrels. At the present time production fluctuates between 1000 and 1200 barrels daily. Three different crudes have been obtained from the field and termed according to producing horizon as "Berea," "Saginaw" and "Dundee." The bulk of the oil comes from the Berea and is of exceptional grade. Fresh from the wells the oil tests 47 degrees Be. gravity, but samples sent to laboratories for analyses show a variation of gravities between 42 degrees and 45.6 degrees Be. During winter months when losses by evaporation are at a minimum the gravity of the oil as marketed averages about 45.9 degrees Be. It is so light that there are high losses by evaporation unless special precautions are taken. The oil contains from 37 to 40 per cent gasoline, but recoveries of about 50 per cent have been made. The differences in yields are due in part to differences in losses by evaporation but chiefly to differences in the methods of refining. A general idea of the crude oil analyses may be obtained from several available which are considered to be representative.

DISTILLATION AND ACID TREATMENT OF SAGINAW CRUDE.

Control Laboratory — April 26, 1926.

Tests on Crude.

Gravity 43.5, Sulphur 0.407, Flash room Tem., Color, Dark Green, Pour, below 0; B. S. & W. trace.

OPERATION No. 1.

Distillation of crude — Charge 7000 cc.

Cuts.	Still Temperature.	Time.	Gravity.	Gravity at 60°F.
First Over	130	3.00	.....	.....
5%	225	3.07	76.0 at 66	75.1
10%	235	3.14	72.3 at 64	71.8
15%	250	3.19	66.2 at 64	65.7
20%	270	3.24	63.0 at 64	62.5
25%	290	3.29	60.2 at 65	59.6
30%	308	3.33	57.5 at 64	57.0
35%	345	3.39	55.0 at 63	54.7
40%	385	3.45	52.5 at 65	52.0
45%	420	3.50	49.8 at 66	49.2
50%	455	4.00	47.0 at 67	46.4

Above run made without steam.

Product.	% Operation.	% Crude.
Crude Naphtha over to 46.4	50.00	50.00
Topped crude (bottoms)	47.50	47.50
Loss	2.50	2.50
Total	100.00	100.00

Tests on Cuts.

Crude Naphtha.

Gravity, 59.0, Initial 116, End Point 463.

Topped Crude.

Gravity, 31.2; Vis. at 100-61; Pour, 30; Color, Dark Green.

OPERATION No. 2

Acid Treatment of topped crude — Charge 3000 cc.

The topped crude was treated with 25 lb. per bbl. of 66° Be′ acid and blown for 25 minutes at 150°. It was then allowed to settle for 2 hours at 150°F. and the sludge then drawn off.

Product.	% Operation.	% Crude.
Acid Oil	93.34	44.34
Loss (Including sludge)	6.66	3.16
Total	100.00	47.50

OPERATION No. 3.

Neutralization of acid Oil — Charge 2800 cc.

The acid oil was given a wash of 20° Be′ caustic soda using 4% by volume. The caustic was put in at room temperature and together with the oil raised to 180° at which temperature it was agitated for ten minutes and allowed to settle at 180° for 2 hours. The caustic was then drawn off and the oil given a wash with 50% by volume of boiling water.

Product.	% Operation.	% Crude.
Treated Topped Crude	96.07	42.60
Loss	3.93	1.74
Total	100.00	44.34

Tests on Treated Topped Crude.

Gravity, 31.5; Vis. at 100-59; Pour, 35; Color, Green.

OPERATION No. 4.

Reduction of topped crude — Charge 2400 cc

Cuts % Operation	% Crude.	Still Temp.	Time.	Gravity.	Gravity at 60°F.
First Over	.....	310	2.00	.....	.....
5	2.13	370	2.06	45.6	43.7
10	4.26	390	2.12	43.8	42.2
15	6.39	400	2.19	42.3	41.0
20	8.52	414	2.29	41.9	40.3
25	10.65	430	2.38	40.0	38.8
30	12.78	445	2.46	39.5	37.8
35	14.91	465	2.59	38.5	37.0
40	17.04	485	3.15	37.6	36.0
45	19.17	500	3.28	36.7	35.0
50	21.30	505	3.38	35.1	33.4
55	23.43	515	3.49	36.1	32.9
60	25.56	530	4.00	33.2	30.9
65	27.69	540	4.10	32.6	30.0
70	29.82	560	4.20	32.7	29.3
75	31.95	585	4.40	29.3	27.0
79.8	33.99	.....	.....	28.5	26.6
20.2	8.61	Cylinder Stock			

Products.	% Operation.	% Crude.
W. W. Distillate (Over to 40.3)	20.00	8.52
Gas Oil (40.3 to 36.0)	20.00	8.52
Wax Distillate (36.0 to 26.6)	39.80	16.95
Cylinder Stock (Bottoms)	20.20	8.61
Total	100.00	42.60

Tests on Cuts.

W. W. Distillate

Gravity, 42.1; Flash, 168.

Gas Oil.

Gravity, 37.8; Flash, 240; Fire, 285.

Wax Distillate.

Gravity, 30.6; Flash,310; Fire, 340; Vis. at 100-66; Pour, 45.

Cylinder Stock.

Gravity, 18.3; Flash, 500; Fire, 565; Vis. at 210-190; Pour, 90; Color, Dark Green.

OPERATION No. 5.

Rerun of Crude Naphtha and W. W. Distillate — Charge 1000 cc

The naphtha from operation No. 1 and W. W. Distillate from Operation No. 4 were mixed and run through a fractionating column.

Product.	% Operation.	% Crude.
Gasoline (Over to 425)	82.00	47.99
Kerosene (425 to 485)	11.40	6.67
Gas Oil (Bottoms)	4.70	2.75
Loss	1.90	1.11
Total	100.00	58.52

Tests on Cuts.

Gasoline.

Gravity, 59.0; Initial, 138; End Point, 422.

Kerosene.

Gravity, 42.6; Flash, 156.

OPERATION No. 6.

Rerun and cracking wax distillate.

The wax distillate was rerun using a small amount of steam thereby slightly cracking the distillate.

Product.	% Operation.	% Crude.
Gas Oil (Over to Wax)	34.38	5.83
Cracked Wax Distillate	63.13	10.70
Wax Distillate Bottoms	2.49	.42
Loss	0.00	0.00
Total	100.00	16.95

CRUDE OIL ANALYSIS—MADE BY THE PURE OIL COMPANY.

Control Laboratory — September 22, 1925.

Tests on Crude.

Crude from No. 1 Well—2 miles Northwest Saginaw, Michigan. Berea Sand 1838-1873 ft. Saginaw Prospecting Company. See Mr. R. J. Sloan's report to Mr. McIlvain, September 21.

Gravity, 42.9; Sulphur 0.295; Flash, Room Temperature; Color, Dark Green; Pour, below 0; B. S. & W., .08%.

Distillation of Crude

Charge 5000 cc.

Cuts.	Still Temperature.	Time.	Gravity.	Gravity at 60°F.
First over.	145	1.40		
5%	255	2.00	71.5 at 72	69.9
10%	270	2.10	65.1 at 76	63.1
15%	275	2.16	61.0 at 77	59.0
20%	277	2.24	59.6 at 78	57.6
25%	280	2.34	58.0 at 78	56.0
30%	285	2.41	55.4 at 78	53.6
35%	300	2.51	52.9 at 79	51.1
40%	333	3.02	49.9 at 80	48.1
45%	355	3.12	47.5 at 80	45.7
50%	375	3.20	45.0 at 80	43.3
55%	387	3.25	43.0 at 80	41.0
60%	403	3.33	41.0 at 84	39.1
65%	415	3.41	39.2 at 83	37.5
70%	425	3.54	37.4 at 85	35.5
75%	442	4.06	35.0 at 90	32.9
80%	454	4.12	34.2 at 106	31.1
82.78%	fire out	4.12	31.1 at 95	28.8
14.0%	Coke or bottoms			
3.22%	Loss.			

Tests of Cuts from Crude.

Crude Naphtha to Gravity 45.7 45.00%.

Gravity, 55.5; I. B. P., 156; E. P., 474.

W. W. Distillate to Gravity, 37.5 20%.

Gravity, 40.4; Flash (T. C. C.),162.

Gas Oil to Gravity 35.5 5.00%.

Gravity, 35.5; Flash, 270; Fire, 290.

Wax Distillate to Gravity, 28.8 12.78%.

Gravity, 313; Flash, 310; Fire, 340; Vis. 61/100; Pour, 50.

Fuel Oil or Flux to Gravity 14%.

Gravity, 19.8; Flash, 475; Fire, 525; Pour, 80; Vis. 126.

The "Saginaw" crude from the Saginaw Field proper was of the highest gravity found in the area having an amber color and showing a test of 52 degrees Be. gravity. The color darkened somewhat as the oil aged. Other "Saginaw" crude from the wells in Shiawassee and Gratiot counties ranged from 38 degrees to 44 degrees Be.

"Dundee" oil varies from 36 to 42 degrees Be. gravity and usually has a smell of sulphur. The color is commonly green although it sometimes approaches a dark brown by transmitted light. This oil, as all limestone crudes, shows considerable variance but is considered very high grade.

When the field first began to produce, Berea oil brought a price of $2.95 a barrel. Heavy production in the Mid-Continent pools caused the price to fall until late in 1926 it was quoted as low as $1.46. Negotiations made by Saginaw producers with the principal buyers were effective in bringing about an increase, and the present price of $1.95 per barrel has prevailed for some time. "Saginaw" crude brings $2.05 per barrel and "Dundee" oil is listed at $1.95.

Early in the history of the field the oil was shipped entirely by tank-car to the Sun Oil Company refinery in Toledo, Ohio, and the National Refining Company at Cleveland. A small amount was sold to the Imperial Oil Company refinery at Sarnia, Ontario. Early in 1927 the Standard Oil Company of Indiana entered into the refining of Michigan Crude with the construction of a refinery at Zilwaukee, located north of Saginaw. Prior to the completion of this plant some of the contracted oil was shipped to their Whiting, Ind., refinery for treatment. A composite of the monthly production during 1927 as compiled from refinery

figures submitted by the Sun Oil Co., the Standard Oil Company of Indiana, and the National Refining Company follows:

January	29,669.41	Barrels
February	27,532.71	"
March	36,553.63	"
April	41,538.26	"
May	38,643.24	"
June	40,986.63	"
July	36,435.18	"
August	38,646.21	"
September	41,459.44	"
October	36,510.83	"
November	33,754.04	"
December	31,598.57	"
Total for 1927	433,328.15	Barrels

The large number of small operators makes computation of the decline of production in the field rather difficult except for individual producers. Many of the wells which were drilled early in the life of the district declined no more than half of their initial production during the first six months. Others which were put down later in the town lot section and came in from 25 to 30 barrels dropped off to 10 and 15 during the first two weeks. The decline was therefore extremely variable and was not so much controlled by location on structure or order of completion as by the proximity of wells in the municipal area of Saginaw.

The Saginaw Prospecting Company drilled most of the wells in the early development, and Fig. 6 shows the decline of their first ten completions. Wells number 1, 2, 8, 9, and 10 exhibit a moderate initial decline whereas those numbered 3, 5, 6, and 7 fall off very rapidly for the first two weeks. These comparisons together with the rapid ultimate decline of Number 8 well bring out very clearly the differences in sustained production from various parts of the field. In Fig. 7 the decline of the Saval Development Company wells demonstrates a similar relationship.

The future life of the field has been roughly estimated from the Saginaw Prospecting Company holes numbered 1, 2, 4, 5, 6, 7, 8, and 11 by the Beal Family Curve Method. In Fig. 8 the first three years' production is graphically shown on a logarithmic scale. By extending this curve of the average well to an economic limit of 10 barrels per quarter year we find the duration of economic production to be 11½ years. The best well of the group in accordance with this method would have a life of 14½ years and the poorest would have a life of 5 years. These figures are by no means all conclusive or final because the data comes from so few wells in a limited area. They should, however, act as a guide in future management of the field.

The Standard Oil Company of Indiana refinery at Zilwaukee was completed in September, 1927, at an estimated cost of about $250,000. The equipment is in the nature of a skimming plant with two stills and about 2,000 barrels daily capacity. Storage consists of two 20,000 barrel tanks and the oil is transported from the field by a 3-inch pipe line. One hundred leases are served by this gathering system of which there are 17 miles of line. Nineteen pump stations are necessary to transport the crude from wells to storage. Products derived from the process are gasoline, kerosene, furnace oil, and fuel oil.

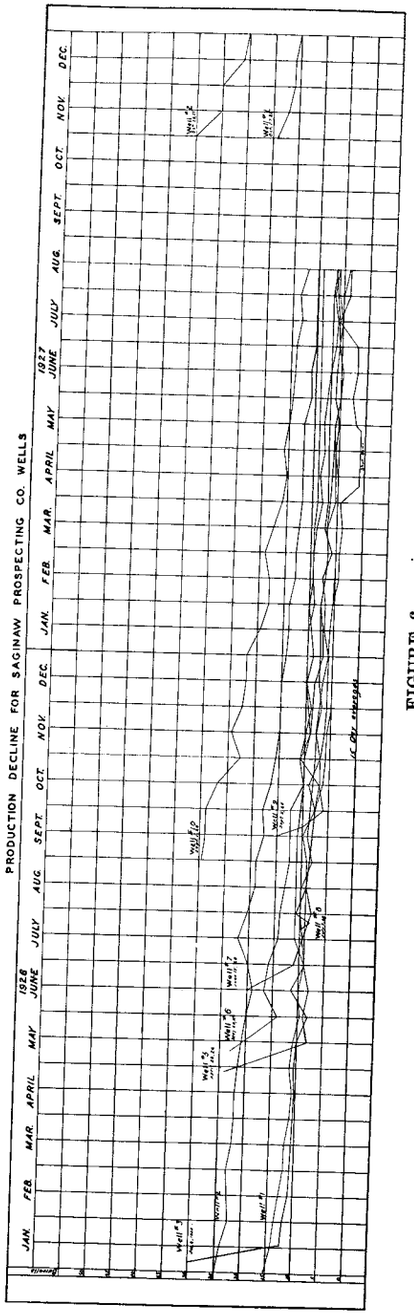


FIGURE 6
Production Decline for Several Saginaw Prospecting Company Wells.

GEOLOGICAL CONDITIONS.

The section involved in the district is well known from the extensive drilling to a depth of about 3000 feet. The deepest well in the field was drilled by the Sun Oil Co. on the Dr. Bagshaw No 3 in the SW/ SW of Section 10, T. 12 N., R 4 E. and reached 3200 feet depth. Formations included from the surface downward are Pleistocene; Pennsylvanian (Saginaw formation and Parma sandstone); Mississippian (Bayport limestone, Michigan Series, Upper Marshall or Napoleon sandstone, Lower Marshall formation, Coldwater shale, Sunbury formation, and Berea grit); Devonian (Antrim shale, Traverse formation and Dundee limestone).

In this rock series at Saginaw three important water horizons and three oil producing formations have been found. Although small quantities of water are prevalent in the Saginaw formation, the Parma sandstone is the first water bearer of importance. This water, because of its comparatively shallow depth, is but slightly brackish. The first heavy brine flow is found in the Napoleon sandstone at a depth of about 600

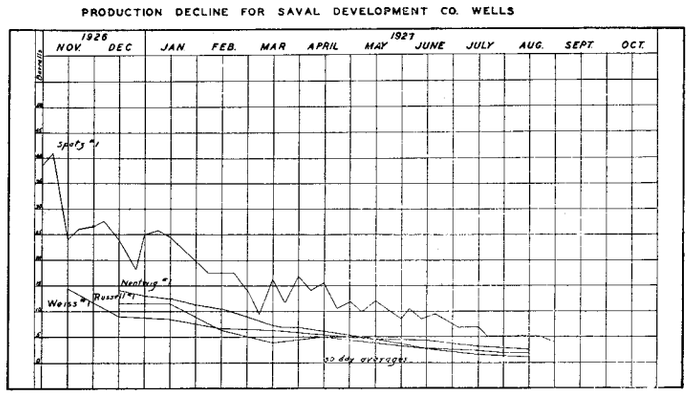


FIGURE 7.
Production Decline for Saval Development Company Wells.

feet. A small quantity of brine is occasionally encountered in the Lower Marshall. The third water of importance is the very strong brine found below the oil pay in the Berea grit, which by analysis gave over 340,000 parts per million of solids, chiefly sodium chloride.

The first oil pay and the chief producing formation of the field comes in the top 12 to 20 feet of the Berea sandstone. This "sand" is extremely fine grained and closely cemented or silty, although locally there are more porous areas. Upon one examination most of the grains were found to pass the 180 mesh sieve. The character of this pay accounts for the variance in initial yield and slow decline of production. Customary procedure has been to give the wells a shot of from 60 to 80 quarts of nitroglycerin which in many cases makes the production when only a small show of oil is present. The depth to the Berea varies from 1793 to 1864 feet depending upon the location on structure.

The second pay formation is found in the top of the Traverse limestone and has been called the "Saginaw sand." This name is rather mislead-

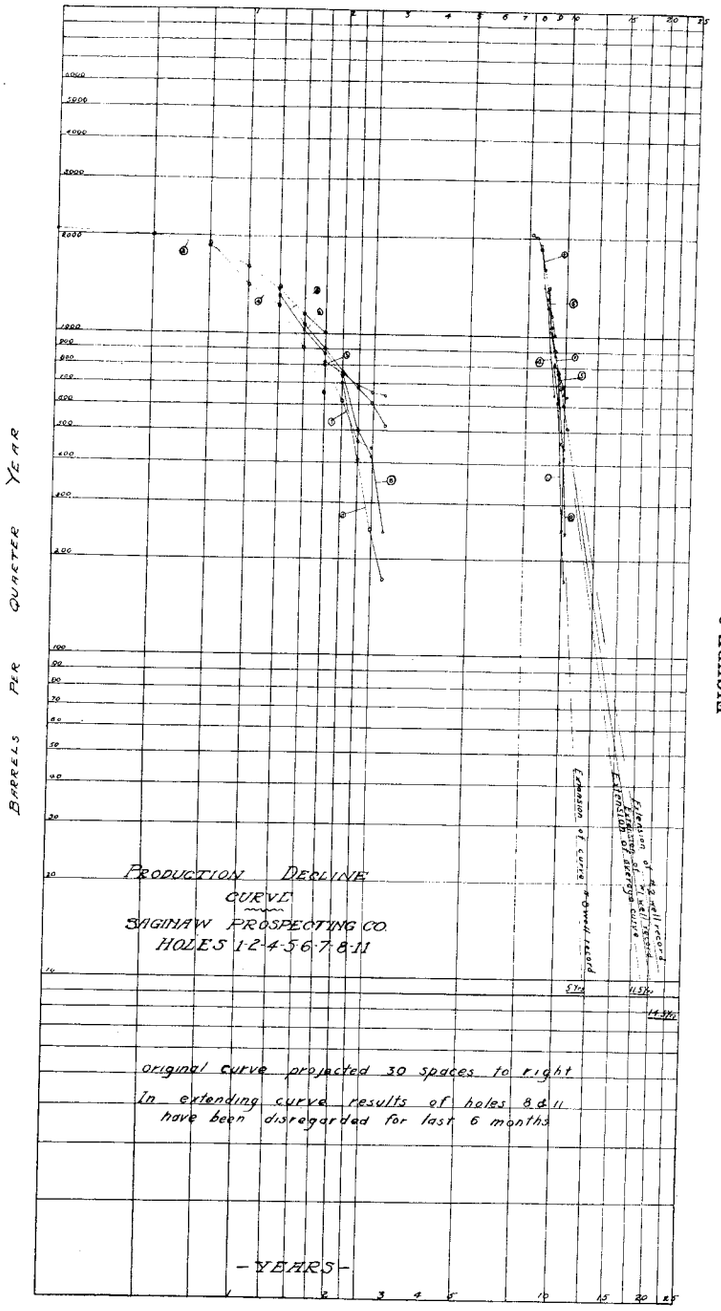


FIGURE 8.
Composite Production Decline Curves Extended to Show Future Production
(Saginaw Prospecting Company Wells)

ing because of the similarity to Saginaw formation of the Coal Measures and also because the pay is not a sand but a porous limestone bed. The depth at which it occurs is about 2300 feet and the possibilities of production are very uncertain because of local occurrence of the porous conditions. Hopes were aroused for this formation when the Sun Oil Company brought in a gusher on March 19, 1927, which was good for an initial production of from 475 to 500 barrels. This well located on the F. Steltzriede farm in the SW¼ of NE¼ of Sec. 11, T. 12 N., R. 4 E. found 4 feet of good pay at 2323 feet but decline was rapid and after a month it was producing only 28 barrels per day. A well drilled by the Western Drilling and Oil Company within the city of Saginaw and about a mile southeast of the Sun Oil Co. well made about 120 barrels initial daily production, but its decline was also rapid. About a month after the big discovery five dry holes had been obtained from the "Saginaw sand," and the concensus of opinion was that uncertainty made drilling to this depth an unprofitable venture. Later direct offset failures added support to this contention.

The third pay formation at Saginaw is in the top part of the Dundee limestone where porous conditions occur. The top is encountered at from 2900 to 3000 feet in the Saginaw field proper, and although pays have been found anywhere from the top to 79 feet in the best productive zone is between 30 and 40 feet in the formation. Several wells were operated in the Dundee for a time but the only one now producing is located on the Bliss Petroleum Company Fred Engel lease in the SW¼ of Sec. 10, T. 12 N., R. 4 E. Latest reports show this well to be making about 20 barrels per day.

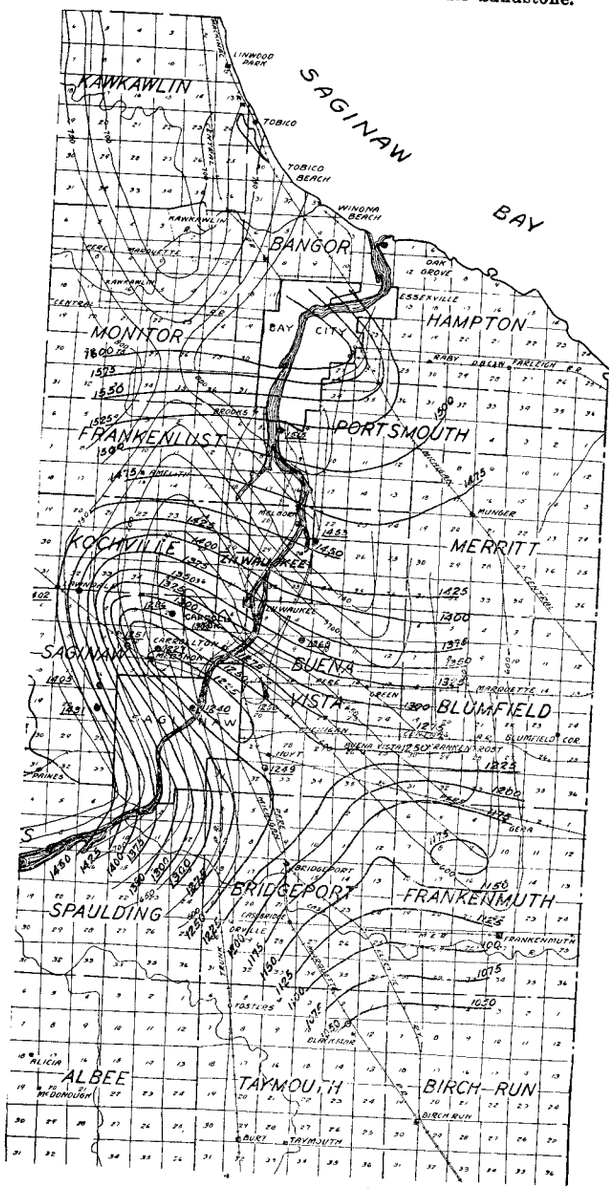
The structure at Saginaw was first defined by drilling to the Marshall formation, and the first contour map was drawn for the top of the Napoleon. Later limitation of structure by drilling to the Berea shows that the contours for the Berea do not quite parallel those for the Napoleon sandstone, especially east of the city. The comparison between the early map drawn for the Upper Marshall and the present Berea structural map is shown in Fig. 9. The amount of difference is not large, but it appears to control to a very important degree the local form of the structure and the distribution of the oil. The evidence at first, though incomplete, suggested that the upper surface of the Berea was quite undulating. More careful measurements of depths in the later wells show that the undulations are apparently larger and gentler than was at first indicated.

In the producing area the interval between the top of the Upper Marshall to the Berea averages about 1200 feet, but except toward the north the interval varies from about 1220 feet to a maximum of 1298 feet in north Bay City and 1301 feet at St. Charles. This roughly accords with the theory that the forces which cause compression are in general greatest along the crests of anticlines; therefore soft formations are more compressed and thinner on the top of such structures than on the flanks. Two sections extending northwest-southeast along the crest of the fold and northeast-southwest across the flanks aid to bring out this relationship.

These sections are shown in Figure 10 and include a comparison of three wells across the flanks and six wells along the crest of the anticline.

FIGURE 9.

Structural Contour Map of the Saginaw Anticline Compared with an Early Structural Contour Map Drawn on the Marshall Sandstone.



The recent development of the Saginaw field shows that just north of the city the crest of the fold is somewhat farther west than previously ging northwest. The t was supposed from rd Kawkawlin. The ses into a pronounced

pe with much steeper st dip is as much as y half as pronounced. f a broader regional Port Huron and Mt. it of closure has been finite since there has ion to give accurate

in this direction of defined on the flanks so rather well known. uction cuts off to the on the east side of signed to combat the rohibited drilling in

ist, 1925, some three represent an average hree million dollars. stimated at $800,000, ction has fluctuated, barrels daily. There s no new drilling is rely drilled and only

on on Michigan's oil ations. Besides the ave established them- Company of Indiana output by building areas attest to this

of Michigan several e fallacy of get rich lisagreeable features proved to them the tion and the alleged ne the exact location em how an oil field and its various stip-

ulations, and the various phases of technology connected with the industry. In a large way it has given them an insight into a new business with many peculiar difficulties and vexing problems.

FIGURE 10

Comparison of Well Sections Across the Saginaw Oil Field.

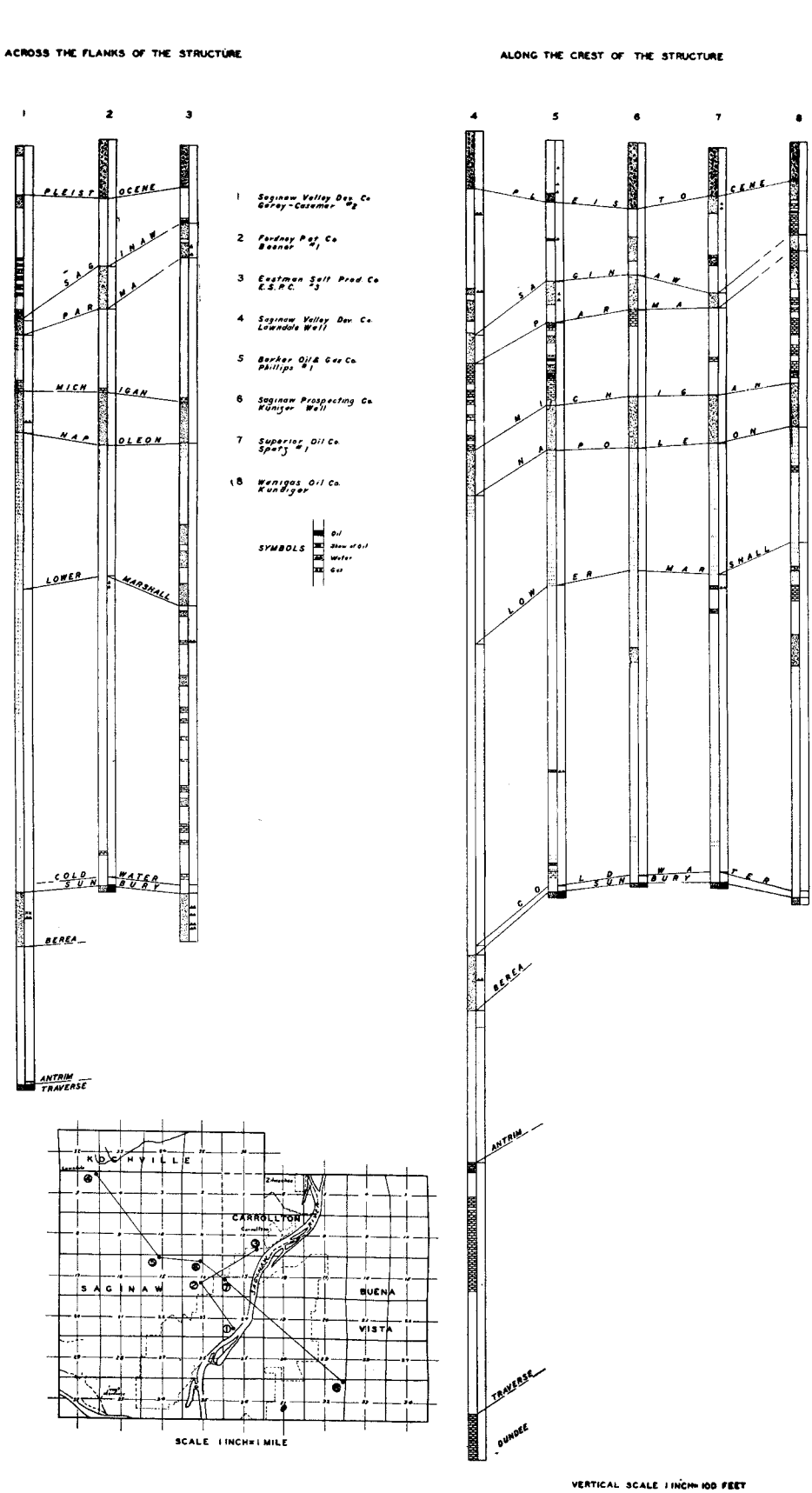
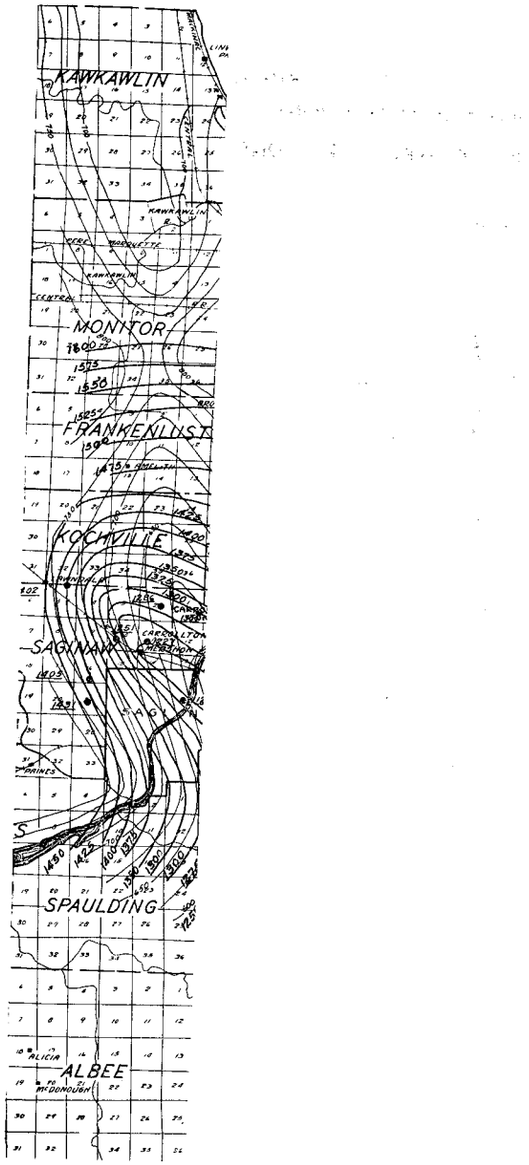


FIGURE 9.

Structural Contour Map of the Saginaw Anticline Compared with an Early Structural Contour Map Drawn on the Marshall Sandstone.



The recent development of the Saginaw field shows that just north of the city the crest of the fold is somewhat farther west than previously indicated and that it has an elongated nose plunging northwest. The top of the anticline is flatter and broader than it was supposed from early data, and does not veer to the north toward Kawkawlin. The fold extends east-southeast through the city and passes into a pronounced saddle beyond the city limits on the southeast.

The flexure is elongated and of the asymmetric type with much steeper dip on the west flank than on the east. Southwest dip is as much as 100 feet to the mile, whereas northeast dip is hardly half as pronounced. There are indications that this nosing is a part of a broader regional disturbance extending northwest from between Port Huron and Mt. Clemens toward the center of the basin. The amount of closure has been estimated at between 40 and 50 feet, but this is indefinite since there has been very little drilling in a southeasterly direction to give accurate evidence.

There are possibilities of extension of the field in this direction of closure. The limits of the pool have been closely defined on the flanks of the anticline, and the northwestward extent is also rather well known. More drilling will be necessary to show where production cuts off to the southeast, but it is probable that much of the city on the east side of the river is underlain by oil. So far ordinances designed to combat the fire hazards and public nuisance features have prohibited drilling in the business district proper.

SUMMARY.

Since the discovery of the Saginaw pool in August, 1925, some three hundred wells have been drilled in the area. These represent an average investment of $10,000 or a total of approximately three million dollars. Returns from the oil produced in 1927 have been estimated at $800,000, which is thought to be a conservative figure. Production has fluctuated, but at present the average is about one thousand barrels daily. There are prospects of early dimunition of this amount as no new drilling is under way at present time. The field is almost entirely drilled and only a few inside locations remain.

The results of the field have been to focus attention on Michigan's oil possibilities and to promote extensive wildcat operations. Besides the major companies, many contractors and promoters have established themselves here from other states. The Standard Oil Company of Indiana has declared itself of Michigan's potential petroleum output by building a small refinery at Zilwaukee. Already three new areas attest to this confidence.

The Saginaw Oil Field has taught the people of Michigan several lessons in oil field practice. It has shown them the fallacy of get rich possibilities from close-in town lot drilling, and the disagreeable features of an oil field within a large city. It has adequately proved to them the difference between geological control of oil accumulation and the alleged super-human power of certain individuals to determine the exact location for successful drilling. It has demonstrated to them how an oil field development takes place, the meaning of the oil lease and its various stipulations, and the various phases of technology connected with the industry. In a large way it has given them an insight into a new business with many peculiar difficulties and vexing problems.

TYPICAL WELL RECORDS FROM THE SAGINAW OIL FIELD

SAGINAW (SAGINAW COUNTY).

M. DEINDORFER WELL NO. 1 CITY PROPERTY.

SAGINAW PROSPECTING CO.

Location: W ½ of the NE ¼ Sec. 14, T. 12 N., R. 4 E. 200 feet from E. line and 200 feet from S. line of Deindorfer farm.
Elevation: 605.4 feet above sea level.
Drilled in 1925 by Regan and Goll, well contractors, Lancaster Ohio. Record from driller's log furnished by the company.

	Thickness feet	Depth feet
Pleistocene:		
No record	133	133
Pennsylvanian:		
Saginaw Formation:		
Black slate	27	160
Shale	66	226
Sand	19	245
Shale	60	305
Gray sand	60	365
Blue slate	25	390
Brown lime	50	440
Parma Formation:		
White sand	45	485
Mississippian:		
Michigan Formation:		
Green slate	55	540
Blue slate	15	555
Gray sand	10	565
Blue slate	45	610
Napoleon (Upper Marshall) Formation:		
Sand; salt water	125	735
Marshall Formation (Lower Marshall):		
Red rock	95	830
Blue slate	45	875
Red rock	35	910
White slate	55	965
Red rock	100	1065
White slate	150	1215
Broken up sand	55	1270
Coldwater Formation:		
Blue slate	460	1730
Red rock	10	1740
White slate	80	1820
Sunbury Formation:		
Black slate	15	1835
Berea Formation:		
Sandstone with oil	37	1872

Drilling commenced—7-25-25.
Drilling completed—8-22-25.
Casing record—10", Drive pipe, 145'; 8¼" casing, 745'; 6 ⅝" casing, 1873'.
Tubed with 2 inch tubing. Well cased to bottom and last two joints perforated to within 10 feet of the bottom.
Well was making about 17 barrels of oil and 1 barrel of water per day on January 6, 1926.

SAGINAW (SAGINAW COUNTY)

BLISS PETROLEUM CO. NO. 1

Location: Near the SW corner of the NE ¼ of the NE ¼, Sec. 14, T. 12 N., R. 4 E.
Elevation: 602.5 feet above sea level.
Drilled in 1925.

	Thickness feet	Depth feet	El. A. T.
Pleistocene:			
No record	201	201	.....
Pennsylvanian:			
Saginaw Formation:			
Gray shale	29	230	.....
Dark gray shale	10	240	.....
Very dark gray shale	10	250	.....
Black shale	12	262	.....
Gray sandy shale	5	267	.....
White sandstone with fragments of coal; pyrite, mica	42	309	.....
Gray shale	39	348	+254.5
Parma Formation:			
Medium grained white sandstone	54	402	.....
Coarse grained gray sandstone	15	417	.....
Black shale*	40	457	+145.5
Mississippian:			
Bayport Formation:			
Gray dolomite; pyrite; chert; quartz	12	469	.....
Brown dolomite; small amount of chert and pyrite	6	475	+127.5
Michigan Formation:			
Greenish gray, shaly, dolomitic, and limy sandstone; pyrite	51	526	.....
Gray, fine grained sandstone; pyrite	24	550	.....
Gray shale	8	558	.....
Gray sandstone with fragments of black and greenish gray shale; pyrite	6	564	.....
Gray and dark gray sandy shale; pyrite	15	579	.....
Gray shaly sandstone	10	589	.....
Greenish gray sandstone; pyrite	6	595	.....
Greenish gray sandstone and dark gray shale; pyrite	11	606	−4.5
Napoleon Formation:			
Gray sandstone with some shale (from above?)	4	610	.....
White medium grained sandstone	15	625	.....
Gray medium grained sandstone	6	631	.....
Fine grained white sandstone	61	692	.....
Fine grained gray sandstone	44	736	−133.5
Marshall Formation:			
Fine grained red shaly sandstone; mica	6	742	.....
Red sandy shale	5	747	.....
Extremely fine grained red shaly sandstone; mica	16	763	.....
Extremely fine grained red and green shaly gritstone; mica	34	797	.....
Extremely fine grained red shaly sandstone; mica	28	825	.....
Extremely fine grained greenish gray sandstone with some red sandstone; mica	10	835	.....
Gray sandstone and dark gray shale; mica	30	865	.....
Red shaly sandstone; mica	22	887	.....
Red shaly sandstone and gray shale	10	897	.....
Dark gray sandy shale; mica	65	962	.....
Red sandy shale; mica	89	1051	.....
Coldwater Formation:			
Typical Coldwater does not appear above 1,300 feet. The base of the Marshall is taken as the base of the red color but probably really extends to 1,300 feet. Gray sandy shale; mica (some red; probably mixed from above)	17	1068	.....
Extremely fine grained sandstone	11	1079	.....
Gray sandy shales	217	1296	.....
Gray shales; some mica	124	1420	.....
Plastic gray shale	20	1440	.....
Plastic gray shale	24	1464	.....
Gray shale some sand and mica	205	1669	.....
No record	51	1720	.....
Red and gray shale	12	1732	.....
A confusion of samples at this point.			
A sample marked 1729-1735 is black shale	3	1735	.....
Black shale, pyrite	12	1747	.....
Dark gray shale; pyrite	46	1793	.....

*This black shale, an unusual local occurence noted in other Saginaw wells, is included with the Parma although that formation is defined as a sandstone. In reality this shale represents an un-named member of the Pennsylvanian.

BLISS PETROLEUM CO. NO. 1—*Continued*

	Thickness feet	Depth feet	El. A. T.
Sunbury Formation:			
Black shale	10	1803	.....
Berea Formation:			
Black shale and sandstone	13	1816	1213.5
Very fine grained sandstone; some black shale fragments	3	1819	.....
Very fine grained sandstone; fragments of gray shale	7	1826	.....
Gray shale and some sandstone	2	1828	.....

A sample marked 1826-1828 contains material like that from 1816 and is probably either out of place or mixed in the sludge pit.

SAGINAW (SAGINAW COUNTY)

SUN OIL COMPANY NO. 1 WEISS

Location: In the W ½ of the SE ¼, Sec. 11, T. 12 N., R. 4 E.
Elevation: 603 feet above sea level.
Samples received from 1700 to 1835 feet. Drilled in, March 29th, 1926. Shot with 40 quarts, March 30th. Swabbed 50 barrels, April 1st; 25 barrels, April 2nd. 8 feet of pay sand. Estimated at a 25 barrel well.
Drillers log received through H. L. Barnett, geologist.
Thickness questionable as only conspicuous changes were recorded.

	Thickness feet	Depth feet
Pleistocene:		
Drift	.....	152
Pennsylvanian:		
Saginaw Formation:		
Rock	.....	220
Black shale	.....	320
Broken sandstone and shale	.....	360
Parma Formation:		
White sandstone	.....	*440
Mississippian:		
Michigan Formation:		
Shale	.....	470
Black shale and shells	.....	586
Napoleon Formation:		
Broken sandstone	.....	**606
White sandstone (brine)	.....	625
Marshall Formation:		
Red rock	.....	***825
Marshall and Coldwater Formation (undivided):		
Blue shale and red rock	.....	1230
Sand	.....	1265
Blue shale	.....	1720
Red shale some blue shale	5	1725
Gray sandy shale	75	1800
Coldwater and Sunbury Formations (undivided):		
Black shale and gray sandy shale	8	1808
Sunbury Formation:		
Black shale	17	1825
Berea Formation:		
Very fine grained sandstone	10	1835

*From comparison with other records it seems probable that this figure represents the depth to the top of the Parma.
**Probably the *top* of the Napoleon.
***Probably 825 feet to the *top* of the Marshall.

EXPLORATIONS RESULTING FROM SAGINAW DEVELOPMENT

SAGINAW COUNTY.

As a result of the Saginaw Oil Field and the outlining of the Saginaw Anticline, extensive exploration took place in an effort to find a similar fold continuing to the southeast or a parallel fold to the southwest.

Some of the major operators in the Saginaw Field proper took the lead in these developments, but the majority of the wells were drilled by local syndicates or outside interests. The center for activities southeast of the city of Saginaw was at Birch Run while the locality of drilling interest to the southwest of Saginaw was located within a short radius of St. Charles. Other wells were drilled more directly east and west of the city in hopes of extending the immediate field. Several important showings were found but no substantial production was obtained and prospects were decidedly discouraging for Saginaw County. Out of 21 wells drilled one small producer resulted from the Dundee Formation at Birch Run, and a favorable showing was found in the same horizon north of Frankenmuth. Other wells near Birch Run showed some oil and enough gas was tapped in a test south of Frankenmuth to cause a fire which burned the rig and created considerable damage. In spite of the fact that efforts to find a new Berea pool seemed to very little avail, operators would not concede that the district has been condemned for further development. At the close of 1927 the idea still prevailed that nearby structures which resulted from similar forces to that which formed the Saginaw Anticline would have to exist, and that other prolific pools would be found in the same general area.

SOUTHEAST OF CITY OF SAGINAW

BIRCH RUN TOWNSHIP

The first well south of the village of Birch Run was spudded in on December 18, 1926. The location was on the farm of Mike Courtney in the extreme northwest corner of the NE¼ of Section 29 and the Saval Development Company were the backers of the project. This organization was largely made up of Saginaw men, the name "Saval" indicating Saginaw Valley, and R. T. Hill was General Manager of the concern. The top of the "Berea Sand" was found at 1532 feet and a show of oil along with a small amount of water was encountered at a depth of 1556 feet. After plugging back, the well was shot and a flow of water with some oil ensued. The first production was estimated by Mr. Hill as 5 to 6 barrels per day, and after the well was pumped down it made from 5 to 10 barrels daily with some gas. Further pumping netted an average daily output of about 2 barrels, but the hole was finally abandoned.

The Wolohan Petroleum Company was organized with 50,000 shares of non-par value stock to carry on further prospecting in the vicinity of Birch Run on the M. Courtney property. The new location was some distance to the southeast of the first one and the Western Drilling and Oil Corporation of Saginaw were contractors on the well. Drilling operations were commenced on May 1, 1927, and the Berea formation which was reached at a depth of 1535 feet carried no favorable indications of either oil or gas. The top of the Traverse occurred at 2009½ feet and the Dundee limestone was found at 2521 feet. Pays were present in the Dundee formation near the top and at depths from 2542 to

2588 feet, and the total depth was given as 2595 feet. The well pumped 3 barrels during the first ten days and on August 14th the Dundee was shot with 180 quarts of nitroglycerin. Although exact figures are not available at the present time, it is reported to be a very consistent producer.

An organization known as the B and B Petroleum Company drilled on the Pat Sauve farm in the NE¼ of the NW¼ of Section 19. This location was just south of the Pere Marquette railway tracks. P. D. Snavley was president of the company and J. F. Marshand was one of the principles of the operation. The Berea formation was encountered at 1534 feet and the "sand" was shot between 1534 and 1548 feet with no significant results. The Traverse was found at 1985 feet and this formation was also dry. The top of the Dundee limestone occurred at 2510 feet and a pay was tapped at 2535 feet which was shot on June 9, 1927, with a very good showing. On July 16th there was 1000 feet of oil in the hole. Production fell off rapidly with the removal of the first oil and after drilling 90 feet in the Dundee, the well was abandoned.

W. E. Ellis of Grosse Pointe, Michigan, drilled a well on the Ed Kobs farm in the West ½ of the SE¼ of Section 3, which was located about two miles south of Frankenmuth. The Cheers Drilling Company were contractors and drilling was carried well into the Dundee formation. The Berea formation occurred at 1672 feet and water was encountered at 1701 feet which made 4½ bailers in 45 minutes. The top of the Traverse was found at 2125 feet and a strong flow of gas was struck at 2139 feet. The well came in about midnight and the gas caught fire immediately. Flames shot about 20 feet above the top of the pipe and before the fire could be checked the rig burned down, leaving the tools in the hole. When operations were resumed the gas sand was shot with only a very small increase in flow resulting. When gauged the well showed 175,000 cubic feet of gas. Water was encountered at 2265 feet which amounted to about 25 feet in the 6-inch pipe. Steel line measurement showed the Dundee at 2674 feet and on August 30th drilling had continued 104 feet into this formation with no important showing.

Willard Johnson and associates of the Bacon Petroleum Company sunk a test on the R. Muhleman farm located in the NW¼ of the NW¼ of Section 18. A show was found in the Berea, the top of which occurred at 1535 feet. The Traverse occurred at 2040 feet and was unproductive throughout. The Dundee formation was encountered at 2570 feet and a show of oil was present at 2585 feet. Drilling was continued into the Monroe formation with some shows, but water carried in the hole made drilling difficult and accurate appraisal of the possibilities was almost impossible. The last reports showed the well at about 2900 feet.

The J. & S. Corporation of Detroit put down a well to the Berea which was located on the W. J. Smith farm just north of Birch Run in the NW¼ of the NW¼ of Section 20. The Marshall was found at 380 feet and the Berea at 1536 feet. The bottom of the Berea occurred at 1562 feet and the well was plugged and abandoned on September 9, 1927.

BLUMFIELD TOWNSHIP

The Sun Oil Company drilled a "wildcat" well in the NW¼ of the NW¼ of Section 8 which was based on a structure worked out from coal seam data in the Uncle Henry Mine. The location was about one-half mile north of Wadsworth Road, and a half-mile east of the mine. A

block of leases including about 4000 acres was held under a partnership plan in the general vicinity. This important test was made in conjunction with the Consolidated Coal Company and was significant in respect to the use of coal seams as key beds in determining structure. It proved rather conclusively that such evidence could not be used to determine sub-surface structure because of the irregularities of coal seam disposition and the unconformity existing at the base of the Pennsylvanian. The Berea formation was penetrated at 1970 feet and a strong flow of brine occurred between 1988 and 1998 feet where drilling was discontinued. The top 18 feet of the sand was very much broken up and did not show either oil or gas, and the brine bearing portion was much lighter in color than that above. The well was plugged and abandoned at 1998 feet on January 25, 1927.

BUENA VISTA TOWNSHIP

Three wells were drilled in Buena Vista township which directly adjoins Saginaw to the east. The Gardner Petroleum Company of Tulsa, Oklahoma, put down a test in 1926 on the Schwannecke farm located in the SE¼ of the NE¼ of Section 33, which reached a total depth of 3244 feet. This well finished at 340 feet in the Dundee formation and water, which was found at 2908 feet and 3237, filled up too far to handle.

The Wanigas Oil Company, a local concern originating in Saginaw, drilled in the NE¼ of the NE¼ of Section 32, on the Kundinger property and the well was completed at 1878 feet in the Berea formation. The top of the Berea was encountered at 1862 feet and no substantial showing of oil or gas was present. The well was not continued deeper because of the unfavorable structural location, and was abandoned without being given a shot.

A well was drilled on the E. G. Rust farm by the Saginaw Prospecting Company in the NE¼ of the NE¼ of Section 9. The Berea was found at 1953 feet, and after drilling to 1998 feet, the tools became stuck in the hole and could not be recovered. The formation was broken and no signs of oil or gas were present. Water found at 45 feet in the sand was hardly noticeable when drilling, but the hole filled up while fishing for the tools. A second string of tools was lost in the well during the fishing operations. Although the intention had been to go to the Saginaw and Dundee, this misfortune caused the abandonment of the hole.

A well was commenced on September 12, 1927, by Crowley & Carr, contractors, which was located in the southwest side of the city of Saginaw between Park and Ward Streets in the NE¼ of the NW¼ of Section 30. This hole was known as the Curtin well of the Star Petroleum Company and J. W. Fordney was connected with the project. The location which was just south of Plelon Street on an 8-acre plot between two switch spurs of the Grand Trunk Railway was somewhat remote from the Saginaw Oil Field proper. The "Berea sand" which was found at 1847 feet, contained no commercial quantities of oil or gas. Drilling was continued to the "Saginaw sand" and the top of the Traverse formation occurred at 2354 feet. Production was obtained from the "Saginaw sand" at 2358 feet and the well swabbed 40 barrels of high grade crude during the first day. After being put on the pump, the output fell off rapidly.

FRANKENMUTH TOWNSHIP

Early in 1926 the Michigan Petroleum Company (formerly Brown City Prospecting Co.) commenced a well which was located in the SE corner of the SW¼ of Section 4. The top of the Berea was found at 1792 feet and a hole full of water developed at 1827 feet. The well was drilled to 1844 feet and temporarily abandoned. Late in August operations were resumed to drill to the Dundee. The top of the Traverse which was also unproductive occurred at 2298 feet, and complete samples furnished by George T. Bench showed this formation to be 512 feet thick. Many delays in drilling took place, but the Dundee was finally reached in July, 1927, and the well bid fair to be a producer. The top of the Dundee formation was penetrated at 2898 feet and although there was a small show at about 25 to 30 feet in, the best pay was found at 2894 and 3010 feet. On July 9, 1927, the well was shot with 150 quarts of nitroglycerin and 30 barrels of oil were swabbed during the first 24 hours. Two days later, on July 11th, there was 900 feet of fluid in the hole and indications were favorable for a good well. However, a second shot spaced 42 feet apart from the first was put off with the tools, and a difficult fishing job resulted. Efforts were made to drill by the tools and after penetrating 19 feet below them a shot of 40 quarts was applied. The results of this were not altogether successful and operations were shut down for the winter at a total depth of 3036 feet.

TAYMOUTH TOWNSHIP

The first well in the immediate vicinity of Birch Run was drilled by S. M. Bacon and others on the George Judd farm. This test was located in the SE¼ of the NE¼ of Section 11, and about 1600 feet southeast of an old well put down in the early seventies, in which some oil and gas had been reported at depths from 1545 to 1645 feet. A stray sand containing some oil was encountered at 1018 feet and the operators decided to shoot it with nitroglycerin in order to determine its possibilities. The shot damaged the casing so that the tools could only be run about 300 feet in the hole and the well was ultimately abandoned without being drilled to the Berea.

A second location was made by S. M. Bacon and others on the Samuel Cedar farm in the NW¼ of the SW¼ of Section 12, and drilling was commenced on Jan. 19, 1927. This well, which was drilled by Lemunyon Bros. of Saginaw, reached the Berea formation at a depth of 1605 feet and went 27 feet into the sand without encountering production. The casing was pulled and the hole was plugged and abandoned on August 7, 1928.

The R. V. Dillard Company drilled a well on the D. D. Atkins property in the northeast corner of the NE¼ of Section 31. The Marshall sandstone was reported from 540 to 695 feet and the Berea from 1731 to 1789 feet. Numerous shale streaks occurred in the Berea, which showed a very broken character, and the well proved to be a dry hole.

SAGINAW COUNTY (S. E. OF CITY)

Location	Sec.	T.-R.	Township.	Farm.	Company.	Elev.	Drift.	Marsh.	Berea.	Trav.	Dundee.
N.W./N.E.	29	10N-6E	Birch Run.....	M. Courtney.....	Saval Dev. Co.....	638	120	330	1532	1987	
N.E./N.E.	29	10N-6E	Birch Run.....	M. Courtney.....	(Western Drilling Co.).....	635	.....	330	1535	2009	2521 Pay—2542-88
N.E./N.W.	19	10N-6E	Birch Run.....	Pat Sauve.....	Wolohan Pet Co.....	615	.....	.....	1534	1985	2510 Pay—2535
N.W./N.W.	20	10N-6E	Birch Run.....	W. J. Smith.....	(U. F. Marchand).....	630	.....	380	1536	(175,000)	
W½/S.E.	3	10N-6E	Birch Run.....	Ed. Kobs.....	B. & B. Pet Co.....	625	81	425	1672	2125	2674
N.W./N.W.	18	10N-6E	Birch Run.....	R. Muhleman.....	W. E. Ellis.....	625	.....	335	(Show) 1535	2040	2570
N.W./N.W.	8	12N-6E	Blumfield.....	Geo. L. Shapland.. (Unc. Henry).....	F. O. Snavely et al). J. & S. Corp.....	597	104	695	1970	.....	
N.E./N.W.	30	12N-5E	Buena Vista...	Curtin.....	Willard Johnson (Bacon).....	605	119	595	1847	2354	
S.E./N.E.	33	12N-5E	Buena Vista...	Schwanneeke.....	Sun & Cons. Coal Co.. Star Pet. Co.	614	100	598	1852	2329	2904
N.E./N.E.	32	12N-5E	Buena Vista...	Kundiger.....	(Crowley & Carr).....	613	96	593	1862	.....	
N.E./N.E.	9	12N-5E	Buena Vista...	E. G. Rust.....	Gardner Pet. Co.....	585	93	735	1953	.....	
S.E./S.W.	4	11N-6E	Frankenmuth..	Chris. Rogner.....	Wanigas Oil Co.....	632	100	570	1792	2298	Pay—2984,3010, 2898
N.W./S.W.	12	10N-5E	Taymouth.....	Samuel Cedar.....	(Malin Clover Cont)... Sag. Prosp. Co	615	.....	415	1605	.....	
S.E./N.E.	11	10N-5E	Taymouth.....	Geo. Judd.....	Mich. Pet Co..... (Lemunyon Bros.).	.....	.....	425	.....	.....	
N.E./N.E.	31	10N-5E	Taymouth.....	D. D. Atkins.....	S. M. Bacon et al.....	635	.....	540	1731	.....	
					S. M. Bacon et al.....						
					R. V. Dillard.....						

TYPICAL WELL RECORDS
FROM
SAGINAW COUNTY, SOUTHEAST OF THE CITY OF SAGINAW

BIRCH RUN (SAGINAW COUNTY)

SAVAL DEVELOPMENT COMPANY

Location: On farm of Mike Courtney in the extreme N. W. corner of the N. E. ¼ of Sec. 29, T. 10 N., R. 6 E.
Elevation: About 635 feet above sea level.
Record by W. Osgood from samples furnished by R. L. Hill of the Saval Company.

	Thickness feet	Depth Feet
Pleistocene:		
Surface formations	No record	No record
Mississippian:		
No record to		316
Michigan Formation:		
Brown dolomitic limestone	4	320
Upper Marshall Formation:		
Gray sandstone (considerable pyrite)	40	360
White sandstone	61	421
Lower Marshall Formation:		
Gray shale	20	441
Gray sandy shale	45	486
Gray sandy shale (slight buff tinge)	6	492
Bluish gray sandy shale	10	502
Red sandy shale	10	512
Gray shaly sandstone	38	550
Blue-gray micaceous shale	50	600
Reddish micaceous sandy shale	10	610
Gray micaceous sandy shale	170	780
Red sandy shale	50	830
Coldwater Formation:		
Blue shale	25	855
Gray shaly sandstone	15	870
Blue shale	370	1240
Gray micaceous shaly sandstone	5	1245
Gray shale	140	1385
Red sandy shale	10	1395
Gray shale	52	1447
Light gray micaceous sandy shale	33	1480
Red and gray shale	11	1491
Gray shale	10	1501
Red and gray shale	6	1507
Sunbury Formation:		
Dark gray to black shale	33	*1540
Berea Formation:		
Sandstone	33	1573

*According to more accurate measurements the Berea sand was tapped at 1532 feet.

FRANKENMUTH TOWNSHIP (SAGINAW COUNTY)

CHRIS ROGNER FARM

Michigan Petroleum Company (formerly Brown City Pros. Co.).
Location: On Chris Rogner farm, near S. E. corner S. W. ¼ Sec. 4, T. 11 N., R. 6 E, Frankenmuth Township, Saginaw County.
Elevation: 634± feet above sea level.
Continuation of well drilled by Geo. T. Bench (?) in 1926 and finished in 1927. Log compiled by R. B. Newcombe from samples submitted and driller's record furnished by D. P. Geiger.

	Thickness feet	Depth feet
Pleistocene:		
Surface deposits	118	118
Pennsylvanian-Mississippian:		
Coal Measures and Michigan Series	452	570
Mississippian:		
Upper Marshall Sandstone	135	705
Lower Marshall and Coldwater Formations:		
Red rock	195	900
Blue shale	250	1150
Water sand	5	1155
Blue slate	445	1600
Pink shell	10	1610
Blue slate	90	1700
Sandy shell	40	1740
Blue slate	5	1745
Red rock	5	1750
Blue slate	10	1760
Sandy shell	8	1768
Sunbury Formation:		
Black shale	24	1792
Berea Formation:		
Sand	52	1844
No record	468	2312
Devonian:		
Traverse Formation:		
Buff shaly limestone (drills fine) (2314-2317 missing)	11	2323
Blue calcareous shale	31	2354
Grayish buff limestone and blue shale	6	2360
Blue shale	10	2370
No record	5	2375
Blue shale and gray limestone	4	2379
Gray to buff limestone	5	2384
Gray limestone	1	2385
Blue calcareous shale	17	2402
Blue to gray flinty limestone (somewhat iron stained)	8	2410
Buff limestone (iron stained)	20	2430
Light gray to bluish limestone	5	2435
Gray to buff limestone	3	2438
Blue shale	4	2442
Light to dark gray limestone	4	2446
Buff limestone (iron stained)	27	2473
Blue shale	15	2488
Gray to bluish shaly limestone	21	2509
Light gray to buff limestone	9	2518
Buff limestone	4	2522
Gray to buff limestone	20	2542
Gray limestone	12	2554
Buff limestone	34	2588
Blue calcareous shale with some red streaks and fossils in upper part	222	2810
Bell Formation (?):		
Light gray calcareous shale	87	2897
Blue shale and gray limestone	1	2898
Dundee Formation:		
Dark gray to buff limestone	32	2930
Buff limestone (drills fairly fine)	54	2984
Buff crystalline limestone (drillings somewhat coarser than above)	26	3010

Hole full of water at 1827 feet.
10-inch drive pipe 118 feet.
8-inch casing 710 feet.
Steel line measurement.

Note: Rigging up August 31, 1926 to drill to Dundee limestone.

SAGINAW (SAGINAW COUNTY)

SCHWANNECKE FARM

GARDNER PETROLEUM CO.

Location: S. E.¼ of N. E. ¼ of Sec. 33, T. 12 N., R. 5 E., Buena Vista Township.
Elevation: 614 feet above sea level.
Drilled in 1926. Samples furnished by Gardner Petroleum Company.

	Thickness feet	Depth feet
Pleistocene:		
Surface	25	25
Clay	65	90
Gravel (thin sheet of coal)	10.5	100.5
Pennsylvanian:		
Saginaw Formation:		
Sand	84.5	185
Sandy shale	15	200
Dark blue shale	15	215
Sandy shale	14	229
White sand	111	340
Sandy shale	10	350
Parma Formation:		
White sand	55	405
Mississippian:		
Michigan Formation:		
Gray limestone (moderately effervescent)	20	425
Gray sandy limestone	15	440
Gray sand	10	450
Gray sandy dolomite	20	470
Sandy shale (with mica)	70	540
Sand	10	550
Sandy shale	20	570
Sand	10	580
Sandy shale	10	590
Sandy limestone	8	598
Upper Marshall Formation:		
Sand	112	710
Sandy shale	18	728
Lower Marshall Formation:		
Red sandstone	10	738
Red sandy micaceous shale	77	815
Blue shale	35	850
Red sandstone	30	880
Blue shale	80	960
Red sandstone and blue shale	20	980
Blue micaceous shale	20	1000
Red shaly sandstone	30	1030
Coldwater Formation:		
Blue shale	20	1050
Red and blue micaceous shale	40	1090
Blue shale	128	1218
Sand (show of water)	5	1223
Sandy shale	97	1320
Blue shale	390	1710
Red sandy shale	20	1730
Blue shale	65	1795
Fine grained gray sandstone	16	1811
Dark gray shale	21	1832
Sunbury Formation:		
Black shale	20	1852
Berea Formation:		
Fine grained gray sandstone	7	1859
Shale	2	1861
Shale and sand	25	1886
Sandstone	71	1957
Devonian:		
Antrim Formation:		
Dark blue shale	71	2028
Black shale	249	2277
Gray limestone	4	2281
Black shale	48	2329
Traverse Formation:		
Brown limestone	14	2343
Blue shale	44	2387
Brown limestone	26	2413
Blue shale	18	2431
Brown limestone	69	2500
Dark gray limestone	35	2535

GARDNER PETROLEUM CO.—*Continued*

	Thickness feet	Depth feet
Brown or buff limestone	88	2623
Blue shale	281	2904
Dundee Formation:		
Shales and limestone	34	2938
Brown limestone with some shale	306	3244

Water:
Hole filled up 225 feet over Sunday at 2908 feet.
Hole filled up 100 feet while drilling a screw at 3237 feet.
Too much water to handle at 3244.
Filled to top with 80% mud fluid.

SOUTHWEST OF CITY OF SAGINAW

BRANT TOWNSHIP

A well was drilled in 1927 by Voorhees and Sovereign on the Ephriam Loackridge farm in the SE¼ of the SE¼ of Section 28. This location was in the extreme southeast corner of the section, 150 feet north of the road and 225 feet west of the road, and 2 miles directly south of the village of Brant. V. M. Voorhees was the contractor and W. J. Sovereign of Bay City was associated with the project. The Marshall was penetrated at 770 feet and the Berea at 1955 feet. The Berea formation was dry and although drilling was continued deeper, the well was abandoned at 2125 feet in the Antrim brown shale. Plugging operations were completed on October 10, 1927.

CHESANING TOWNSHIP

A well was commenced by J. R. Keenan and others on the Wm. Harris farm in the NE¼ of the NW¼ of Section 8, which was located about 300 feet south of the road and about 1 mile northwest of the village of Chesaning. The contract for drilling was made with the Western Oil and Drilling Company of which Jack Hendricks was president. The well was continued to a depth of 798 feet where operations were suspended for lack of funds. The top of the Upper Marshall formation was found at 675 feet and drilling was stopped in the red sandy shale of the Lower Marshall. In the winter of 1927-28 the outfit was purchased by V. M. Voorhees for work in Muskegon Field and the well was plugged and abandoned.

SPAULDING TOWNSHIP

The P. D. Snavley Company in which Charles Hunt was interested, drilled on the Thos. Holihan farm in the SW¼ of the SW¼ of Section 14. The location was 750 feet from the road and 250 feet from the line fence. C. A. Perry of Saginaw was the contractor and according to last reports the well was shut down at 2800 feet. The Marshall was found at 700 feet and the Berea at 1920 feet. A crevice was tapped in the Berea at 1927 feet and water was found at 1990. The formation was unproductive of either oil or gas.

St. CHARLES TOWNSHIP

McLaughlin and associates put down a well about a mile south of St. Charles on the J. Craven farm in the NE¼ of the NW¼ of Section 17. The Marshall occurred at 625 feet and the top of the Berea was encountered at 1920 feet. A showing of oil was reported in the Parma formation at 225 feet and some of the Berea samples contained traces of petroleum. The well was abandoned as a dry hole at a total depth of 1927 feet.

SWAN CREEK TOWNSHIP

E. J. Miller of Toledo, Ohio, put down a test on the O. K. Bailey farm in the SE¼ of the NE¼ of Section 19. The location was about 3 miles north of St. Charles and C. A. Perry was the drilling contractor on the well. The Marshall was reported at 865 feet and some water was found at about 1450 feet in the Coldwater formation. The Berea, which occurred from 1983 to 2073 feet, was dry. A very small amount of gas was found in the Traverse formation, the top of which was reached at 2442 feet according to steel line measurement. Drilling was carried on to a total depth of 2491 feet and the "Saginaw Sand" was shot with 100 quarts of nitroglycerin. No production resulted and the location was abandoned on Dec. 14, 1927.

NORTH AND WEST OF CITY OF SAGINAW

CARROLLTON TOWNSHIP

A well was put down by the Bacon Petroleum Company in the NW¼ of the SE¼ of Section 1, which was about a mile northwest of Carrollton. No production was found in the Berea, the top of which was encountered at about 1888 feet.

SAGINAW TOWNSHIP

In the early part of the development which grew out of the Saginaw Oil Field a "wildcat" well was drilled by Chas. Murrin, contractor, on what was known as the Morning lease. This location was in the SE¼ of the NW¼ of Section 13 and on the south side of the Tittabawassee River. The Berea formation was reached at a depth of about 2084 feet with no significant showing of oil or gas. Drilling was continued but no data is available pertaining to formations encountered.

The Saginaw Prospecting Company put down a deep test on the Hemmeter farm in the NE¼ of the SW¼ of Section 21. The location for the well was about a mile northeast of Saginaw on Brockaway Road and Hagan & Hagan were contractors. Drilling operations were commenced on September 24, 1926. A strong flow of artesian water was tapped in a gravel pocket in the drift at about 110 feet. The stream spurted into the air to heights ranging from 40 to 80 feet, and flowed from the pipe at a rate estimated to be some 200 barrels per day. After a few days the flow partly subsided, was shut off, and drilling was continued. The top of the Berea was found at 2056 feet and there was 45 feet of sand. The Traverse formation occurred at 2450 feet with 25 feet of "Saginaw Sand." The Dundee was reached at 3210 feet and contained a trace of dead oil. The well was continued to a total depth of 3473 feet and was finally abandoned as a dry hole.

V. M. Voorhees and others drilled a well on the property belonging to Mrs. Marshall, in the SE¼ of the SW¼ of Section 16. This location was out State Street about 2 miles west from its intersection with Bay Road, and several hundred feet north of the highway. The Berea formation occurred at depth of 2031 feet and was unproductive of oil or gas. The hole was plugged and abandoned.

The Bliss Petroleum Company drilled a dry hole on the Carl Boldebuck farm in an effort to find an extension of the Saginaw pool to the north. The location was in the NW¼ of the SE¼ of Section 2. The Berea was reached at about 1881 feet with scarcely any showing of oil and gas.

SAGINAW COUNTY (Southwest of City)

Location.	Sec.	T.-R.	Township.	Farm.	Company.	Elev.	Drift.	Marshall.	Berea.	Traverse.	Dundee.
S.E./S.E.	28	10N-2E.	Brant	E. Loackridge	Voorhees & Sovereign	622	206	779	1955		
N.E./N.W.	8	9N-3E.	Chesaning	Wm. Harris	Kennan, et al	635	50	675			
S.W./S.W.	14	11N-4E.	Spaulding	Thos. Holihan	(Chas. Hunt) R. D. Snavley	593	149	700	1920		
S.E./N.E.	19	11N-3E.	Swan Creek	O. K. Bailey	E. J. Miller	603	94		1983	2442	
N.E./N.W.	17	10N-3E.	St. Charles	J. Craven	McLaughlin (et al)	605	51	625	1920		

SAGINAW COUNTY (NORTH OF CITY)

Location.	Sec.	T.-R.	Township.	Farm.	Company.	Elev.	Drift.	Marshall.	Berea.	Traverse.	Dundee.
S.E./S.E.	1	12N-4E.	Carrollton		Bacon Petroleum Co.	588			1888		
N.W./S.E.	2	12N-4E.	Saginaw	Carl Boldebuck	Bliss Petroleum Co.	595			1881		
S.E./S.W.	16	12N-4E.	Saginaw	Mrs. Marshall	V. M. Voorhees (et al)	625			2031		
N.E./S.W.	21	12N-4E.	Saginaw	Hemmeter	Hagan & Hagan Saginaw Prospect Co.	625			2056	2450	3210
S.E./N.W.	13	12N-4E.	Saginaw	Morning	Chas. Murrin (Cont.)	595			2084		

TYPICAL WELL RECORDS
FROM
SAGINAW COUNTY SOUTHWEST OF THE CITY OF SAGINAW

BRANT (SAGINAW COUNTY)

E. LOCKRIDGE No. 1

Location. Two miles south of Brant in S. E. corner of S. E. ¼ of S. E. ¼ of Sec. 28, T. 10 N,-R. 2 E. Brant Township, Saginaw County 150′ North of road and 225′ west of road.
Elevation: 622 feet above sea level.
Drilled in 1927 by Voorhees and Sovereign on the Ephriam Lockridge farm. Record compiled by R. B. Newcombe from log submitted by J. C. Wilson. (Figures adjusted in several places to make up discrepancies in measurement).

	Thickness feet	Depth feet
Pleistocene:		
Drift Material:		
Red sand (water)	15	15
Gravel	3	18
Blue clay	15	33
Gravel	5	38
Blue clay	8	46
Limestone	15	61
Blue mud	15	76
Lime	10	86
Blue mud	5	91
Coal-broken-slate	3	94
Water sand	5	99
Lime	15	114
Blue mud	20	134
Lime	10	144
Blue mud	27	171
Lime	15	186
Blue mud	20	206
Pennsylvanian:		
Saginaw Formation:		
Brown shale	70	276
Lime	24	300
Blue shale	47	347
Lime	10	357
Shale	36	393
Lime	5	398
Shale	18	416
Lime	10	426
Shale	5	431
Parma Formation:		
Sand (water at 500 feet)	64	495
Lime	20	515
Sand	30	545
Mississippian:		
Michigan Formation (undifferentiated):		
Red rock	15	560
Lime	10	570
Slate	10	580
Lime	33	613
Lime and slate	12	625
Lime	25	650
Slate	54	704
Lime	20	724
Slate	15	739
Lime	10	749
Slate	20	769
Lime	10	779
Upper Marshall Formation: (Napoleon)		
Sand	10	789
Lime	10	799
Sand	75	874
Lower Marshall Formation:		
Red rock	85	959
Slate	10	969
Red rock	136	1105
Coldwater Formation:		
Gray slate	815	1920

E. LOCKRIDGE No. 1—*Continued*

	Thickness feet	Depth feet
Lime	5	1925
Gray shale	25	1950
Sunbury Formation:		
Black slate	5	1955
Berea Formation:		
Berea sandstone	25	1980
No record	145	2125
Antrim Formation:		
T. D. in brown shale	.....	2125

Note: Because of the loose usage of the term lime it is nearly impossible to make a sharp differentiation in several cases.

ST. CHARLES (SAGINAW COUNTY)

WELL OF McLAUGHLIN AND ASSOCIATES

Location: On farm of J. Craven in N. E. ¼ of the N. W. ¼ of Sec. 17—T. 10 N-R. 3 E.
Elevation: 605 feet above sea level.
Figures submitted by driller and corrected from partial set of samples.

	Thickness feet	Depth feet
Pleistocene:		
Surface deposits	51	51
Pennsylvanian:		
Saginaw Formation:		
No record	39	90
Coal	1.5	91.5
No record	98.5	190
Coal	3.5	193.5
No record	1.5	195
Parma Formation:		
Yellow sand (showing of oil)	30	225
No record	275	500
Mississippian:		
Michigan Formation:		
Blue shale	75	575
Lime	25	600
Gray sandstone (some pyrite)	5	605
Dark gray shale and white gypsum	20	625
Pyrite, gypsum, light gray sandstone, and gray shale	.....	to 625
Napoleon (Upper Marshall) Formation:		
Light yellowish sandstone, ferruginous	.....	to 800
White sandstone with gray shale and pyrite	18	818
Lower Marshall Formation:		
Fine grained red sandy shale	.....	at 818
No record	.....	1920
Berea Formation:		
Fine grained white sandstone and gray shale	22	1942
Blue-gray shale	2	1944
Fine grained white sandstone and gray shale (pyrite)	2	1946
Hard light gray oily sandstone and blue-gray shale	4	1950
Gray shale (some sandstone and pyrite)	7	1957

SWAN CREEK (SAGINAW COUNTY)

E. J. MILLER, O. K. BAILEY WELL No. 1

Location: S. E. ¼ of N. E. ¼ of Sec. 19, T. 11 N., R 3 E., Swan Creek Township, Saginaw County (near St. Charles).
Elevation: 603 feet above sea level (approximately).
Record compiled by R. B. Newcombe from set of samples of the sands, and driller's log from memory.
Drilled in 1927 by C. A. Perry for E. J. Miller, Toledo, Ohio.

	Thickness feet	Depth feet
Pleistocene:		
Drift material	94	94
Pennsylvanian:		
Saginaw Formation:		
No record	271	365
Parma Formation:		
Flow of water		at 365
Mississippian:		
Michigan Formation:		
Lime shells and blue shale	(?)	760
Napoleon (Upper Marshall) Formation:		
Sandstone	105	865
Red rock	80	945
Coldwater Formation:		
Blue shale, lime, and sandy shell (water at 1450, about 3 bailers to the screw)	935	1880
Red rock	60	1940
Blue shale	20	1960
Sunbury Formation:		
Black shale	20	1980
Berea Formation:		
No samples	28	2008
Gray shale and light gray sandstone	8	2016
Light gray sandstone (some dark gray shale and iron staining)	20	2036
Fine grained shaly gray sandstone	10	2046
Gray shale with some ligher gray sandstone	10	2056
Gray sandy shale	17	2073
Yellowish sandstone	7	2080
Bedford Formation (?):		
Gray shale	135	2115
Devonian:		
Antrim Formation (at least in part):		
Black to brown shale and lime shells	317	2442
Traverse Formation:		
Gray limestone	3	2445
No record	15	2460
Buff limestone	3	2463
Gray shale and buff limestone	10	2473
Hard gray shale	10	2483
Calcareous soft gray shale	4	2487
Gray shale	4	2491

Pipe Record:
10-inch drive pipe at 94 feet.
8¼-inch casing at 880 feet.
Plugged well back to 2474 and shot Saginaw sand with 100 qts. Very small showing of gas.

PORT HURON DISTRICT AND THUMB REGION.

Since the early days of the Port Huron Oil Field, the area has always been one of interest and development. Several wells were drilled at various times in the townships to the north of the city of Port Huron. In 1924 two drilling projects were fostered by J. C. Gaines of Port Huron and wells were put down in Fort Gratiot and Grant Townships. Some very good shows were obtained from the Dundee in these wells but they were not operated.

The Michigan Petroleum Company, which was first organized as the Sanilac-St. Clair Prospecting Company, sunk two wells on the O. J. Richardson farm south of Blaine, St. Clair County. John Link of Brown City was manager of the operations and the location for the first well was made by George T. Bench with the aid of an instrument. A producing well was obtained in the first attempt and the second hole is now being drilled.

Early in the summer of 1925 a company was formed by J. W. Pattison at Caro, Michigan, which was called the Tuscola Community Oil Company. Lee R. Stewart, David Taylor, and M. G. Atwood were trustees of the organization and a deep test well was commenced in June. A later organization was effected with J. W. Pattison, president; Wm. Kinde, Jr., vice pres.; and M. G. Atwood, secretary and treasurer, and the name was changed to the Caro Oil Company. The well was completed in September, 1925, with no substantial findings of oil or gas.

Frank Obee of Minden City, Sanilac County, started a well in the summer of 1927 on his own farm. A group of leases had been obtained in the surrounding territory by E. K. Cleveland and associates of Sandusky, Michigan. Mr. Obee built his own rig, used a tractor for power, did his own drilling, and independently financed the project. Through some misunderstanding between Mr. Obee and adjoining leaseholders, the well was never carried below a depth of 700 feet. Operations were shut down in October and the derrick was blown over during the winter.

A number of shallow test holes were put down in the northern part of the "thumb" by the Pure Oil Company. These operations, which were carried on under an agreement with the Sebewaing Prospecting Company, were for the purpose of determining structure from "Key" beds and ascertaining the most favorable place to drill a deep test. No further steps have been undertaken but a deep well is proposed for the summer of 1928.

The "thumb" region has offered a rather attractive center for both leasing and prospecting because of its location between the Saginaw and Port Huron districts. The Saginaw structure trends southwestward in this general direction and the anticline which crosses the St. Clair River at Port Huron extends northward so as to point toward the adjoining counties of the "thumb." It is only logical that important folding which has controlled oil accumulation exists in the area between these two known structures. In addition, the Berea formation which gives the chief production at Saginaw, is known to exist as a definite, well defined sandstone horizon. This is an important point to consider, because the Berea is entirely lacking in the western part of the State. Adequate testing and scientific determination of geological structure will probably prove this area to be significant in the future oil production of Michigan.

SANILAC COUNTY

The well put down by Frank Obee on his own farm was located in the SE¼ of the SE¼ of Section 17, T. 14 N, R. 14 E., Minden township. The measurements of the location were 75 feet west of the road and 50 feet south of the line fence, and the rig stood near a large gravel pit. At the total depth of about 700 feet the well was still drilling in the Coldwater formation. Fresh water was found at 119 feet and salt water at 370 feet, and a show of gas was reported at 200 feet. Drilling may be continued in the summer of 1928.

ST. CLAIR COUNTY

J. C. Gaines and others drilled their No. 1 well in 1924 on the H. Kiel farm near Zion in Grant township. The location was in the NW¼ of the SW¼ of Section 26, T. 8 N., R. 16 E. The top of the Traverse formation was found at 435 feet and the Dundee limestone was found at 820 feet. Oil showings occurred in the Dundee at 844 feet, oil and gas at 912 feet, oil at 947 feet, and salt water at 977 feet. The well was completed at a total depth of 989 feet.

The number 2 well drilled by J. C. Gaines and others was on the Leigh Hill farm near Gardendale. This location was in the southeast corner of the SE¼ of the SW¼ of Section 18, T. 7 N., R. 17 E., Fort Gratiot township. The Traverse occurred at 235 feet and the Dundee was encountered at 610 feet. Shows of oil and gas were present all through the top part of the Dundee limestone and a considerable amount of free oil was found between 625 and 635 feet. The well was abandoned at a total depth of 744 feet.

The Sanilac-St. Clair Prospecting Company first drilled in the NW¼ of Section 27, T. 8 N., R. 16 E., Grant township, on the south 120 acres of the O. J. Richardson farm. The well was about 400 feet east of the road and 100 feet south of the lane back of Mr. Richardson's barn. The Traverse formation occurred at 495 feet, the Dundee at 875 feet, and the Detroit River at 1025 feet. The "black water" was found at 1020 feet and deeper flows were encountered at 1190 and 1265 feet. An oil pay was tapped at 1250 feet and 15 feet of formation was productive. The total depth of the hole was 1265 feet and since the bottom packer did not shut off the water completely, the well has continually pumped some water along with the oil. The second well on the Richardson farm which was drilled deeper found the top of the Salina at 2140 feet and the white Guelph dolomite occurred at 3735 feet. This thickness of Salina formation included 1575 feet of strata, the greatest yet known in Michigan. A show of gas was encountered at 3765 feet and the gas kept increasing to 3780 feet. A further increase in the amount of gas occurred from 3795 to 3800 feet. Drilling was continued to a depth of 3960 feet, where it was decided to ream the hole down from 1730 feet so as to make a deep test to the Trenton limestone. According to last reports, the reaming operations were almost completed, and with the resumption of actual drilling this should be the deepest well in the State of Michigan.

TUSCOLA COUNTY

The Caro Oil Company drilled a deep well, which was just two miles north of the Caro City Hall. The location was on the David Taylor farm in the SE¼ of the NE¼ of Section 27, and the hole reached a total

depth of 3454 feet. The Marshall formation occurred at 572 feet, the Berea at 1936 feet, the Traverse at 2409 feet, and the Dundee at 3028 feet. Although the top of the Detroit River Series was not so well defined, it was determined to be at about 3342 feet. The well was completed in this formation and since no important shows were found, abandonment followed.

SANILAC COUNTY.

Location.	Sec.	T.-R.	Township.	Farm.	Company.	Elev.	Drift.	Marshall.	Berea.	Trav.	Dun.	Mon.	Syl.	Salt.	Guelp.	Trenton
S.E./S.E.	17	14N-14E	Minden.....	F. Obee.....	Frank Obee.....	805	60	.....	.....	.....	.....	.....	.....	.....	.....	.....

TUSCOLA COUNTY.

Location.	Sec.	T.-R.	Township.	Farm.	Company.	Elev.	Drift.	Marshall.	Berea.	Trav.	Dun.	Mon.	Syl.	Salt.	Guelp.	Trenton.
S.W./N.E.	27	13N-9E	Almer.....	David Taylor.....	Tuscola Oil Co.....	780	206	572	1936	2409	3028	3342	.....	.....	.....	.....

ST. CLAIR COUNTY.

Location.	Sec.	T.-R.	Township.	Farm.	Company.	Elev.	Drift.	Marshall.	Berea.	Trav.	Dun.	Mon.	Syl.	Salt.	Guelp.	Trenton.
S.E./S.W.	18	7N-17E	Ft. Gratiot..	Leigh Hill.....	Gaines.....	657	123	.....	.....	235	605	.....	.....	.....	.....	.....
N.W./S.W.	26	8N-16E	Grant.....	H. Kiel.....	Gaines.....	759	269	.....	.....	435	820	.....	.....	.....	.....	.....
S.W./N.W.	27	8N-16E	Grant.....	O. U. No. 1 Richardson	Sanilac St. Clair Pros. Co.....	729	206	.....	.....	495	875	1025	.....	.....	.....	.....
600' E. of No. 1 S.W./N.W.	27	8N-16E	Grant.....	Richardson No. 2.....	Mich. Petroleum Co...	729	.....	.....	.....	.....	.....	.....	.....	2140	3735	.....

SOUTHEASTERN DISTRICT.

... the southeastern part of the state along the outer

were commenced in February, 1927, and continued through the greater part of the summer and fall of that year. The location, which was about a half mile northwest of Anchor Bay, measured 1000 feet from