SOME FEATURES OF THE UPPER SURFACE OF THE TRENTON LIMESTONE IN INDIANA.

WILLIAM N. LOGAN, Indiana University.

Prominent features of the upper surface of the Trenton limestone in Indiana as revealed by well logs and by the study of drillings was presented by the writer in a publication[1] issued in 1920. In the map prepared and published in that report the position of the upper surface of the Trenton was indicated by contour lines which were separated by intervals of 100 feet. The necessary information for the preparation of such a map was obtained from a study of well records, some of which had been published in the reports of the Indiana Geological Survey. Additional information was obtained from records collected by the writer and from a study of the drillings from deep wells. The map as then constructed disclosed certain outstanding structural features of the surface of the Trenton in Indiana.

Since the publication of that map a large number of deep wells have been drilled in Indiana in portions where deep wells had not been drilled before and by the study of the records of these wells and of many more samples of drillings our knowledge of the position of the upper surface of the Trenton has increased. However, the major features as outlined on the map of 1920 still remain the major features and only minor changes are made in their configurations.

The three most notable features are the geanticline, the northeastern geosyncline, and the southwestern geosyncline. The geanticline is an arch of the surface which extends from the southeastern portion of the state toward the northwestern part. It is commonly called the northwestern arm of the Cincinnati geanticline. The main arch extends northward in the region of Cincinnati. The geanticline in Indiana is marked by three prominent features as outlined by contours drawn on the surface of the Trenton.

The Trenton arch is at its greatest height in the southeastern portion of Indiana where in parts of ten counties it is at 100 or more feet above sea level. This high area extends from Ohio County to the northern portion of Henry County. From the latter point the surface of Trenton descends from an elevation of 100 feet above sea level to an elevation of 200 feet below sea level about the central portion of Miami County. The northern portion of Cass County has an elevation of 300 feet below sea on the surface of the Trenton. Northwest of the latter point the surface of the Trenton rises until in the central part of Lake County it attains an elevation somewhat greater than 200 feet below sea level. The sag in the arch has a width of about 20 miles between the minus-300-foot, or greater, contour lines.

[1] "Petroleum and Natural Gas in Indiana," W. N. Logan, 1920, Ind. Dept. Cons. Pub. No. 8.

"Proc. Ind. Acad. Sci., vol. 38, 1928 (1929)."

15—44023

Fig. 1—CONTOUR MAP OF THE UPPER SURFACE OF THE TRENTON LIMESTONE IN INDIANA. Contour interval 100 feet. Contours representing elevations from 100 feet above sea level to 4,500 feet below sea level. Contours outlining the Northwestern Arm of the Cincinnati Geanticline, the sag in the arch, the arch beyond the sag, the northeastern geosyncline, and the southwestern geosyncline.

The arch which rises above the sag in the northwestern portion of Indiana is connected with the elevated area in the northern part of Illinois. From this elevated region the LaSalle anticline extends southward.

The Northeastern Geosyncline. Northeastward from the Cincinnati geanticline in Indiana the surface of the Trenton limestone descends toward the center of the basin in southern Michigan. The pre-Pleistocene rocks deposited on the surface of the Trenton in this area range in age from Ordovician to Pennsylvanian. The southwestern limit of the basin is the geanticline above mentioned. Across the top of the geanticline it is probable that a large part if not all of the formations once extended. It is not probable that these formations were ever as thick as the corresponding ones in the basins.

The dip of the surface of the Trenton away from the axis of the arch is gentle at first, not exceeding ten feet to the mile, but the dip increases as the center of the basin is approached until it reaches 30 or more feet per mile.

The thickness of the formations above the Trenton on the geanticline near its highest point in southeastern Indiana is only 400 feet at

Brookville in Franklin County. At Anderson in Madison County the thickness of the formations above the Trenton is 814 feet. At Kokomo the formations above the Trenton have a thickness of 912 feet.

In the sag of the arch in Cass County at Logansport the surface at the Trenton lies beneath 995 feet of sediments. In the elevated region northwest of the sag at Crown Point in Lake County 723 feet of bed rock sediments overlie the Trenton which lies at an elevation of 183 feet below sea level.

From an elevation of 66 feet above sea level at Anderson in Madison County the surface of the Trenton descends to more than 1,300 feet below sea level at Howe in the northern part of Lagrange County. At the same rate of dip the surface of the Trenton would reach an elevation of approximately 1,500 feet below sea in the northeastern corner of Steuben County. Since no wells have been drilled in that part of the state the record is incomplete for that portion of Indiana.

There is little doubt that minor structural features are present on the surface of the Trenton in the Northeastern Geosyncline. Indications of these are revealed by the 100-foot contour lines but deep-well spacing is not close enough to outline these definitely from present available records, except in a few small areas.

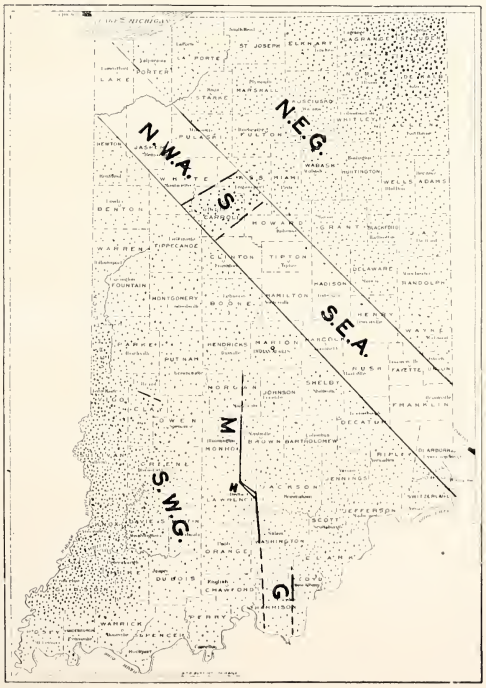

Fig. 2—A STRUCTURAL MAP OF INDIANA. Showing the position of the Northeastern Geosyncline, dotted area, N. E. G., the Southeastern Geanticline, S. E. A., the Sag, S., the Northwestern Geanticline, N. W. A., the Southwestern Geanticline, S. W. G., the Mt. Carmel Fault, M., the Heltonville Fault, H., the Greenville Fault, G.

The Southwestern Geosyncline. Southwest of the Cincinnati Geanticline the largest structural feature is the Southwestern Geosyncline. The surface of the Trenton in this basin descends in a southwestwardly direction from an elevation of 66 feet above sea level on the arch at Anderson in Madison County to 109 feet below sea level at Indianapolis in Marion County. From the latter elevation it descends to 780 feet below at Martinsville, and to 1,332 feet below sea in the southwestern part of Monroe County.

In a southward direction from Crown Point in Lake County the surface of the Trenton descends from an elevation of 183 feet below sea level to 379 feet at Kentland. At Fowler in Benton it has descended to 400 feet below sea, at Rockville in Parke County to 1,412 feet, and at Otter Creek Junction in Vigo County to about 2,000 feet below sea level. Near Robinson in Crawford County, Illinois, the surface of the Trenton lies at an elevation of approximately 3,750 feet below sea level.

By using the same thickness for the formations lying between the top of the Mississippian and the Trenton in the Robinson well for the wells in the lowest portion of the basin in the western part of Gibson County, Indiana, it is assumed that the Trenton lies approximately 4,500 feet below sea in this portion of Indiana, as is indicated by the contour lines on the accompanying map. There is a gradual thickening of formations toward the center of the basin. By taking into account this increase in thickness it is reasonable to assume that since something more than three thousand feet of sediments lie above any evidence of crystalline rocks on the arch that approximately 8,000 feet of sediments lie within the geosyncline in southwestern Indiana. This remarkable thickness of sediments extending in a vertical distance of approximately one mile and one-half forms a notable example of the gradual deepening and filling of synclinal areas.

Minor Features of the Southwestern Geosyncline. One of the most notable features of the Southwestern Geosyncline is the Mt. Carmel Fault which has been traced by the writer from the southern part of Morgan County to the southern part of Washington County. From the latter point the fault apparently passes into a monocline which extends to the Ohio River. In Lawrence County in the region of Heltonville there is a split off from the Mt. Carmel fault which the writer has named the Heltonville Fault. This fault lies at a maximum distance of one mile to the west of the Mt. Carmel.

Rift line. The rift line of the fault is covered in most places by residual materials. There are a large number of places where the limestones of the Harrodsburg, Salem or Mitchell have been brought in contact with the shales or silt stones of the Borden. In such places the Borden is usually covered with residuals but the limestones may stand out as prominent topographic units. On a small branch of Twin Creek north of Mt. Carmel church in Washington County the contact of the Borden with the Harrodsburg and with the overlying Salem is clearly marked. South of this point a line of sinks show the position of the fault line to the Mt. Carmel church. South of the church the Borden lies at the horizon of the Salem. To the east of Clifty Caves about one-

half mile a line of sinks reveal the position of the fault line. Since the Mitchell limestone occupies the surface on both sides of the rift through the southern part of Washington County and the limestone is largely concealed by residual materials indications of its position are not abundant.

Though investigations are not complete for the southern portion of the county indications of the eastward dip of the limestones in some of the quarries are suggestive of the continuance of the fault though for the western part of Harrison County because of steep westward dips monoclinal conditions are suggested.

Tracing of the fault northward from the southern portion of Morgan County is difficult because of the covering of glacial drift over the bedrock formations. West of Mooresville the records of some of the wells suggest fault conditions but not enough information has been secured to warrant extending it to that point.

Nature of Faulting. There is little evidence that faulting has occurred west of the Mt. Carmel fault. If a displacement of the strata is present it is of minor importance. The nature of the faulting seems to have been the downward dropping of a hinged block toward the east. This block varies in width from one and one-half to two miles. From the hinge the strata dip eastward toward the fault line. Since the normal dip of the formations is westward from the hinge-line anticlinal conditions are produced along the hinge. A stretching of the crustal strata by an upward movement east of the fault line or by an upward thrust along the hinge might account for the faulting.

Periods of Movement. Topographic and physiographic evidences of intermittency of movement along the fault line are not found. If they ever existed in the form of hanging valleys on the upthrow side and of broad valleys on the downthrow side these evidences have been removed by the long erosion which has followed the last uplift. There are no striking evidences of rejuvenated streams such as must have been present in the strata along the fault line had not the strata in which these stream valleys were cut been removed by erosion.

In the rocks along the rift line there is evidence of more than one period of movement though there is little evidence that the second movement was of more than minor importance. The time interval between the two movements must have been of considerable duration since the fragments of the brecciated zone were firmly cemented before the second movement took place. Fragments of shale which were included in the limestone fragments during the first period of movement were faulted during a subsequent movement which was sufficiently long after the first for the rock fragments to become firmly cemented. It is evident that these inclusions would not have undergone faulting had they not been firmly held by the cementing materials.

Amount of Throw. The amount of displacement of the faulted block varies at different points along the rift line. Estimates based on levels taken at the contact of the Harrodsburg with the Borden at the fault line and at the hinge line range from 159 feet to more than 200 feet. Estimates made on the rate of eastward dip of the limestone in some localities produce larger results.

Age of the Fault. The youngest beds in contact at the fault line are Mississippian in age. If Pennsylvanian rocks were present they have been removed along the fault line by erosion. It is probable that the faulting occurred during the Appalachian Revolution near the close of the Paleozoic Era. Contemporaneous with that great epeirogenic movement which brought to a close the depositional era in the eastern part of the United States faulting and minor folding took place in the southwestern geosyncline. In the western part of the basin Pennsylvanian rocks are involved in the faulting. These faults appear to be of minor importance in comparison with the Mt. Carmel fault and its associates, the Greenville fault, and the Heltonville fault.

The Heltonville Fault. In the region of Heltonville there is a fault which is apparently a split-off from the Mt. Carmel fault uniting with it at both extremities of the former. The rift line of the Heltonville fault is exposed in the bed of North Leatherwood Creek at a point just east of the wagon crossing under the Southern Indiana railroad. At this point the fault line is approximately parallel with the Mt. Carmel fault which crosses the same creek about one mile to the east. At the fault line in the creek bed the Harrodsburg limestone has been faulted against the Borden shales. The limestone has been much fractured and reunited with calcite, slickensides have been developed, and in places fragments of shale have been thrust into the limestone fragments. Interfingering of limestone and shale also occurs along the fracture zones.

North of Leatherwood Creek the direction of the Mt. Carmel fault is toward the northwest and if the Heltonville fault continues with the same direction northward it must pass into or across the Mt. Carmel fault at a point less than a mile north of the Heltonville fault at the creek crossing. Toward the south the Heltonville fault is traceable to within a short distance of where it apparently again unites with the Mt. Carmel fault. On the Heltonville fault the downthrow is toward the west while on the Mt. Carmel fault it is toward the east. The amount of throw on the Heltonville fault is less than that on the Mt. Carmel.

The Greenville Fault. A fault extends from some point north of Greenville in Floyd County southward toward the Ohio River near Evans Landing. The downthrow of the fault is toward the west. In the southern part of Harrison County the structure may have passed into a monocline with a rather steep dip. Investigations are not complete in this region though some facts have been collected which may throw some light on the problem.