

THE SUB-TRENTON FORMATIONS OF INDIANA.

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Our knowledge of the geological formations in Indiana which are older than the uppermost part of the so-called Trenton limestone is derived solely from the study of drillings from deep wells. Deep well drilling in the search for natural gas began in Indiana about the year 1886. Within the succeeding decade a large number of wells had been drilled in many parts of the state. However, none of the earlier wells penetrated below the base of the Ordovician, in fact none of them reached the base of the Ordovician. One of the deepest of the early wells was drilled in the southwest corner of the court house square at Bloomington. This well had a depth of 2,730 feet and was completed in the Shakopee limestone at a point some 400 feet above the base of the Ordovician.

Attempts were made to correlate the formations encountered in the deeper wells but in the light of more recent studies some errors of correlation resulted. For instance the St. Peter sandstone of the Ordovician was correlated with the Potsdam sandstone of the Cambrian.

Interpretations and earlier correlations were based largely upon the records furnished by well drillers, and very little study of drillings was undertaken. Very naturally drillers made errors in interpretation which led to errors of correlation.

In recent years drillings from many deep wells have been obtained and these have been studied in the laboratory to the end that we are now able to correlate with greater confidence.

The deepest well in Indiana was drilled at Greentown in Howard County. This well was drilled by the Chicago Gas Company. It lacks only four feet of being 4,000 feet in depth. Through the courtesy of that company the writer has obtained a remarkably complete set of drillings from this well. The samples taken were for each five feet of depth. A study of these samples and the samples from other deep wells in Indiana has enabled the writer to make the following correlations of the Sub-Trenton formations of the state. The most complete section was obtained from the Greentown well and that section is referred to in the succeeding pages as the type section.

THE ORDOVICIAN PERIOD.

The St. Peter Sandstone.—The formation immediately underlying the Trenton limestone in Indiana is the St. Peter sandstone which belongs to the Canadian division of the Ordovician. The sandstone is composed of small rounded grains of translucent to transparent quartz which are cemented with a calcareous or dolomitic cement. The size of the grains of the St. Peter sandstone at its outcrop at Ottawa, Illinois, varies from .1 mm to 1 mm in diameter, the average being about .5 mm.

The grains from the Indiana wells are much smaller, ranging from .01 mm to .2 mm in diameter. Among the quartz grains are many particles of pyrite. Where these particles have been oxidized the quartz grains are stained yellow though the sandstone is commonly white.

The thickness of the St. Peter in Indiana varies from 15 feet to more than 200 feet. It appears to have a minimum thickness near the apex of the Cincinnati geanticline and to increase in thickness in the basins beyond the arch. There is apparently an increase in fineness of grain from bottom to top.

At East Chicago the St. Peter has a thickness of 75 feet; at Greentown, 120 feet; at Cloverdale, 70 feet; at Bloomington, 224 feet; at Greensburg, 188 feet; and at Middlefork, 210 feet.

The Shakopee Limestone.—The formation which underlies the St. Peter sandstone in Indiana is a white to yellowish-gray, cherty, dolomitic limestone which the writer has assigned to the Shakopee formation of the Canadian division of the Ordovician.

While the formation is largely limestone there are layers of sandstone and thin beds of chert present. Near the middle of the formation there are some layers of sandstone which are fine of grain and resemble the St. Peter in texture and appearance. The thickness of the Shakopee in Indiana varies from 72 to 100 feet, usually, though at East Chicago the formation is credited with a thickness of 314 feet. In the Greentown well the thickness is 80 feet; in the Lacrosse well, 95 feet; in the Cloverdale well, 72 feet; and in the Greensburg well, 100 feet.

The New Richmond Sandstone.—A calcareous sandstone lies beneath the Shakopee limestone. This formation is correlated with the New Richmond which is the basal member of the Canadian division of the Ordovician. The drillings from the formation consist of rounded quartz grains of white, yellow or brown color. They also contain pyrite crystals and white and yellow calcareous particles and a few chert particles.

The thickness of the New Richmond in Indiana varies from 26 to 210 feet. In the Cloverdale well the thickness assigned to it is 210 feet; in the Greentown well, 180 feet; in the Middle Fork well, 45 feet; in the East Chicago well, 26 feet.

The Ononta Dolomite.—A coarse cherty limestone which underlies the New Richmond sandstone has been correlated with the Oneonta dolomite, which may be Cambrian. The drillings of this formation are composed of coarse particles of limestone and chert which are white or yellow in color. Pyrite crystals are present and many of the grains are stained with limonite.

This formation is placed by Ulrich and Walcott in the Ozarkian division of geologic time. In Wisconsin the formation has a thickness varying from 100 to 200 feet. In Indiana the thickness varies from 67 to 105 feet. In the Greentown well the assigned thickness is 100 feet; in the Cloverdale well, 67 feet; in the Lacrosse well, 70 feet; in the Greensburg well, 94 feet; and in the East Chicago well, 105 feet.

The Madison Sandstone.—Drillings from the Greentown well show a fine grained calcareous sandstone lying beneath the Oneonta dolomite. This formation has been assigned to the Madison formation. The thickness of the sandstone is 30 feet which is the thickness it attains in eastern Wisconsin. In the other deep wells of the state the Madison is not differentiated but it is probably included in the Oneonta.

The Mendota Dolomite.—A fine sandy dolomitic limestone lies beneath the Madison sandstone in the Greentown well. This formation has been assigned to the Mendota. Its thickness is 25 feet and in eastern Wisconsin it has a thickness of 20 feet. In the other deep wells of Indiana, the formation has not been differentiated and probably is included with an adjacent formation. The Mendota is included in the Ozarkian.

The Devil's Lake Sandstone.—In the Greentown well the drillings reveal the presence of a white fine-grained sandstone beneath the Mendota dolomite. This formation has been assigned to the Devil's Lake horizon of the Ozarkian. The drillings consist of fine quartz grains, some broken fragments of larger quartz grains, some pyrite concretions, and calcareous matter. The thickness of the sandstone in the Greentown well is 100 feet and it has about the same thickness in eastern Wisconsin. This formation is assumed by the writer to be the basal member of the Ozarkian in northern Indiana.

THE CAMBRIAN PERIOD.

The Jordan Sandstone.—Below the Devil's Lake sandstone is a sandstone composed of larger grains which are stained red or grayish-brown in color. This formation contains much more pyrite than the overlying sandstone. It has been assigned to the Jordan formation of the Cambrian. It has a thickness of 150 feet in the Greentown well. As differentiated in the Cloverdale well it has a thickness of 223 feet; in the Greensburg well 200 feet; and in the Bryant well, 60 feet. In the latter some of the rocks above may belong to the Jordan horizon. The formation in the Bryant well contains fresh water. The Jordan is the source of fresh water supplies in the Chicago region.

The Lodi Shale.—In the Greentown well the Jordan sandstone rests upon a bed of shale which has a thickness of 45 feet. This shale is probably equivalent to the Lodi shale in the Wisconsin section of Ulrich. In his Wisconsin section Ulrich suggests the Thempealeu Epoch to include the Norwalk sandstone, the Lodi shale member, the St. Lawrence limestone and a basal shale (unnamed). The Norwalk sandstone is absent in eastern Wisconsin and appears to be absent in Indiana. At least the writer was not able to differentiate the horizon. The Lodi shale has a thickness of 50 feet in western Wisconsin and a maximum thickness of 25 feet in eastern Wisconsin.

The St. Lawrence Limestone.—Beneath the Lodi shale is a shaly dolomitic limestone which has a thickness of 45 feet in the Greentown well. The St. Lawrence has been used by some writers to include more than the limestone stratum. The basal shale layer which is present in

the Wisconsin section seems to be absent in Indiana. In the Iowa section the St. Lawrence is represented by 50 feet of sandy dolomitic limestone, which corresponds very closely with the thickness in the Greentown well.

The Franconia Sandstone.—A series of glauconitic sandstones containing thin beds of shale and shaly limestone lie below the St. Lawrence limestone in Indiana. Three divisions are recognizable. The uppermost is a shaly, calcareous, greensand which has a thickness in the Greentown well of 120 feet. The middle member consists of limestones and shales containing less glauconite and measuring 140 feet in thickness. The lowest member is composed of greensands, shales and limestones which contain a larger amount of glauconite than the middle member. The lowest member has a thickness of 100 feet,

The Mazomanie dolomitic sandstone which occurs in the eastern Wisconsin section above the Franconia does not appear to be present in Indiana. The basal members which are present in western Wisconsin are not present in Indiana although the total thickness in Indiana is greater than the total thickness given for the formation in Wisconsin. The glauconitic particles are in the form of grains and the casts of microscopic shells of foraminifera.

The Dresbach Sandstone.—The Franconia formations rest upon a gray sandstone containing a calcareous cement, a fine grain, and greensand particles. The thickness of the formation in the Greentown well is 290 feet. The writer has correlated it with the Dresbach which is present in Minnesota and in Wisconsin sections in which it is given a maximum thickness of 250 feet.

The Eau Claire Sandstone.—The Eau Claire formation in Wisconsin consists of 350 feet of shales. In the Greentown well below the Dresbach sandstone there is a series of sandstones, sandy cherts, and shales which have a thickness of 305 feet which the writer has assigned to the Eau Claire horizon. The sandstone is composed of small rounded quartz grains. The chert and shale seem confined to the middle portion of the formations which contain much pyrite and magnetic iron particles.

The Mt. Simon Sandstone.—The Mt. Simon sandstone as it is represented by drillings from the Greentown well consists of a coarse grained, red colored rock composed of rounded quartz grains among which are particles of pyrite and magnetite. This formation in western Wisconsin has a thickness of more than 200 feet while in eastern Wisconsin the thickness exceeds 700 feet. The thickness in Indiana is 500 feet.

THE ALGONKIAN PERIOD.

The Bayfield Sandstone.—The Mt. Simon sandstone is assumed to close the Upper Cambrian or St. Croixan Epoch in Wisconsin. Below the Mt. Simon sandstone in the Greentown well there are about 50 feet of red and white medium grained sandstone which may represent a portion of

the Bayfield stage of the Keweenawan Epoch of the Algonkian period. This sandstone contains many particles of magnetic iron compounds.

The Igneous Intrusion.—Below the 50-foot stratum of sandstone the drill penetrated an intrusion of igneous rock which has a thickness of 20 feet. This intrusion appears to be a dike or sheet of diabase. This igneous rock is composed of feldspar, magnetite, and smaller quantities of other minerals.

The formation immediately below the igneous rock is sandstone of the same appearance and composition as the sandstone immediately above the intrusion. The thickness of the lower sandstone is 31 feet but the well was completed at this depth, namely 3,996 feet.

In the preparation of this discussion the writer acknowledges his indebtedness to the reports of the State Surveys of Wisconsin, Iowa, Illinois and Michigan. Especially to "Notes on New Names in Table of Formations and on Physical Evidence of Breaks between Paleozoic Systems in Wisconsin," by E. O. Ulrich, *Trans. Wis. Acad. Sci. Arts and Letters*, July 1924, and to "Some Deep Borings in Illinois" by J. A. Udden, *Ill. Geol. Sur. Bul.*, No. 24, 1914.

