PRE-PLEISTOCENE TOPOGRAPHY, LITHOLOGY AND GLACIAL DRIFT THICKNESS OF LIVINGSTON AND SHIAWASSEE COUNTIES, MICHIGAN

Thesis for the Degree of M. S.
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Roderick Kent Moore

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PRE-PLEISTOCENE TOPOGRAPHY, LITHOLOGY AND GLACIAL DRIFT THICKNESS OF LIVINGSTON AND SHIAWASSEE COUNTIES, MICHIGAN

By

RODERICK KENT MOORE

AN ABSTRACT

Submitted to the College of Science and Arts of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Geology

1959

Approved _____

ABSTRACT

On the basis of nearly 1100 water wells, oil and gas wells and coal borings that penetrated the bedrock below the glacial drift in Shiawassee and Livingston Counties, Michigan, maps have been drawn depicting the bedrock configuration, the bedrock lithology and the variation in glacial drift thickness.

The glacial drift thickness in Livingston County decreases steadily to the west from 300 feet along the eastern border of the county to an average of 100 feet along the western border. In Shiawassee County it averages about 100 feet in thickness except east of Corunna where it thins to the extent that bedrock is exposed. It appears that the thickness of the drift was influenced by the bedrock topography, filling most lows and thinning over highs resulting in the relatively level topography of today.

Two main pre-glacial river valleys have been outlined. One of them is located in the extreme southern part of Livingston County and flowed to the east, partially in accordance with the divide caused by the Howell Anticline which diagonals the county from southeast to northwest. The other main stream headed in the northwest corner of Livingston County, flowed initially to the west, then curved in a 180 degree path around the surface expression of the nose of the

northwest plunging Howell Anticline in the south-central portion of Shiawassee County. It then passes through the village of Durand and curves to the north to what was apparently the Saginaw Lowland drainage system. Both pre-glacial valleys tend to avoid areas of surface sandstone and follow areas of shale.

It is possible that the Bayport Formation is present on both sides of the Howell Anticline and that the Parma Sandstone may be present immediately beneath the drift in Shiawassee County.

About 80 percent of the report area is underlain by shale, 19 percent by sandstone and the remainder by limestone and sandy shale.

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The writer wishes to acknowledge the financial support for this study made available through the National Science Foundation program for Summer Fellowships for Graduate Teaching Assistants.

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INTRODUCTION

NATURE OF REPORT

The configuration of the bedrock immediately below the glacial drift in Michigan has long been a source of curiosity. A general picture of the bedrock topography was gained through contouring the bedrock using the information gained from rather widely spaced oil wells. To get as much information as possible the author additionally contacted all water well drillers in the two counties and from them sought specific locations of wells drilled that penetrated the bedrock; thickness of the glacial drift at these particular locations; and, when recorded or remembered by the driller, the lithic character of the initial bedrock formation encountered. Utilization of this information has given a more complete insight as to the topography of the bedrock, the till thickness, and general lithology of the rock underlying the drift.

SOURCES OF INFORMATION

The sources of data for this paper were: (1) oil well logs obtained from the Michigan Geological Survey; (2) water well logs from the published reports and water well files of the Michigan Geological Survey, Ground Waters Division; (3) public water well files

of the United States Geological Survey, and; (4) unpublished records collected by a field canvass of water well drillers.

BASES FOR CONSTRUCTION OF MAPS

The county bedrock topography maps, drift thickness maps and bedrock lithology maps are constructed on county base maps to the uniform scale of one inch equals one mile. The land surface altitude of each well, when not given in a description of the borings, was determined by interpolation from the United States Geological Survey topographic maps which cover the entire area of the work and are contoured in 5, 10 or 20 feet intervals.

Although some error was undoubtedly introduced by interpolation of land surface elevation, and again when the specific locations of over 90% of the wells is based entirely upon the memory of the respective driller, it is believed the sum of these errors is not appreciable enough to alter the general bedrock drainage interpretation.

Information gained from well logs and by personal communication with water well drillers was plotted to a degree of accuracy as high as possible under the conditions of map scale and verbal description. Over 1000 wells were used. Each of the wells has been plotted and the bedrock elevation indicated. Thus, the basis of the writer's

interpretation can be shown and, as other wells are drilled, used to increase the accuracy of any similar endeavor.

A contour interval of 25 feet was chosen to depict the bedrock topography. A lesser interval is not feasible because of the rapidly changing elevations in localized areas and a greater interval subtracts from the accuracy of interpretation. In the isopach map of the glacial drift a contour interval of 20 feet was considered the optimum.

Solid lines are used to indicate contours in regions of abundant control. Broken lines indicate areas of little control. Broken lines with question marks show areas of very little control. It must be rembered that the well locations were drilled for the express purpose of finding oil, water or coal and therefore are not located geographically for best results in this study. Undoubtedly, as additional information is obtained, corrections will be required. It may be said that the contours define the rock surface and drainage channels in a general way and can serve as a guide for further and more intensive exploration which is necessary to fully outline the pre-glacial erosion surface.

The maps depicting the lithic character of the formations immediately below the drift are based on only a portion of the total wells. In many cases neither the water well drillers nor their logs recall the rock type encountered.

SCOPE OF WORK

There have been investigations of bedrock topography in several other regions of Michigan, but Shiawassee and Livingston Counties have not been studied in their entirety, nor in detail. This study is a portion of a larger current program in the Geology Department covering Hillsdale, Branch, Calhoun, Jackson, Ingham and Eaton Counties. These studies will cover an area of investigation from the Ohio border to the northern boundary of Shiawassee County. This, in turn, borders an area to the north where the bedrock topography was contoured in the process of thesis work by E. C. Rhodehamel (1951), a former student of Michigan State University. It is hoped that this work will eventually be a portion of a rigorous examination of the entire bedrock surface of Michigan, a full understanding of which is lacking.

Outside of scientific curiosity, enlightment in the following categories was hoped for prior to the compilation of data: (1) an aid or guide in any future geophysical exploration such as seismic work in determining the bedrock level below the drift; (2) to map the locus of water-bearing gravel beds;--which proved impossible due to the lack of information on well logs; (3) to provide data for a map that water well drillers could use for better information on depths to bedrock, thereby being an economic aid when casing

lengths, drilling time and other aspects are considered; (4) to gain a better understanding of the boundaries of the different rock types found below the drift; (5) to determine the configuration of pre-glacial drainage channels, and; (6) to determine any correlation between structure and pre-glacial drainage, or structure and type of rock.

LOCATION, PHYSIOGRAPHY AND DRAINAGE OF REPORT AREA

The report is restricted to the counties of Shiawassee and Livingston, which are located in the central south-eastern part of the lower peninsula of Michigan, northwest of Detroit.

The physiography of Shiawassee County exhibits a generally undulating, morainic surface in the southern half of the county and, till and lake plains in the northern portion of the county. Its soils have been developed from moraines, outwash and lacustrine deposits of fine sand and clay. The surface relief varies from 960 feet in sec. 35, T5N, R1E to 640 feet in sec. 6, T8N, R3E along the Shiawassee River.

The physiography of Livingston County includes esker systems, as reported by Leverett (1915, pp. 212-214), located along the western border of the county. Leverett also describes an esker trending north from the city of Howell towards the village of Oak Grove.

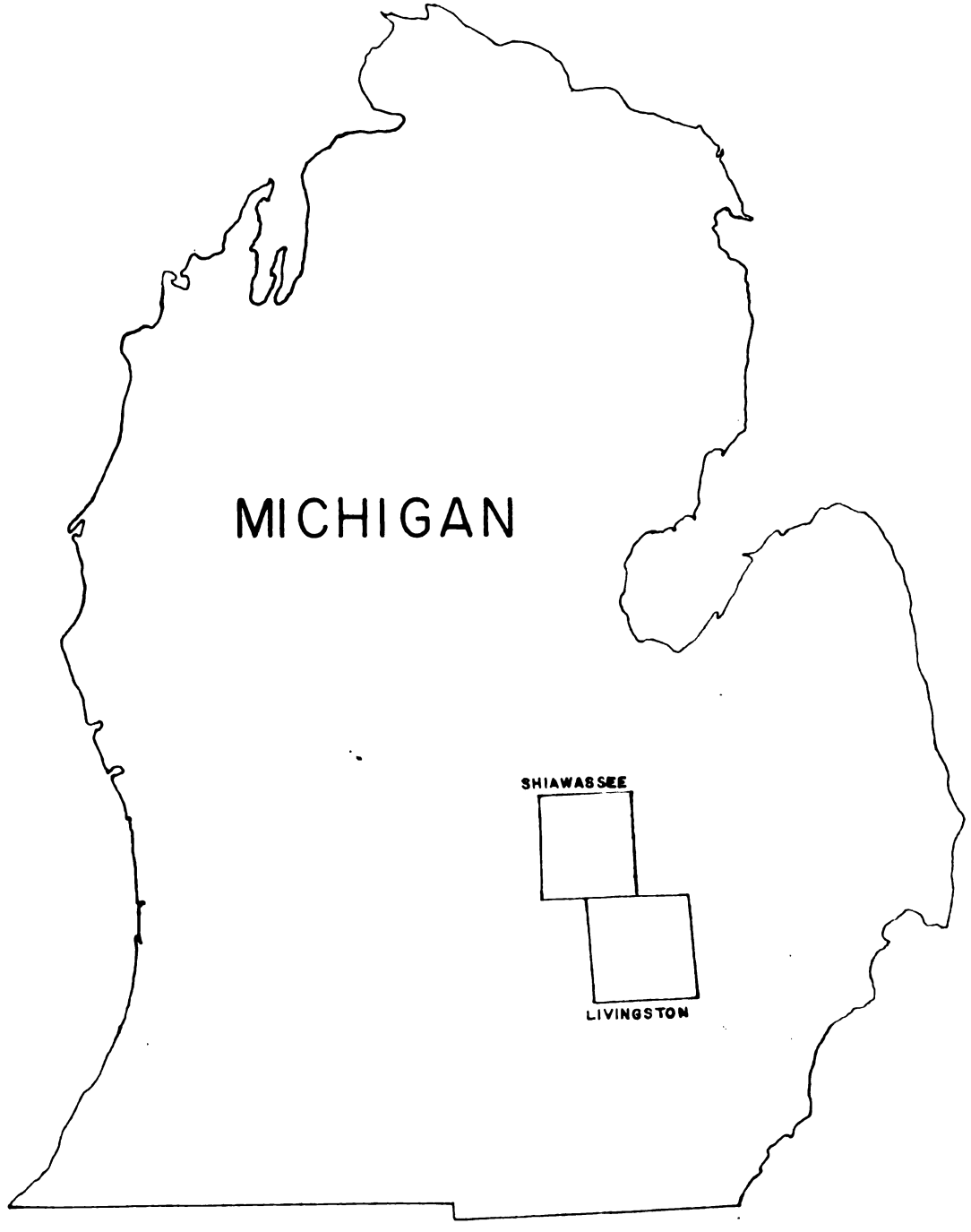

Figure 1. Index map of Michigan showing location of report area.

Numerous kames are present, such as the prominent one southwest of Howell that serves as the site for the Howell Sanitorium. Kettle and knob topography is displayed in the southern-most portion of the county and lacustrine topography and resulting deposits are described by Newcombe (1935, p. 1185, fig. 2), in the central southwest part of the county. These varied glacial and lacustrine features are interspersed through a general morainic topography with relief varying from 1220 feet in sec. 13, T2N, R6E to 830 feet in sec. 6, T4N, R5E.

Drainage in Livingston County is northward to the Shiawassee River, southward to the Huron River and westward to the Grand River. In Shiawassee County the drainage is northward to the Shiawassee and Misteguay Rivers and westward to the Looking-glass and Maple Rivers.

PREVIOUS WORK

The earliest important papers pertaining to the bedrock topography of the state were written by Spencer (1891-1894). He described a large pre-glacial river channel that extended from the western side of the state, easterly through the middle part of the state to Saginaw Bay. Spencer named this river the Huronian River and believed that it was a tributary to the Laurentian River which was entrenched in the basin of Lake Huron.

Later, Mudge (1897) wrote of two additional tributaries to the Huronian River. One of them, the Gypsum River, flowed southward and drained the north-central part of the Southern Peninsula, while the other, the Hastings River, flowed northward from Kent and Barry Counties.

The first comprehensive bedrock contour map of the Southern Peninsula was drawn by Lane (1899). This prototype has been but little changed in recent years, with bedrock contour maps by Newcombe (1933), Grand and Pringle (1943), largely conforming to the map drawn by Lane.

There have been many papers written on bedrock topography in the central portion of lower Michigan, but very little concerning the counties of this report. Newcombe (1933, p. 208) compiled water well and oil well data, and drew a map of the bedrock configuration in the central part of Livingston County. He showed that the bedrock topography has a general "high" extending from the southeast to the northwest in the vicinity of Howell and he postulated that this was the bedrock surface reflection of the Howell Anticline. He believed that the Howell Anticline had exercised much control upon the pre-glacial drainage of the area.

The post-glacial drainage of Shiawassee County has been given some attention by Bretz (1953, p. 376), who described a large glacial river channel found south of Owosso and Corunna, extending

across the county. Treatment of other pre-glacial drainage or topography is lacking, however.

STRATIGRAPHY

The sedimentary rocks of the Southern Peninsula of Michigan are downwarped into a large synclinal trough which is termed the Michigan Basin. The Basin is formed of nearly concentric belts of strata that, as a general rule, are successively older in age as you progress outward from the center of the basin which is near the geographical center of the Southern Peninsula. Shiawassee and Livingston Counties are to the southeast of the center of the basin. According to Martin (1957) and earlier work by Ehlers, Landes, Cohee and Martin (1936), the glacial drift in these counties is underlain by strata of Mississippian and Pennsylvanian age. The younger rocks are found mainly in Shiawassee County. A brief review of the generalized stratigraphic section of those rocks located immediately below the drift in the report area is as follows:

Pennsylvanian System

Saginaw Group

Saginaw Formation.--this formation consists of sandstones, shales, coal measures and lime stones that are of a cyclical nature.

Parma Sandstone.--quartzose, white, water bearing sandstone, phases of which are conglomeratic. The lowest formation of the Pennsylvanian System.

Mississippian System

Meramec-Osage Group

Bayport Formation.--white, light gray, dark gray and bluish limestone, dolomitic limestone and dolomite with local lenses of sandstone. Very irregular in distribution.

Kinderhook Group

Napoleon Sandstone or Upper Marshall Formation.--white to gray, non-fossiliferous, pyritiferous sandstone. An important water-bearing formation.

Lower Marshall Formation.--white to gray or red micaceous, fossiliferous sandstone that grades downward into sandy red and blue shale.

Coldwater Shale.--gray, red and green shale with lenses of limestone and dolomite.

Berea Sandstone.--fine grained, micaceous, gray, yellow or brown sandstone depending upon the prevalence of pyrite and degree of weathering.

Much of the general stratigraphy above is based on the works of Newcombe (1932), Kelly (1936), Martin et al (1936), and Tarbell (1941). Outcrops of Saginaw sandstones and shales are found in Shiawassee County (Plate 2).

PLEISTOCENE

Excepting the six outcrop areas in Shiawassee County, the glacial drift immediately overlies the aforementioned formations everywhere in the report area. The glacial drift was deposited

during the Wisconsin glacial advance of the Pleistocene epoch. It is believed by some (Leverett, 1915, p. 72; Martin et. al. 1936) and others, that there is a pre-Wisconsin drift, possibly Illinoian, that preceded it. Leverett (1915, p. 289) describes the older till as being darker in color, more stony and generally very well cemented. He states that it is the "hardpan" encountered and logged by most water well drillers. This "hardpan" has been mentioned to the author by water well drillers on numerous occasions.

According to Leverett (1915, pp. 196-197) the southern portion of Livingston County is an interlobate area between the southwestwardly moving Saginaw ice lobe and the Huron-Erie ice lobe. Much of the area north of this interlobate tract is covered principally by a till plain of the Saginaw ice lobe. Also present are outwash plains and inland lake sediments as described by Newcombe (1935, p. 1184).

The Pleistocene in Shiawassee County is also a result of the Saginaw ice lobe, which at one time occupied the wide valley of Saginaw Bay. Martin (1958) describes the glacial activity responsible for the deposition of the morainic system in the southern half of the county. In the northern half the sediments are largely till plain overlain in some locales by the lacustrine deposits of Glacial Lake Saginaw. Leverett (1915, p. 254) reports esker systems southwest of the city of Owosso.

The Cary substage of the Wisconsin glacier marked the retreat of the ice of the Saginaw lobe (Bretz, 1953, p. 359). Antevs (1934, pp. 304-311) states that this substage culminated about 27,500 years ago, while Hough (1958), through work with Carbon 14 dating, believes it was much more recent.

The thickness of the glacial drift varies from 330 feet in the NE 1/4, sec. 24, T3N, R6E of Livingston County to complete absence in several locations of T7N, R3E of Shiawassee County. It generally consists of sand, gravel and boulder clay.

GENERAL STRUCTURE OF THE AREA

The structure in the report area is a segment of the overall structure of the Michigan Basin. Feneman (1938, pp. 451-452) states that the rocks of the Michigan Basin dip very gently from three positive areas: (1) the Canadian Shield, especially that part of it in Wisconsin and Northern Michigan; (2) the Cincinnati Arch, and; (3) the Kankakee Arch. From these localities younger beds crop out and dip at small angles toward three synclinal basins, one of which is the Michigan Basin. The Michigan Basin is elongate in a northwest-southeast direction and contours on the top of different formations in the basin show some faults and/or folds trending in the same direction. In some cases they are believed related to pronounced stresses occuring during the downwarping of the basin and also related to the movement in adjoining areas, or other secondary causes (Newcombe, 1933, pp. 102-113). Pressure causing the downwarping seems to have been applied from the northeast as most of the folds have their steep sides to the southwest.

The presence of additional structural conditions in Livingston County has been known for some time. R. A. Smith (1912, p. 164) referred to the possibility of a "very pronounced arching of the strata in the vicinity of Fowlerville." Newcombe (1928,

p. 215) termed the structure the Howell-Owosso Anticline and illustrated it with a generalized sub-surface map drawn on the top of the Berea formation. This paper was followed by another (Newcombe, 1933) which gave a much more detailed account of the structure. Kilbourne (1947) wrote an unpublished thesis on the origin of the Howell structure. Following is a brief review of the works of these authors.

The structure extends from the southeast corner of Livingston County diagonally across the county to the northwest corner and possibly into Shiawassee County where it may be related to the arching of the strata near Owosso. The strike of the rocks is north 26 degrees east, with the regional dip to the northwest in conformation with the structure of the Michigan Basin. The Howell Anticline also plunges in the same direction. Structure contour maps, based on oil well data, have suggested about 150 feet of closure near the southeast corner of the city of Howell; also that the structure is an asymmetrical plunging anticline with the southwest flank dipping 300 to 560 feet per mile and the northeast side dipping 100 to 120 feet per mile. The southwest side of the structure is apparently faulted. It is believed that the faulting started in the basement rocks and that the present "high" is an anticline resulting from the normal faulting.

BEDROCK TOPOGRAPHY

One of the primary purposes of this paper was to gain an interpretation of the bedrock surface of Shiawassee and Livingston Counties, with the main goal of outlining pre-glacial drainage channels and noting the bedrock surface expression of the Howell Anticline. Well over 1000 wells that penetrated the bedrock were used in constructing the maps. While this seems a formidable figure, many additional borings would bring about a much more accurate interpretation of the bedrock topography. However, with the information gathered, some interesting aspects of the pre-Pleistocene erosion surface have been mapped.

HOWELL ANTICLINE

No obvious bedrock surface espression of the Howell Anticline may be observed. The sub-surface crest of the structure has never been positively located, but the general trend of the structure follows a sinuous course from the southeast to the northwest in Livingston County, about two miles south of the city of Howell. Its trend at the northwest corner of the county is somewhat in doubt, though according to Newcombe (1933, p. 208, fig. 38) it may bend northward and pass near Owosso. Newcombe (1933, p. 208, fig. 37)

collected water well data and along with existing oil and gas well information, constructed a map of the bedrock surface in central Livingston County. He stated that there was a definite reflection in the bedrock surface of the Howell structure.

This writer, using additional information and control, believes that any expression of the "high" that traverses the county is negligible. A generally high, linear element can be postulated as extending from the SE 1/4 sec. 7, T2N, R5E, thence into sec. 31 of T3N, R3E. However, it can be seen on Plate 1 that southwest of the above points the bedrock surface steadily increases in elevation, with local fluctuations, while northeast of the locations the bedrock elevation decreases. It seems plausible that locations given above are no higher in elevation than would be expected under the circumstances of the prevailing bedrock topography that has been revealed. It does seem quite probably, however, that at one time there was a significant topographic "high" that might have been present and had a dominant controlling effect upon the pre-glacial drainage of the area, as none of the trunk streams outlined cross the general lows of the structure.

Some suggestion of surficial expression of the Howell structure can be postulated in Shiawassee County. In T5N, R3E and T5N, R2E contouring by the author has outlined an enclosed high that could be interpreted as the nose of the northwest plunging anticline.

It appears that throughout the rest of the area studied, pre-Pleistocene erosion has removed all other surface reflection of the structure that might have existed.

PRE-GLACIAL DRAINAGE CHANNELS

Two rather prominent pre-glacial channels have been outlined. One of them rises in the southwest corner of Livingston County and is shown as the projected low through the lower tier of townships (Plate 1). It is quite evident in the village of Pinckney and throughout the rest of this paper it will be referred to as the Pinckney Channel. The other conspicuous valley begins in T4N, R3E of Livingston County (Plate 1), and is temporarily lost as it leaves the county. It is believed that this channel continues across Northeast Ingham County and is contiguous with the channel outlined in sec. 36, T5N, R1E of Shiawassee County (Plate 2).

This channel then proceeds to the northeast and passes through the village of Durand. The course of the channel is in question north of Durand, but there is some suggestion that it continues northward along the eastern edge of the county. It may possibly leave Shiawassee County. Hereafter, in this report, this pre-glacial river valley will be referred to as the Durand Channel.

Two other less defined channels are to be seen in Shiawassee County. One of them begins in the highlands northwest of

the village of Vernon, continues through Corunna and becomes quite pronounced east of Owosso. It then follows a generally northward direction towards the Saginaw Lowland drainage area but its position is indefinite near the northern border of the county because of lack of control. This channel, hereafter termed the Owosso, can very possibly be correlated with a bedrock valley mapped by Rhodehamel (1951, Plate 1) in Saginaw County. The particular channel mapped by Rhodehamel exists in sec. 36, T9N, R3E of Saginaw County, just north of Shiawassee County.

The second, rather poorly defined channel, apparently drained the highland west of Owosso. Its path can be followed through the northwest quarter of Shiawassee County. It enters the southwest corner of Saginaw County and apparently connects with the prominent valley mapped there by Rhodehamel. The rock surface map of Shiawassee County was drawn without any foreknowledge of the channels depicted in Saginaw County by Rhodehamel and the results are therefore unbiased as to direction and configuration. The results are not coincidental and supports the general accuracy of the bedrock interpretation in these two areas.

Further examination of the two adjacent thesis areas points out the possibility that the Durand Channel, which is shown leaving the county of Shiawassee in a northeast direction, could be tributary to the valley contoured in T10N, R6E of Saginaw County by Rhodehamel.

Several short tributaries draining the surrounding highland areas join the Durand Channel throughout its course. They are readily seen to be feeders to the trunk stream, their gradients being steeper, the valleys narrower, and joining in the characteristic manner with the obtuse angle of juncture upstream. The trunk stream in Livingston County, the Pinckney Channel, is joined by short tributaries in the western part of the county. There is a large valley to the north that merges with the main channel in Pinckney. This could well be a very important feeder, but lack of control diffuses its route. However, it is a very pronounced low and undoubtedly within it was located the valley bottom of a stream that drained much of the southwest quarter of Livingston County.

OTHER FEATURES

The bedrock topographic surface of the remaining report area is mainly one of gently undulating surface, much like the present topography. There are local variations, however, that should be noted. Beneath the city of Howell there is a rather extensive low area with about 80 feet of apparent closure. North of the city are two more areas of enclosed low topography. Seemingly, there are no exits from these areas to give foundation to the premise that the lows are the result of stream erosion, unless it is through the region to the east where well data is seriously lacking. There could be several

explanations for the occurrence of these lows; glacial erosion, groundwater erosion, wasting away caused by meteoric waters, erosion influenced by structure, and others. Another low area is located about 6 miles southeast of Howell. According to Newcombe (1935, p. 1185) this area was once the site of an ancient inland lake.

The topographic low under the village of Durand possibly was caused by glacial plucking of the bedrock after the valley was formed by stream erosion, as it is not plausible that the river would erode a depression 80 feet lower than the elevation of its bed several miles downstream.

If closer control were available, relatively accurate observations might be made as to the pre-glacial erosion stage of the region studied. However, such general evidence as, the relatively narrow valley floors, the gradient generally exceeding 5 feet per mile, the sparse drainage system, infer that the area was in the youthful stage when overrun by the glacier.

The regional bedrock topography shows a general decrease in elevation in Livingston County from west to east, and in Shiawassee County a decrease from the south in all directions. The highest bedrock elevation is found in sec. 30, T1N, R3E (Plate 1) and the lowest elevation in sec. 4, T8N, R1E (Plate 2).

GLACIAL DRIFT THICKNESS

The glacial drift over Livingston and Shiawassee Counties varies in thickness from 0 to 330 feet. The drift reaches its maximum thickness along the eastern and northeastern borders of Livingston County (Plate 3) and is thinnest in the east-central part of Shiawassee County (Plate 4).

On a regional basis the thickness of the drift has been decidedly influenced by the bedrock topography. It is thickest where bedrock elevations are lowest and thins over bedrock highs. It fills pre-glacial valleys so completely that no surface evidence of the valleys exist. On the present surface there is no indication of the Durand or Pinckney Channels, but the glacial drift thickness contours are obviously closely allied with the bedrock contours outlining the two trunk streams. This is readily discernible by comparing Plates 2 and 4. Also some of ths small tributaries can be recognized through the isopach maps of the drift.

Influence of topography on the drift thickness may be noticed locally, however. Many of the small, isolated "highs" and "lows" that have been contoured on Plates 3 and 4 are the result of the drift topography. An example is found in the center of sec. 24, T2N, R4E of Livingston County. The thickness of over 200 feet is the result of a large kame.

It should be understood by the reader that the map depicting the drift thickness was drawn with the express purpose of illustrating the regional picture. Plates 3 and 4 do not reveal the local effects of the undulating topography and therefore it is suggested by the author that Plates 1 and 2 should be used in conjunction with present topographic maps to obtain a more accurate picture of the thickness of the drift in areas not in juxtaposition to wells used in this report.

BEDROCK LITHOLOGY

Of nearly 1100 wells and borings plotted on Plates 1 to 4, only 600 wells supplied data pertaining to the bedrock lithology (Plates 5 and 6). The lithic character of the bedrock was not recorded, or remembered, on a large portion of the total.

The lithology of the bedrock immediately below the drift consists of the following rock types in order of decreasing areal extent: shale, sandstone, limestone and sandy shale.

The most persistent rock type by far is shale, which is encountered below the drift in about 80 percent of the study area. Sandstone makes up the bulk of the remaining 20 percent, with limestone and sandy shale being of slight areal extent.

Most of the shale in Livingston County (Plate 5) is Coldwater Shale, (Martin, 1957), and nearly all of the shale in Shiawassee County (Plate 6) is Saginaw Shale. The extensive tract of sandstone along the western third of Plate 5 most closely follows the trend of the Marshall sandstone as does the sandstone underlying the city of Corunna (Martin, 1957). The geologic ages of the other sandstone bodies on Plate 6 are unknown, but, again, they may be lenses of sand within the Saginaw Formation. The regions of sandy shales are believed to be facies changes of the encompassing formations.

It was not a purpose of this paper to delineate geologic boundaries of formations within the area studied and the following discussion is not an attempt to do so. However, with nothing more to go on than the lithic character of the bedrock there are some interesting observations that can be made and should be pointed out.

Martin (1957) drew the geologic map of Michigan from the compilation of oil and gas well data, which is profuse in some areas and lacking in others. Livingston County has 78 oil and gas well locations and these were utilized by Martin in arriving at the geologic boundaries in the county. The lithologic map drawn by the author (Plate 5) was arrived at through use of the 78 oil and gas wells, plus over 200 water wells, therefore giving a somewhat more complete insight as to the overall character of the rock surface beneath the drift. The map drawn by Martin outlines a small area of Bayport Formation in the extreme northwest corner of Livingston County. Whether this "Bayport" is limestone or another facies of the Bayport is not known. The author recorded no limestone in this area.

It can be seen on Plate 5, though, thattwo rather extensive areas of limestone were found to the southeast and east, respectively. Taking into consideration the trend of the Howell Anticline and the fact that the southwest flank is steeply dipping and the northeast flank is

gently dipping, it appears structurally feasible that the two elongated bodies of limestone could be Bayport Limestone; their respective positions from the axis of the anticline are in accordance with structure, the lithology is correct, and their bedrock surface outcrop is elongated sub-parallel to the anticline.

Objection to the possible Bayport age of the limestone is that the sandstone both to the northeast of the northern-most limestone body and southwest of the limestone area passing through Fowlerville, has been designated as the Marshall Sandstone, which is older and would not be expected to occur further out on the limbs of the anticline. However, these sandstones might be the Parma Sandstone, which is younger than the Bayport Formation, and would therefore be expected to occur stratigraphically between the Bayport formation and the younger Saginaw Formation that abuts and overlies it as according to Martin (1957). The sandstone and limestone locality southeast of Pinckney may be related in the same manner.

The discussion above is only an observation made by the author and could be totality erroneous. However, this work does bring to light the nature of some stratigraphic problems that exist in the area. It suggests further the advisability of using water well data in addition to oil and gas well data in the construction of sub-surface geologic maps in the Michigan Basin area.

INTER-RELATIONSHIPS OF TOPOGRAPHY, LITHOLOGY AND STRUCTURE

Topography, lithology and structure are enmeshed in a cause and effect relationship which has had a bearing on the results perceived in this study. These topics will be discussed under headings that best express their interrelationships.

STRUCTURE AND TOPOGRAPHY

Although little surface expression of the Howell Anticline remains, its effect upon the pre-glacial drainage can be seen. There are no trunk valleys that transect the northwest-southeast axis of the anticline, nor are any of the outlined tributaries oblivious of it. The eastern extension of the Pickney Channel does seem to be an exception to the above statement (Plate 1), but it is felt by the writer that this can be explained. According to maps by Martin et al (1936, 1957) and Cohee (1944), the Howell structure has been nearly breached in this vicinity, most likely by erosion. This has exposed, or almost exposed, the Berea-Bedford formations. This being the case, it does not seem unreasonable that the Pinckney Channel would adopt the breached portion of the anticline as its river bed.

Another observation concerns the Durand Channel, which apparently had its headwaters in northwestern Livingston County. From here the channel heads westward for a short distance into Ingham County then bends to the north and connects with that part of the valley seen in sec. 36, T4N, R1E (Plate 2). Its course then gently bends until it is trending to the east. In other words, the channel has made an almost 180 degree change in course. Examination of Plates 1 and 2 show that the course of the channel abuts the nose of the highland to its right throughout this change. It is postulated that the channel here follows the contour of the nose of the plunging Howell Anticline. The channel then follows an eastward course to the village of Durand, thus staying south of the bedrock highland in the vicinity of Owosso. To the author this suggests that there is no continuous structural high through Livingston and Shiawassee Counties, rather, it shows the two highs are possibly not connected--at least in the region of the Durand Channel. Possibly the Shiawassee "high" is related to some of the anticlines to the north, or northwest, such as the Mr. Pleasant structure, rather than the Howell structure.

The regional structure also effects the direction of drainage. It can be seen that the Durand and Owosso Channels, and the channel near Carland (Plate 2), all flow generally to the

north. This effect of the Central Lowland drainage system which was directed toward the present day Saginaw Bay (Rhodehamel, figs. 1 and 2). The Pinckney Channel in Livingston County was not effected in the same manner and its direction of drainage to the east is understood by reference to a map of the bedrock surface of the Lower Peninsula of Michigan (Rhodehamel, fig. 5) that shows the central part of western Livingston County as the drainage divide in the study area. The influence of this divide and the low bedrock elevation to the east explain the course of the channel.

TOPOGRAPHY AND LITHOLOGY

The lithology of the bedrock surface may have given direction to the drainage channels. Whether the following discussion is based on coincidence, rather than genetic relationship is uncertain, but an observation of some interest can be made.

When comparing Plates 5 and 6 against Plates 1 and 2, it is obvious that almost the entire course of each channel is found in shale and seemingly is influenced by sandstone bodies.

The Pinckney Channel has its headwater tributaries located within the sandstone in the southwest corner of Livingston County. It then is traced through a shale region to the village of Pinckney. Incidentally, in this area the writer has mapped a

continuous sandstone body (Plate 5) that extends from the southern county line through Pinckney, then up to Rush Lake, a distance of about 6 miles. This lithic area was drawn on the basis of seven wells that penetrated sandstone, two of them near Pinckney and five of them located near Rush Lake, about 3 miles distant. Therefore, with the lack of closely spaced control points, there could be an unmapped shale area bisecting the sandstone.

As the Pinckney Channel approaches this area it bends sharply to the south, and though it does cross the sandstone body (as mapped), it seems to have at least been diverted. It then follows very closely the course of the present day Huron River throughout the rest of its path, constantly in an area of shale.

Durand Channel also appears to have its headwaters in an area of sandstone (Plate 1). Its course then follows the semi-circle previously described. It maintains its route in the shale that lies between the two large sandstone areas in Shiawassee County to such an extent that the argument of coincidence seems lacking. The channel then crosses a strip of sandstone west of Durand and continues its path to the north in an area of shale. The Owosso Channel follows the same pattern. It heads in a sandstone high, then traverses the Saginaw Shale to the north.

When comparing the erosive susceptibility of sandstone and shale, it seems quite likely that a stream bed would favor the

more easily eroded shale. This, possibly, gives cause to the above observations.

STRUCTURE AND LITHOLOGY

Some consideration of the interrelationship of structure and lithology has previously been given (p. 24). Another case in which structure and lithology are interrelated would be that of the sandstone underlying the city of Howell (Plate 5). This sandstone, the Berea (Martin, 1957) is older than the surrounding Coldwater formation and it is located very near the supposed axis of the Howell Anticline. On the bedrock topographic map (Plate 1), a very noticeable enclosed low has been contoured in the same location. In fact the outlines of both are similar. It seems feasible that the Berea was exposed through excessive erosion of the Coldwater Shale, thus revealing the underlying formation. The origin of this extensive low may be explained by its proximity to an area of deformation. The city of Howell is essentially located very near the subsurface crest of the anticline that passes diagonally through the county. This city drilled its water wells about 2 1/2 miles from the center of town. This was necessary due to the fact that the water in deep wells within the city limits was much too salty to be patable. This suggests that possible jointing and fracturing is profuse in the underlying rocks of this locality, as salt water is prone to collect in

areas where the joints and fractures can act as channelways for the connate water within the surrounding rocks. Also, it was reported to the writer that a water well drilled on the north side of the city struck a crevice in the bedrock that necessitated drilling in a new location. Therefore, it seems that there is substantial evidence pointing toward quite severe fracturing in the Howell area. If this is the case, erosion could have been accelerated, giving rise to wasting away of the Coldwater formation and exposing of the Berea.

CONCLUSIONS

The maps, if properly used, could be an invaluable aid to the water well drillers of the two counties, as well as an aid to those undertaking geophysical surveys. They have given a better understanding of the pre-glacial drainage of the area and knowledge of the lithic character of the pre-Pleistocene bedrock surface.

It is believed that enough evidence has been presented to strongly suggest that structure and pre-glacial drainage of the counties are intimately related. The Howell Anticline in Livingston County and its counterpart (?) in Shiawassee County being the agents of direction and control upon the drainage.

Lithology and drainage also appear relative to one another, with sandstone "highs" serving as headwater areas of the pre-Pleistocene rivers, and bodies of shale serving as the host for the main route of the river valleys.

The Howell structure might have had effect on some of the minor topographic features, such as the bedrock low underlying the city of Howell.

It is hoped that his study will act as a stimulus for further exploration of the bedrock surface of Michigan and that some of the problematical areas encountered, and as yet unsolved, will be the centers of additional research.

SUGGESTIONS FOR FURTHER STUDY

It is believed additional study of the area would be very rewarding. Several observations have been made by the author that should be refuted or supported by additional work: (1) Are the two limestone areas mapped on Plate 5 Bayport Limestone?; (2) Has there been an excessive amount of fracturing in the strata below Howell--enough to cause the pit-like erosion of the Coldwater Shale and consequent exposing of the Berea Formation?; (3) Does the lithologic character of the bedrock have any profound subsequent influence on the location and direction of the pre-glacial river valleys, at least enough so that the old river would tend to seek shale and avoid sandstone?; (4) Are the Howell Anticline and the Owosso "High" unrelated as suggested by the course of the Durand Channel?; (5) Is the sandstone body, in southeast Shiawassee County, Parma Sandstone rather than Marshall?; (6) What is the pattern of pre-glacial drainage in the adjoining counties (excluding Saginaw)? These counties should be investigated and mapped so that an overall picture of the pre-Pleistocene surface could be projected.

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APPENDIX

WATER WELL DRILLERS

Name	Area of Operation
LIVINGSTON COUNTY	
Brown, W Howell	Northern half of Livingston County
Goff, Charles WhitmoreLake	Extreme SE corner of the county
Grieve, Guy Howell	Howell and vicinity
Meabon, Marshall Pinckney	Lower tier of townshipsin county
Miller, Glen Howell	Entire county
Sorrel, R. L. Pinckney	Local
SHIAWASSEE COUNTY	
Archer, Charles Chapin	NE quarterof Shiawassee County
Ballou, Roy Owosso	Entire county
Coles, Victor Laingsburg	Local
DeDen, George Byron	SE quarter of Shiawassee County

Cornel, Sam, Jr. Morrice	Local
Lovejoy, R. Swartz Creek	Durand and vicinity
Newman, A. Byron	Local
Spears, J. E. New Lothrop	Local

[redacted]

Pocket No.: 6 Plates

[redacted]