THE WABASH ARCH.

Careful study of the rock out-crops and of the sections obtained from gas wells in northern Indiana have fully confirmed the report made by Professor Gorby in which evidence of a notable disturbance of the Niagara strata was traced across Indiana far into Illinois.

The name *Wabash Arch* has been objected to by the State Geologist of Ohio, Professor Orton; but we shall keep it, notwithstanding. If men who claim to be devoting their lives to science would trouble themselves less about the jargon of nomenclature and more about gathering facts we should see much better progress in the direction of practical scientific success. We have given the name *Wabash Arch* to the upheaval in Indiana, and *Wabash Arch* it shall be. If Professor Orton take away the name, he must take away the upheaval along with it!

Beginning at Kentland, in Newton County, and passing eastward across Indiana, we shall find at each out-crop of the Niagara rock unmistakable evidence of a disturbance of the strata. It was by the aid of such an exploration that I was led to foresay that few, if any, gas wells would be successful along the immediate line of the Wabash River from Lafayette eastward. I ventured this prediction long before any boring for gas had been done along the river. Of course I knew that there was risk, and, for that matter, there still is risk. Gas may yet be found in vast quantities just where I have said it would not be found; still I adhere to my forecast, because there is every reason upon which to base it. Gas is very likely to escape through rock whose strata are broken and the break un covered to the open air. This condition I found at intervals all along the Wabash, and Professor Gorby verified what I had discovered, as shown in his excellent sketch published in the 15th report of this Department. In one matter I was mistaken. I took it for granted that, because the Wabash River appeared to be running, as it actually is running, in an irregular rift in the Niagara rock, it was, therefore, following pretty nearly the summit of the anticline. The facts have since shown that the disturbance is very broad and of a billowy, broken, irregular form, straggling widely across the State in a direction from southeast to northwest in a general way.

That this upheaval took place at the close of the Niagara period, the evidence is conclusive. There is nothing to dispute it, in fact.

Let us review the testimony gathered from all sources. It has been assumed by certain geologists that the arch here discussed is confined to the Trenton formation, or, rather, that it occurred at the close of the Trenton period. Other geologists have insisted upon referring it to the Cincinnati or Hudson River uplift, making it a part of the great arch, so-called, extending from the lakes to Nashville, Tenn. But so far as the Indiana area is concerned, neither of these theories is tenable, if we admit that the Cincinnati arch is confined to the lower silurian formation. In the first place that the Niagara strata are disturbed can not be questioned successfully since they are not found unbroken in any outcrop north of Indianapolis; and, moreover, the gas drillings show that the disturbance is co-extensive with the entire area in Indiana over which the Niagara is the uppermost stratified rock. Were it not for the disturbance evident in the Niagara outcrops, we might assume that the drill showed merely accidental inequalities in the formation, but when these inequalities are considered in connection with the visible cones, arches and faults observable from Kentland to the head-waters of the Wabash, we can not turn away from the inevitable conclusion.

In connection with my assistant, Mr. W. H. Thompson, I have examined all the exposures of stratified rock along the line of the Wabash River, and over the area north of that river, and west of Logansport, with a view to reporting the facts discoverable bearing upon the subject under consideration. Prof. Gorby has carefully re-examined the area east of Logansport to the State line. All the results are included in this paper.

In McKee's quarry, near Kentland, the Niagara strata stand at angles varying between 60° and 88° with the horizon. Indeed, some of them appear to be quite vertical. There is not the slightest evidence of false-bedding here. The rock is gray-blue limestone of coarse grain, and deposited in parallel layers, with thin clayey or marl-like partings. These layers and partings show that the strata are upturned in the form of a cone which has been truncated by the action of the glaciers. The quarrymen take out the stone by a sidewise operation, following the succession of layers by prying them off one after another. It is not first-rate building stone, but has been found good for foundations, cellar walls and the like.

Taken by itself, this abrupt cone of Niagara limestone thrust up in the midst of a prairie, offers a problem of no easy solution; but taken in connection with the condition of the limestone strata along Monon Creek, and with the very similar and far larger cone at Delphi, the truth begins to appear in the form of an extensive and most interesting upheaval of the Niagara rock.

At McKee's quarry the fossils are neither plentiful nor well preserved, but that all those found *imbedded in* the rock are Niagara fossils is beyond

question, whilst those appearing in the clay partings between the strata are, as far as they have been identified, are mostly of the Hudson River formation. Prof. Gorby has suggested, and I am inclined to think correctly, that these lower silurian fossils have been thrown up by the action of gas or water. Evidently they are not in place, because the compact limestone on either side is Upper Silurian.

It has come to be a hobby with geologists that no admission must be made in favor of cataclysms or violent and sudden operations of nature; and yet, within the memory of men now living there has been a breaking and sinking of the crust of the earth in the Mississippi Valley by which the whole face of a large area of country was strangely modified and changed. The earthquake of 1811 was as sudden, almost, as a lightning stroke, or, rather, a series of lightning strokes, and its mighty work was done with all the energy and appalling force of a furious giant. The effects are still visible, and will be probably for all time. Still, if I should say that the upheaval, or rather the disturbance of the Niagara rocks in Indiana, is the result of another just such cataclysmal generation of force as that which wrought the earthquake effects of 1811, there are geologists who would shake their heads and say: "But, my dear sir, there were no sudden upheavals. All the disturbances of the olden time were of slow progression, the effect of centuries and centuries of imperceptible movement. It is impossible, sir, that a chain of mountains should have been thrust up by the impulse of a sudden and irresistible accumulation of pressure, or by a sudden giving way of the earth's crust under a pressure it was no longer able to bear. Don't talk about cataclysms, we have abolished them." Nevertheless, I will talk about ancient earthquakes whose effects were far greater than those of 1811.

That these cones of upheaval in Indiana have been cast up by the sudden crushing of the earth's crust is by no means impossible or improbable. An examination of the texture and fiber of the limestones of these cones will show that at the time of the disturbance they were in some places still in a condition sufficiently plastic to bend and to receive various impressions, and to take on great changes of shape without crushing, while at other places they were broken into small angular fragments, or parted by irregular but persistent cracks and fissures from top to bottom, so far as we can observe.

At McKee's quarry the cone-in-cone structure produced by points of pressure from below, are everywhere to be seen. The force causing these beautiful rosettes in the fiber of the stone has acted in a line exactly perpendicular to the original plane of deposit, showing that the strata were once horizontal, and have since assumed their distorted forms. The fossils, excepting those found in the clay partings, are more or less flattened, indented, twisted and elongated by pressure, showing plainly that they have been subjected to unusual conditions since their deposition.

The strata of the formation at McKee's quarry are not loosely tumbled up, but are set against one another in a compact series, welded together, so to say, by the cement of the clay partings (almost as thin as paper in many places), which usually adheres to the surfaces of the stones when quarried.

The whole rock mass has the appearance of having been subjected to a squeezing process at the same time that it was being thrust upward by an expansive force from below. The arrangement of the structural elements of the rock shows the combined effects of these two agencies: compression from the side and perpendicular thrust from below. All around this area of upheaval the drift is quite deep, more than 100 feet at some points not three miles away, and yet the apex of the cone of rock outcrop on McKee's farm is probably the highest point in Newton county. In every direction the rock surface falls rapidly, and the Devonian shales and limestone are found deposited hard by in an undisturbed condition non-conformably to the Niagara strata. Only a few miles away the subcarboniferous rocks appear horizontally deposited.

Passing eastward to Monon, in White County, and taking a careful survey of the Niagara limestones outcropping along the streams, Mr. W. H. Thompson and myself collected the following facts in addition to those reported by Professor Gorby.

The drift is very thin, and often entirely absent in the little valley of the Monon. During high water the stream lays bare the surface of the underlying limestone, disclosing a most interesting subject for study. The rock is broken into very small angular fragments throughout its substance, as far down as any quarry has been sunk, but the fragments are all in place, separated from one another by fissures running at every possible angle with one another. The surface of the rock-mass is beautifully planed and striæted.

At one place we measured *striæ* that were perfectly straight and parallel for more than thirty feet. Their course was about eight degrees west of south without any correction for magnetic variation. Every thing shows that the cracking and crushing of the Niagara limestone antedates the ice period, for the *striæ* in crossing the fissures show that the force which did the scratching at the same time dragged forward small particles and filled up the cavities or cracks. In some places where the rents or fissures are from six inches to eighteen inches wide; they are filled with drift clay, in which have been found nuggets of copper and other specimens of Lake superior formations. I could not find any evidence whatever of any fissure having been filled with recently assorted matter, which would be the case at some exposed points if the disturbance itself were of recent date.

North of the Monon Creek the Niagara rocks dip northward at the rate of from twenty to thirty degrees, which would appear to indicate a cone

in this region not unlike that at Kentland in general form, but much flatter on account of its slighter inclines.

Near Monticello, in the bank of the Tippecanoe River, there is a massive exposure of the bituminous shales of the Devonian formation, which shows no evidence of disturbance. But in the first gas well at Monticello the Devonian (Corniferous) limestone was the uppermost stratified rock, and it lay under a mass of drift 205 feet thick, as reported by the parties boring it. Now, the surface altitude of Monticello above sea-level is 672 feet; take from this the depth of drift, 205 feet, and we have 467 feet as the altitude of the top of the *Corniferous limestone*, while at Francisville, a few miles distant, the altitude of the top of the *Niagara limestone* is 680 feet. The thickness of the Corniferous limestone at Monticello is about 48 feet. Subtract this from 467=419, the altitude of the surface of the Niagara limestone. This gives a difference of 216 feet in the level of the Niagara limestone between Francisville and Monticello. The black Devonian slate or shale is from 60 to 80 feet thick at the river bank near the Norway mills. Near the point where the Monon flows into the Tippecanoe is an outcrop of Corniferous limestone showing no evidence of disturbance. Thus the Monon Creek flows down from its source on the heights of a Niagara upheaval and joins the Tippecanoe in a Devonian valley. This of itself would be very strong and very competent evidence of an upheaval of the Niagara formation.

Passing eastward into Carroll County, we find the city of Delphi occupying the truncated apex of a cone very similar to the one near Kentland, but far more extensive. Here the strata of the Niagara limestone "stand on edge" at angles indicating an arch of from 45 to 50 degrees, measured by a chord of about two miles. In the bluffs of a deep ravine near the northeastern limit of the city a section of a part of this arch is exposed, affording a fine study of its formation. Hard by in the bluffs of Deer Creek are massive exposures of the Devonian shales deposited horizontally without any evidence of disturbance.

Taking the angle of ascent at opposing points in the Niagara arch at Delphi, and calculating the apex therefrom, I found that the highest point of the cone would have an altitude of about 860 feet above sea level, which would place it nearly exactly on a level with the surface of the Niagara limestone in the Fairmount gas well No. 1, and, indeed, on a fair average with many of the higher points of the gas-area northeast of Indianapolis. The following table will show the altitude in feet above sea-level of the upper surface of the Niagara limestone at some of the highest points in the gas field of Indiana:

New Castle	812	
Fairmount	870	and 858
Jonesboro	678	
Summitville	796	
Marion	752	and 741
Farmland	982	
Winchester	960	
Rushville	884	
Shelbyville	698	
Francisville	680	
Peru	621	
Kokomo	778	
Broad Ripple	672	
Dunkirk	909	
Noblesville	685	
Greenfield	726	
Anderson	776	
Frankfort	563	
Hartford City	813	
Montpelier	836	

This table, when compared with another given below, will show that the Niagara rock, when reported upon by the drill, discloses quite as uneven a surface as does the famous Trenton about whose "*anticlines*" and "*synclines*" so much has been written of late.

TABLE SHOWING ALTITUDE OF TRENTON LIMESTONE.

New Castle	120	feet	above sea level.
Fairmount	41	"	below "
Jonesboro	72	"	" "
Summitville	82	"	" "
Marion	67	"	" "
Farmland	55	"	above "
Winchester	53	"	" "
Rushville	124	"	" "
Shelbyville	79	"	below "
Francisville	200	"	" "
Peru	218	"	" "
Kokomo	97	"	" "
Broad Ripple	109	"	" "
Dunkirk	14	"	" "
Noblesville	85	"	" "
Greenfield	54	"	" "
Anderson	66	"	above "
Frankfort	487	"	below "
Hartford City	40	"	" "
Montpelier	110	"	" "

Taking the foregoing tables, a comparison of figures will show the general westward dip of the strata, in both the Trenton and the Niagara rocks. Of course it should be remembered that the Niagara having been exposed to the great glacial forces, must have been worn away greatly in places, but it must also be considered that as a rule the highest points would be most eroded. Viewed with these conditions in mind and remembering the visible surface proofs of an Upper Silurian disturbance, these tables will be found coinciding with the evidence yet to come.

From Delphi, passing along up the Wabash River, we shall find no evidence of any disturbance until we again see the Niagara rock outcropping, which is near Logansport. There the strata are tilted and distorted with the Devonian limestone, non-conformably deposited over it. At Kokomo and Peru we find the Niagara limestones broken and upturned, showing a continuance of the disturbance, and going on to Wabash, Lagro, Huntington, Marion, and Decatur, we find at every outcrop the unmistakable signs that we are still skirting along the northern verge of the Wabash arch.

The following tables will afford some curious facts:

Table of notable extremes in the altitude of the surface of the Niagara limestone, as shown by the drill:

Francisville	647	feet	above	sea	level.
Oxford	3	"	"	"	"
Frankfort	563	"	"	"	"
Noblesville	685	"	"	"	"
Kokomo	778	"	"	"	"
Rushville	884	"	"	"	"
Crawfordsville	81	"	"	"	"
Well No. 1, at Peru	621	"	"	"	"
Well No. 2, at Peru	690	"	"	"	"
Shelbyville	698	"	"	"	"
Valparaiso	443	"	"	"	"
South Bend	245	"	"	"	"
Elkhart	125	"	"	"	"

By the above it will be seen that from Oxford to Francisville, a distance of about thirty-nine miles, there is a rise of 644 feet in the surface of the Niagara limestone. From Crawfordsville to Frankfort, 28 miles, the rise is 482 feet. From South Bend to Elkhart the fall is but 120 feet in about 20 miles, while at Peru there is a difference of 69 feet between two wells. Shelbyville and Rushville are about 20 miles apart, and the Niagara limestone is 186 feet lower at the former place than at the latter. Although the general dip of the strata, when undisturbed, is westward, the Niagara at Kokomo, as shown in the first table, is 26 feet higher than at Marion, which is 30 miles farther east. Taking a section across the State from Decatur to Crawfordsville, we shall have the following:

	Niagara above sea level.
Decatur	768 feet.
Bluffton	786 "
Marion	752 "
Kokomo	778 "
Frankfort	563 "
Crawfordsville	81 "

Or, if we prefer as near an east and west section as possible, take—

Decatur	768
Huntington	738
Peru	621
Monticello	427

Which shows simply a regular dip westward. The truth, in a nut-shell, is that the drill is not to be relied upon for locating slight disturbances of hidden strata. Everything that the drill has shown with regard to the Trenton rock in Indiana may be explained perfectly by either affirming or denying the existence of obscure folds or anticlines in that deep-buried formation, and the same is true of the Niagara rock. In the case of the latter, however, we have auxilliary evidence of the most indubitable kind with which to corroborate the testimony of the drill. Of course, if the Niagara limestone is folded ever so slightly, it follows that the Trenton is folded also, and the only question left to discuss, is whether the disturbance, if there is one, originated at the close of the Niagara period. If the Niagara formation is disturbed and the immediately superior formations are undisturbed, then my point is made, and I am right in saying that the system of low anticlines in Indiana (which is the chief geological feature of our gas field) was formed as late as the close of the Niagara rock making. Furthermore, if this upheaval is a part of the "Cincinnati anticline," the whole great range of disturbance extending from the lakes to Tennessee, and heretofore referred to the close of the Hudson River period, must now be set down as occuring long after the lower Silurian formations were finished, and as late as the period in which the water-lime deposits were being laid down.

Professor Orton, State Geologist of Ohio, whose attainments are of the highest, has noted, without explaining, the fact that gas is rarely found in the Trenton rock under areas where the Niagara limestone is not the surface or uppermost stratified rock. It appears to me that this of itself is very suggestive of a disturbance which has brough the Niagara to the surface. Indeed, in Indiana the highest points above sea-level are areas wherein the Niagara limestone is the uppermost stratified rock, and some of the lowest points are those capped by the Carboniferous deposits. These facts testify of upheaval on a wide scale.

In my opinion, Professor Cox was on the right track when he suggested that the "Cincinnati anticline" is but part of a great continental disturbance. I think this will be the final verdict of science, but the upheaval will be referred to the close of the Niagara period, and not to the age of the Hudson River rocks.

One fact which should be recorded as of value in connection with the peculiar condition of the Niagara limestone along the line of the Wabash River is the difficulty experienced in boring through it. The drill encounters the strata at an angle often as great as 60°, rarely less than 40°, and the tendency to follow the trend of the hard layers is such that the bore is made very irregular. This trouble was encountered in a marked degree at Logansport and Delphi. It is to this tilted and conical condition of the Niagara strata that we owe the wonderful apparent thickness of the limestone at many points, for in boring through a stratum tilted up at an angle of from 45° to 80°, its thickness is apparently much greater than when drilling through it at right angles. Had the conical upheaval near Kentland never been truncated by glacial action, a drilling near its apex would have shown the Niagara limestone to be (apparently) eight or nine hundred feet thick, owing to the acuteness of the bore's angle with the face of the strata.

Although, as I have said, we must not depend too much upon the story that the drill tells, we may, I think, assume that we are now in possession of facts sufficient to warrant the statement following: If the drift were stripped clean off the Niagara rock of the Indiana gas field, we should see a surface composed of hillocks and hollows, long low swells and sharply abrupt, or, perhaps, truncated cones, a surface, indeed, not unlike a sea whose gale-tossed billows had been turned suddenly into limestone. Upon close inspection we should find that most of the higher points, like those exposed at Kentland and Delphi, have been ground down a great deal by the glacial forces. It may be that the theory is true which assumes that the Devonian and Carboniferous deposits once lay over our entire gas area; but I find the evidence all disputing it directly and emphatically. The coal basin of Michigan and the Carboniferous area of Indiana lie on opposite sides of the great Niagara disturbance the axis of which in Indiana has been named the Wabash Arch. For example, taking a starting point in Gibson County, Indiana, and making a sheer section through the strata to the Michigan coal field, we should find the Niagara limestone far below sea level at our starting point, whence it would gradually rise northward to Frankfort or Kokomo. Then, from some point a little south of the Wabash River would begin a descent northward, which soon would carry the strata below sea level again, showing that, in a general way, there is a low broad swell of the Niagara formation crossing Indiana from southeast, or east to west, or northwest, forming a dividing ridge between the coal fields of Michigan and those of

Indiana. A line drawn from Crawfordsville, in Montgomery County, Indiana, to Elkhart, Elkhart County, Indiana, near the Michigan line, would show, in accordance with the gas bores nearest the line, a ridge of Niagara limestone about 400 to 500 feet higher between the extremes than at them. For instance, at Frankfort the Niagara is 563 feet above sea level, while at Crawfordsville it is but 81 feet above, and at Elkhart but 125 above. Take Martinsville, Kokomo and Elkhart, all in Indiana, and we shall find the Niagara rock surface at Kokomo 770 feet higher than at Martinsville, and 653 feet higher than at Elkhart. In fact, any section from south to north across the Wabash Arch will show a like anticlinal arrangement of the Niagara formation, but not a corresponding or equivalent arching of the superior formations. In other words, the Niagara breaks up through the Devonian and carboniferous rocks, in a general way, and wherever the latter exist on the disturbed area they are laid down non-conformably.

Doubtless the glacial forces removed a large part of the Devonian deposits, for the bituminous shales and even the Corniferous limestone formations appear in scrappy, island-like remnants here and there between areas of Niagara limestone, which, wherever exposed, shows the unmistakable grinding of the glaciers over its surface.

From my point of view, with all the facts at present before me, it appears probable that the upheaval, of which the Wabash arch is a part, is connected with a continental disturbance which occurred at the close of the Niagara period or thereabout, and before the rocks of that formation had hardened into stone. That subsidence followed this upheaval, after the rocks had hardened, and the force of this sinking crushed the stones and arched the Niagara formation into local bubbles or cones as we today find it, at the same time creating the fissures in which the Wabash River is now flowing. Of course all the strata below the Niagara are affected by the disturbance, hence the condition of the gas-bearing Trenton limestone which, as shown by the drill, is lifted up in conical and bubble-like folds or knobs all over our gas-area, and these bubbles need only to be pricked by the drill to emit their long-imprisoned treasures of inflammable matter.

As yet no lasting, high-pressure supply of gas has been found under an area where the Niagara limestone is badly broken. This appears to me strong proof of the fact that where these breaks occur they extend down to the Trenton, and hence have permitted the gas to escape. The Wabash River marks a series of breaks in the Niagara limestone from Huntington, or eastward of there, to Delphi, and no gas of value has been found along that line or north of it, because the strata north of the river *ascends toward* the fissures. South of the river gas has been found in abundance, because the strata *ascends from* the fissures up to the roof of the Wabash arch. Leaving the fissures at Delphi, the Wabash river

cuts through the low rock barrier and flows southward to the Ohio. Northwestward from Delphi (near Francisville) where the Niagara rocks again assume the form of a wide flat bubble, gas is found in considerable quantity, showing that wherever the Trenton is lifted and the Niagara left arched but *unbroken*, gas may be looked for with confidence. I am not prepared to venture an explanation of the correlation between rock-arches and gas accumulations further than to suggest the simple law governing the escape from imprisonment of any substance lighter than air when an opening is presented to it. Wherever the strata confining gas are fissured down to the gas, the gas will escape. Along the way of the Wabash River the rocks are fissured and the gas north of the river has escaped because the Trenton reservoir is *lower* than the fissure; but south of the river the Trenton reservoir being *higher* than the fissure the gas is retained wherever its pressure has been resisted by columns of water, oil or other matter flowing into the fissure, and also into the lower planes of the reservoir; for it is evident that gas will expand until it finds the limit of resistance in every direction. Long before a bore was sunk at any point on the Wabash River I predicted, in accordance with this view, the finding of gas in the area northeast of Kentland, that is in the region of Francisville, and I also predicted the failure to find it at Kentland, Delphi and all along the Wabash, and north of it in a general way, from Delphi eastward, predictions which so far have not failed.

On the Blair farm, about two miles southwest of Francisville, five wells have been sunk, gas being found at a depth of 618 to 625 feet, the drill beginning in the Niagara rock, which is here overlaid with from 6 to 12 feet of modified drift and soil. At a depth of from 10 to 180 feet the drill encounters crevices, cavities and tilted rocks which greatly impede progress. Indeed, the Niagara strata all the way down are broken and uneven, the layers very much slanted and the texture gnarled and refractory.

At a number of points in the Francisville region the Niagara limestone crops out and is fissured and disturbed. On Prewett's farm, five miles northwest of Francisville, there is a sudden drop in the surface of the Niagara limestone. Two wells sunk there show the Niagara at the surface on one side of a narrow marsh, while at the other side a 30 foot stratum of the black Devonian shale is 60 feet under the drift and lying quite level. The two points are less than a furlong apart on a level prairie. This condition of the strata shows either a fault or a sudden dip of the Niagara limestone

In digging a well in the edge of Jasper County, four and a half miles northwest of Francisville, a vertical crevice was found in the Niagara limestone out of which rose a strong vein of water. The crevice was a foot in width and filled with "quick-sand," into which poles were thrust many feet without finding bottom. In this sand were found the bones and antlers of a deer.

On Pinkamunk River, seven miles west of Francisville, there is a sudden dip, or change in level, of one hundred and ten feet in the Niagara limestone within less than a quarter of a mile. The black Devonian shale is always found in the lower planes of these faults or "drops," or monodines, as the case may be, showing that it has been deposited nonconformably.

It may be well to remark just here that in this study I have taken no account of the stratum of water-lime rock, varying from nothing to thirty or more feet thick over most of the Niagara area north of the Wabash. I have treated it as "Niagara limestone," as it appears to have been affected by the disturbance here under consideration, and, moreover, it has been hard to distinguish it at most points.

The following table contains a partial list of sudden changes of elevation in the Niagara limestone near Francisville, Kentland, Monon, and Delphi:

Delphi	150	feet	in less than half a mile.	
Francisville	110	"	"	" quarter-mile.
Francisville	90	"	"	" furlong.
Kentland	250	"	"	" mile.
Monon	60	"	"	" mile.

The above changes of level in a number of instances would be much greater if we calculated the truncated part of the eroded cones. All these inequalities might be referred to the effect of glacial action were it not for the Devonian deposits found resting in level strata above and around them, and for the uptilted, broken, warped and distorted condition of the Niagara rock strata.

The gas found on the Blair farm, above referred to, is of excellent quality, dry, clean and almost odorless, burning with a strong, clear flame. It is found in a grayish magnesian shale, or granular, laminated magnesian limestone, of open porous texture, lying in the dividing line between the Hudson River and the Niagara formations. The gas-bearing stratum is about twenty feet thick, and below it are the Hudson River and Utica shales overlying a very hard close-grained, cherty and barren Trenton limestone. This fertile dividing "seam" afforded a sharp flow of heavy oil in the first well at Francisville at about 630 feet below the surface.

Taking now a wide survey of the area north of the Wabash River, and west of a north and south line through Logansport, we shall find that the surface of the Devonian shale at Valparaiso is seventy-two feet lower than the surface of the Niagara limestone at Francisville, the same shale at Oxford is 367 feet lower than the Niagara at Francisville, and at Monticello the Niagara is 258 feet lower than at Francisville. This view shows that the sudden breaks near Francisville are not local merely, but

part of a great Niagara disturbance which runs across the State. Moreover it clearly demonstrates, in connection with the other facts set forth in this paper, that the Devonian and other stratified formations superior to the Niagara, have not been affected by the disturbance, and that therefore they have been deposited since the disturbance took place.

The chief economic interest attaching at present to the Wabash Arch is connected with the gas and oil deposits found within the hollows of its porous folds. As far as the arch goes both gas and oil are likely to be found save in those areas where the rocks have been so broken as to permit the escape of these substances. In this connection it is interesting to note that in the broken and crushed Niagara rock at Monon the oil has evaporated until there is left in the crevices a tough bitumen of a very dark brown, almost black color, exceedingly heavy and coal-like. The gas has escaped through these crevices, leaving this residuary bitumen to tell the story of its departure. It is entirely possible, almost probable, that a considerable area of paying oil deposit may yet be found on the northern and northeastern slopes of the Wabash Arch. Indeed, some wells already sunk give great encouragement, notably those at Royal Center.