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The Conditions of Oil and Gas Production in Northern Ohio and Indiana.

A PAPER BY PROFESSOR EDWARD ORTON.

Mr. President and Members of the Ohio Institute of Mining Engineers :

I have not been able to prepare a paper especially adapted to this occasion, but if you will find interest in a brief and general statement of the progress and development of the new oil and gas fields of Northern Ohio, I can occupy your time for a few moments with possibly a measure of profit.

Within the last three years a new horizon of petroleum and the gas that originates from it has been brought to light in Ohio and adjacent territory. An horizon that bids fair to be the most prolific single source of gas and oil that has yet been discovered in the United States. The discovery, as you are aware, comes from an unexpected quarter, viz: from the black swamp of old time of Northwestern Ohio. Under its broad and level expanses a few hundred square miles have been found distributed through portions of five counties within which are contained fountains of oil and reservoirs of gas of infinitely more value than any like accumulations hitherto discovered in the State, and fully deserving a place among the most valued repositories of these substances in any quarter in the world.

The good fortune of Findlay and Lima has had a wonderful effect, not only upon the towns directly surrounding them, but upon all adjacent regions, and even upon entire States. Many hundreds of thousands of dollars have been already spent in drilling wells to the Findlay gas rock throughout Ohio, Indiana, Kentucky and Michigan, and even far beyond the limits of these States. Indiana has developed a gas field in this horizon which is, in reality, a bodily extension of the Ohio field, but which greatly exceeds the latter in area, and perhaps also in intrinsic value. Beyond the districts already indicated in Ohio, and the one now named in Indiana, however, there has been no adequate return for the large amount of money spent in exploration. In fact, the productive areas make but a small and almost an insignificant fraction of the entire territory that has been tested.

How are these invaluable accumulations, so limited, and apparently so capricious in their distribution, to be explained?

The answer to this question can be summarily given in the following statements:

1. In fourteen of the northwestern counties of Ohio (and like

conditions prevail in contiguous territory in Indiana) the upper beds of the Trenton limestone, which lie from 1,000 to 2,000 feet below the surface, have a chemical composition different from that which generally characterizes this great stratum. They are found here as dolomite, or magnesian limestone, instead of being, as usual, true carbonate of lime. Their percentage of lime, in other words, ranges between 50 and 60 per cent., instead of between 80 and 90 per cent., as in the formation at large.

These dolomites of Northwestern Ohio are mainly quite free from silicious impurities. The dolomitic composition seems to have resulted from an alteration of a true limestone—at least the occasional masses of true limestone containing fossils that are found on the horizon of and surrounded by the dolomites, are best explained on this supposition. In the change which has been undergone the fossils which the original limestones contained appear to have been for the most part discharged, as is usual in this metamorphosis. The chrySTALLINE character of the dolomite is often very marked, and there results from it a peculiarly open or porous structure. Its storage capacity is much greater than that of ordinary sandstones and conglomerates, so far, at least, as pores visible to the unaided eye are concerned. This phase usually extends from ten to thirty feet below the surface of the formation. In some cases, however, sheets of porous dolomite are found as low as 50 feet, and very rarely as low as 100 feet below the surface.

The area occupied by this dolomitic phase of the Trenton limestone in Ohio has already been indicated. The southern boundary passes through Hancock, Allen, Auglaise and Mercer counties. There is good reason to believe that this phase extends far to the northward and westward beyond the State limits within which it has here been traced. We know that the Trenton limestone is a dolomite when it pitches rapidly down from the northern boundary of Ohio, to make the low-lying floor of the Michigan coal basin; and we also know that it is a dolomite when it rises from under that coal basin as a surface rock of the northern peninsula. In like manner it is a dolomite when it leaves the western boundary of Ohio under deep cover, and it is a dolomite when it reaches the surface once more in the Galena district of Illinois and Wisconsin.

South of the line laid down in Ohio there has not thus far been found a trace of the porous rock on which the oil of Lima and the gas of Findlay depend. The change takes place in Shelby and Logan counties, but beyond them to the southward the Trenton limestone is invariably found with a percentage of more than 75 per cent. of carbonate of lime, and rarely with less than 10 per cent. of silicious impurities. It is possibly this last element that has resisted the dolomitization of the stratum in this region.

To the eastward of the line laid down in Northern Ohio the boundary is less definite. We know that small areas of porous rock are found beyond the line of present production of gas and

oil, but they appear to be isolated; the great bulk of the rock being of the calcareous type. Within the limits named the limestone has a considerable variety of grain and texture, but all the examinations made of it show it to be in the main a dolomite.

2. A porous rock buried one thousand to two thousand feet below the surface of Northwestern Ohio will not be found empty. "Nature abhors a vacuum." With what will its pores be filled? Mainly with salt water. Ninety-nine hundredths, perhaps ninety-nine thousandths of the limestone will be thus occupied, the remaining hundredth or thousandth will be filled with the petroleum and gas which have in the long course of the ages that have passed been gathered from a wide and general distribution through the water into certain favored portions of the great limestone sheet.

3. This salt water will be held under Artesian pressure. The porous limestone containing it rises to-day in Michigan and Illinois, communicating there with surface waters. The pressure of this head of water will be felt through every portion of the porous rock, and when the stratum is pierced by the drill in areas that are thus occupied, the salt water will rise with more or less promptness, depending upon the varying degrees of porosity in the rock. The height to which the water will rise will seem to vary in wells by reason of the different elevations of the locations at which they are drilled, but with reference to sea level, the water columns will be found to closely agree.

The same artesian pressure accounts for the force with which oil and gas escape when their limited reservoirs in the porous rock are tapped by the drill.

4. The accumulation of oil and gas in the porous rock depends altogether upon the attraction of gravitation. The lighter portions of the contents of the porous rock, viz: oil and gas, are forced by gravitation into the highest levels that are open to them. Everything turns on the relief of the Trenton limestone. The gas and oil are gathered in the arches of the limestone, if such there are. In default of arches high lying terraces are made to serve the same purpose; but the one indispensable element and condition of all accumulation is relief. A uniform and monotonous descent of the strata is fatal to accumulation of oil and gas. The sharper the boundary of relief, the more favorable does it become. Absolute elevation is not essential; all that is required is a change of level in the porous rock.

Each division of the field has its own dead line, or salt water line. Salt water reigns universally in the Findlay field 500 feet below sea level, except where some minor local wrinkle may give a small and short lived accumulation of oil and gas. In the Lima field, the salt water line has arisen to 400 feet below tide. In the St. Mary's field, to 300 feet below tide; and in the Indiana field, to 100 feet below tide. These figures stand in every case for the

lower limit of production, with the possible minor exceptions already noted. The rock pressure of the gas decreases to the westward in proportion to this decreasing head of water pressure.

5. The large accumulations are derived from the large terraces. The Findlay terrace, for example, consists of a very flat lying tract, ten or twelve miles across in an east or west line, from which the connected areas of the Trenton limestone slope on every side, to which, therefore, they are necessarily tributary. The gas terrace of Indiana is by far the largest of these several subdivisions of the field. The minor elevations of Oak Harbor, Tiffin and Bryan give rise to the local supplies of gas or oil in these districts respectively.

Some scanty production can be obtained outside the dolomitic limits already laid down, but it must be remembered that there is more or less magnesia in the limestone around the productive portions of the field, and it is quite possible that this production is proportioned to the amount of dolomite in the rock.

These, gentlemen, constitute the briefest statements that I can give you as to the conditions of production of the oil and gas from the Trenton limestone in the new fields.

Mr. Hazeltine: I draw from your remarks, Professor, that the Trenton limestone, if it is of porous formation, will retain gas; but if it is below the level of the salt water there will be no gas or oil that will be of any value; but if the structure is above the horizon of salt water, you may expect to find oil or gas?

Prof. Orton: Yes, sir; and the level will be dependent upon the particular location. The salt water horizon of one field is not necessarily the horizon of all.