Natural Gas in Ontario

BY

EUGENE COSTE, M.E.

TORONTO

PAPER READ BEFORE THE CANADIAN MINING INSTITUTE AT THE ANNUAL MEETING, MARCH, 1900

TORONTO:
JAMES & WILLIAMS, PRINTERS, 10 KING STREET EAST.
1901

Natural Gas in Ontario

BY

EUGENE COSTE, M.E.

TORONTO

PAPER READ BEFORE THE CANADIAN MINING INSTITUTE AT THE ANNUAL MEETING, MARCH, 1900

TORONTO:

JAMES & WILLIAMS, PRINTERS, 10 KING STREET EAST.

1901

Natural Gas in Ontario

By EUGENE COSTE, M.E., TORONTO.

DISCOVERY.

Prior to January, 1889, we had, commercially speaking, no natural gas in Ontario. Small quantities of it had been found in wells drilled for oil or for water or were known to be coming out in natural springs from the ground—notably at Petrolia and Oil Springs (where, in the old days, large quantities were struck, but not utilized), near Ridgetown, at Port Colborne and Niagara Falls, near Hamilton, at and near Collingwood, at Mimico near Toronto, and at the Caledonia Springs. But nowhere then was the quantity of gas obtained sufficiently large to more than partially heat or light one house or two. In the summer of 1888, I persuaded my father, Mr. N. A. Coste, of Amherstburg, Ontario, to form a company (the Ontario Natural Gas Company, of which he was the President) to drill for natural gas in the county of Essex, between the towns of Leamington and Kingsville. On my advice, the first well of this company was located near Ruthven, Ontario. This well, which was afterwards solemnly baptized by the members of the company before a great concourse of people as the "Coste Well, No. 1," struck a large quantity of gas on the 23rd January, 1889, in a very porous, sub-crystalline, bluish-white dolomitic limestone, forming the upper bed of the Guelph formation, at the depth of 1020 feet, or at the absolute depth of 362 feet below tide, as the elevation of the mouth of the well is 658 feet A. T. This was the first natural gas gusher in Ontario, and it was certainly a very large well; its production being, when I first measured it the day after the gas had been struck, a little more than ten million cubic feet per day of gas flowing freely at the mouth of the well. After the well was tubed and the gas was shut in, it registered a rock pressure of 460 lbs. to the square inch. This well opened up the Essex County gas field, now supplying natural gas to the cities of Windsor, Detroit and Toledo. The second large natural gas well in Ontario also opened up an entirely new field and was drilled a few months later, in August of the same year, in the County of Welland, at a location, which I also selected, seven miles east of Port Colborne, on lot thirty-five of the 3rd concession from Lake Erie of Bertie Township. This well was drilled by the Provincial Natural Gas and Fuel Company of Ontario, Limited, which was formed by myself, with a view of developing this new natural gas field to supply the City of Buffalo, only fourteen miles away from the centre of the field. I was then, when the first well was drilled, and afterwards for several years, the manager and engineer of the company. The gas was struck in a white sandstone of the Medina formation, at 836 feet, or at an absolute depth of 218 feet below tide; the flow from the well at its mouth measured 1,700,000 cubic feet of gas per day, and the rock pressure of its confined gas was 525 lbs. 142 wells have now been drilled in this field by the Provincial Natural Gas Company, at a total expense of $703,000.00, the gas being supplied since January, 1891, to Fort Erie, Bridgeburg and Buffalo.

GEOLOGY OF THE ONTARIO GAS FIELDS.

As we have stated above, in the Essex County gas field, between Leamington and Kingsville, the gas is found in the upper bed of the Guelph dolomite. This could not be positively determined until early last year when we drilled a well on the Woodbridge farm, in the Township of Colchester South, down to the depth of 2420 feet. This well found the Trenton limestone at 2150 feet and gave us the first good log of the complete series of the measures underlying that county, and we can now judge exactly of the correct relative position of the gas rock which is the upper part of the Guelph dolomite.

The following logs of some of the wells we drilled in different parts of Essex County reveal many new features of the underground geology of that district:—

Coste Well, No. 1, N.-W. corner Lot 7, in 1st Con of the Township of Gosfield. Elevation of derrick floor 658 ft.; Drilled Dec. 1888 and Jan. 1889.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	Soil	5 ft. to 5 ft.	
	Grey Sand	115 ft. to 120 ft.	With a little clay at 60 ft. and 85 ft.
Onondaga	Brown and grey dolomitic limestones with gypsum and with white and black flint.	380 ft. to 500 ft.	
	Grey blue and shaly dolomites and drab, brown dolomites with a good deal of gypsum. Shaly group.	360 ft. to 860 ft.	
	Dark brown dolomites and gypsum (with gypsum bed from 970 to 985.)	160 ft. to 1020 ft.	A little gas at 910 ft. and 930 ft.
Guelph	Grey blue crystalline vesicular dolomite.	11 ft. to 1031 ft.	Large quantity of gas at 1020 ft. or at 362 ft. below tide.

Well No 3 of the Ontario Natural Gas Company, Limited, on Lot 8 in the 2nd Con. of Gosfield Township. Elevation 663 ft.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	mostly sand	141 ft. to 141 ft.	
Onondaga	Grey, drab, brown and blue dolomites, with gypsum (shaly group from 585 ft. to 930 ft.), gypsum bed from 1055 ft. to 1070 ft.	960 ft. to 1101 ft.	Salt water at 1095 feet, bottom of well at 1101 ft.

Well No. 1, Union Gas Co., in N.-W. corner of lot 17 in 7th Con. of the Township of Colchester, north. Elevation 593 ft.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	mostly clay	65 ft. to 65 ft.	
Corniferous and Onondaga	White grey limestones and brown dolomitic lime-stones with gypsum below 260 ft.	610 ft. to 675 ft.	Sulphur water at 582 ft. and 613 ft.; probably the upper 100 ft. represents the Corniferous.
Onondaga	Grey blue dolomitic shales and shaly dolomites and drab brown dolomites with a good deal of gypsum, gypsum bed 680 ft. to 690 ft.	300 ft. to 975 ft. (of shaly group)	
Onondaga	Dark grey and brown dolo-mites with gypsum, gyp-sum bed from 1125 ft. to 1140 ft.	200 ft. to 1175 ft.	Salt water at 1172 ft.

Well on I. Desjardin's Farm, lot 7 in 3rd Con. of Tilbury West Town-ship. Elevation 603 ft.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	boulder clay	120 ft. to 120 ft.	
Corniferous	White and yellow brown limestones.	130 ft. to 250 ft.	
Oriskany	White yellowish fine sandstone	50 ft. to 300 ft.	

Well on I. Desjardin's Farm—*Continued.*

Formation.	Strata.	Thickness. Depth.	Remarks.
Onondaga	Yellow, white and brown dolomites, with gypsum from 450 ft. to 550 ft; with flint from 550 ft. to 650 ft.; darker brown with gypsum from 650 ft. to 800 ft.	500 ft. to 800 ft.	
Shaly group Onondaga	Blue and brown (mostly quite shaly) dolomite, with a good deal of gypsum.	330 ft. to 1130 ft.	Altogether 1015 ft. of Onondaga.
Onondaga	Dark grey and brown dolomites with gypsum, gypsum bed from 1275 ft. to 1295 ft.	185 ft. to 1315 ft.	
Guelph	White grey crystalline limestone.	18 ft. to 1333 ft.	Salt water at 1315 ft.

In two wells drilled on Joseph Lalonde's farm, about one mile south-west of the Desjardin's farm well, some oil and gas were obtained at 1213 ft. and 1240 ft. (53 barrels being shipped from there to Petrolia) from rocks of the lower part of the Onendaga; quite a little gas and oil were also found on that farm at the bottom of the drift at 114 ft.

Well on the Woodbridge farm, lot 64 in the 1st Con. of the Township of Colchester South. Elevation 648 ft.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	Sand	20 ft. to 20 ft.	
	Quicksand	90 ft. to 110 ft.	
Onondaga	Grey and brown dolomitic limestone with flint and gypsum.	67 ft. to 177 ft.	
	White, fine, sharp sand	10 ft. to 187 ft.	
	White, grey and brown dolomites with white and black flint and with gypsum.	203 ft. to 390 ft.	
	Grey blue and brown dolomites (mostly shaly with a good deal of gypsum), shaly group.	370 ft. to 760 ft.	
	Dark grey and brown dolomite with gypsum (gypsum bed 865 ft. to 875 ft.	150 ft. to 910 ft.	

Well on the Woodbridge Farm—*Continued.*

Formation.	Strata.	Thickness.	Depth.	Remarks.
Guelph and Niagara 215 ft.	Blue white, grey and brown dolomites, quite crystalline and very porous	215 ft.	to 1125 ft.	Salt, black sulphur water at 910 ft. and again at 1010 ft.
Clinton 155 ft.	White and white blue limestones.	155 ft.	to 1280 ft.	More salt water at 1232 ft.
Medina 285 ft.	Grey blue shale	7 ft.	to 1287 ft.	
	Grey blue limestone	5 ft.	to 1292 ft.	
	Green shales	8 ft.	to 1300 ft.	
	Red pink shales	5 ft.	to 1305 ft.	
	Grey blue unctuous shales	88 ft.	to 1393 ft.	
	Grey blue and white sandy limestone	62 ft.	to 1455 ft.	
	Red pink shales	110 ft.	to 1565 ft.	
Hudson River	Grey blue lime shales with shells of lime.	350 ft.	to 1915 ft.	
Utica	Brown and black shales	235 ft.	to 2150 ft.	
Trenton	White and dark grey limestones.	270 ft.	to 2420 ft.	A little gas and oil at 2150 ft.

In a well, drilled about half mile east of Amherstburg, fifty feet of the Oriskney sandstone were found between the depths of 252 to 302 feet.

In wells drilled in lot 12 in 2nd concession of Maidstone Township, some gas was found in the bottom of the drift, on the top of the rock at eighty-two feet, and also in strata of the Onondaga at 700 and 1040 feet. The Orisknay sandstone in the first of these wells was reported to have been struck between 275 and 300 feet.

Another well drilled on lot one in concession one of Maidstone, struck some oil in the upper part of the Corniferous limestone at 115 feet.

The principal features revealed by these logs which we might point out are:—

1st.—In the south and south-east part of the County of Essex, along Lake Erie, the first stratum met with, under a heavy sand drift, is the Onondaga, not the Corniferous, as it was supposed and as shown on the geological maps.

2nd.—Between the Coste Well No. 1 and Well No. 3 of the Ontario Natural Gas Company, in a distance of three-quarters of a mile, there is a dip of eighty feet. This, as shown by the logs of other wells between these two, is due to a fault in the strata running in a direction W.N.W. and E.S.E., and passing only a little to the north of Coste Well No. 1. The logs of other wells to the west of Coste Well No. 1 have also revealed another fault running a short distance west of that well in a direction at right angle to the first fault above mentioned.

This faulty or fractured structure of the strata is a pronounced feature of many oil and gas fields, and this feature was recognized by the late Professor Orton as very well marked in the oil and gas fields of North-Western Ohio. (Geology of Ohio, Vol. 6, p.p. 53, 95 and 96, or page 46, 1st Annual Report, 3rd Organization, 1890). To us, this is one more direct proof to add to those we will enumerate below in support of the volcanic theory of origin of natural gas and petroleum.

3rd.—An extensive bed of gypsum, 10 to 20 feet thick, has been regularly found in the lower part of the Onondaga formation; this bed underlies the greater part of the County of Essex.

4th.—Oil and gas, though the first has not yet been found in paying quantity in the county, and the second only in one field, are already known to exist in many parts of the county and in a number of different strata.

5th.—Large quantities of salt water are always found in Essex County in the Guelph and Niagara and in the Clinton.

6th.—The Orisknay sandstone is well developed under tho western and northern parts of tho county, but is missing in some parts of it, as shown by the record of Well No. 1 of the Union Gas Company, given above.

7th.—Only one well, the Woodbridge well, mentioned above, has yet been drilled down to the Trenton limestone in the county, and this well struck a little gas and some oil in the upper part ot this formation.

The following logs of four of the wells of the Provincial Natural Gas Company will illustrate fully the underground geology of the Welland County field:—

No. 1 Well, Lot 35, Concession 3 from Lake Erie, of the Township of Bertie. Elevatien 618 ft.

Formation.	Strata.	Thickness.	Depth.	Remarks.
	Soil	2 ft.	to 2 ft.	
Corniferous	Dark grey limestone	23 ft.	to 25 ft.	
Onondaga	Grey and drab dolomites and black shales with gypsum.	390 ft.	to 415 ft.	Fresh water cased off at 284 ft.
Guelph and Niagara	Grey dolomites	240 ft.	to 655 ft.	Salt water at 548 ft. cased off at 596 ft.

No. 1 Well—*Continued.*

Formation.	Strata.	Thickness. Depth.	Remarks.
Niagara Shales	Blue shales	50 ft. to 705 ft.	
Clinton	White crystalline limestones, grey and shaly towards bottom.	30 ft. to 735 ft.	A little salt water
Medina	Red sandstone	55 ft. t[illegible]	
	Red shale	10 ft. to [illegible]	
	Blue shale	8 ft. to [illegible]	98 ft.
	White sandstone	5 ft. to 81[illegible]	
	Blue shale	20 ft. to 833 ft.	
	White sandstone	13 ft. to 846 ft.	Gas at 836 ft.

Well No. 14, on Lot 6, in the 15th Concession from Niagara River, of Bertie Township. Elevation 605 ft.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	Clay	38 ft. to 38 ft.	
Onondaga	Dolomites, grey and drab, black shales and gypsum	300 ft. to 338 ft.	
Guelph and Niagara	Grey dolomites	230 ft to 568 ft.	Salt water at 470 ft.
Niagara shales	Blue shales	60 ft. to 628 ft.	
Clinton	White and grey limestones	32 ft. to 660 ft.	
Medina	Red sar[illegible]stone	83 ft. to 743 ft.	A little gas
	Blue sh[illegible]e	15 ft. to 758 ft.	
	White sandstone	16 ft. to 774 ft.	
	Red shales	850 ft. to 1624 ft.	
Hudson River	Blue shales with lime shells	730 ft. to 2354 ft.	
Utica	Black shales	171 ft. to 2525 ft.	
Trenton	White and grey limestones	685 ft. to 3210 ft.	
Calciferous	Yellowish sandstone	45 ft. to 3255 ft.	A little salt water
Archaean	Micaschist	2 ft. to 3257 ft.	

Well No. 61, Lot 2, in 4th Concession Willoughby Township. Elevation 610 ft.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	Clay	18 ft. to 18 ft.	
Onondaga	Dolomites and shales with gypsum	202 ft. to 220 ft.	
Guelph and Niagara	Grey dolomites	220 ft. to 440 ft.	Salt water at 330 ft.
Niagara shales	Blue shales	50 ft. to 490 ft.	
Clinton	White limestones	30 ft. to 520 ft.	A little gas at 495 ft. and a little salt water.
Medina	Red sandstone and shales White sandstone Blue shale White sandstone Red shales	73 ft. to 593 ft. 10 ft. to 603 ft. 12 ft. to 615 ft. 18 ft. to 633 ft. 830 ft. to 1463 ft.	
Hudson River	Blue shales	717 ft. to 2180 ft.	
Utica	Black shales	160 ft. to 2340 ft.	
Trenton	White and grey limestones	670 ft. to 3010 ft.	Gas at 2940 ft. 1000 lbs. rock pressure
Calciferous	Grey coarse sandstone	19 ft. to 3029 ft.	
Archaean	White quartz	1 ft. to 3030 ft.	

Well No. 22, Point Abino, Bertie Township. Elevation 580 ft.

Formation.	Strata.	Thickness. Depth.	Remarks.
Drift	Sand	10 ft. to 10 ft.	
Corniferous	Grey limestones with flint	82 ft. to 92 ft.	
Onondaga	Grey and drab dolomites, blue shales and gypsum	388 ft. to 480 ft.	
Guelph and Niagara	Grey dolomites	235 ft. to 715 ft.	Gas in large quantity at 500, 530 and 580 ft. Salt water at 600 to 630 ft.
Niagara shales	Blue shales	55 ft. to 770 ft.	
Clinton	White limestones	30 ft. to 800 ft.	
Medina	Red sandstone Blue shale White sandstone	80 ft. to 880 ft. 13 ft. to 893 ft. 17 ft. to 910 ft.	Gas at 902 ft.

These four wells are almost on a north and south line across the field in the following order from north to south:—No. 61, 14, No. 1 and No. 22 and the distance between the two extreme wells, north and south, is ten miles. We may point out from the above logs and from the records of the other wells, now drilled in the field to the number of 142, the following features:—

1st.—The strata dip to the south and south east uniformly at the rate of about thirty-five feet to the mile, except for a small synclinal (about one mile wide and thirty feet deep), the axis of which is about one mile north of No. 22 well at Point Abino.

2nd.—Salt water was struck in every well in large quantities towards the middle of the Guelph and Niagara formation. A little salt water is also found in the Clinton, in the White Medina gas rock and in the Calciferous at No. 14, but in none of these formations below the Guelph and Niagara is there anything like a continuous body of salt water, which, on the contrary, lies there in disconnected small bodies of water.

3rd.—Besides being found in the strata indicated in the above logs, gas was also found in some other wells in large quantity:—five feet in the Clinton limestone, ten feet in the red Medina sandstone and in the upper white sandstone of the Medina. Some amber green color oil of a gravity of forty-two and a half degrees Beaume was found in the last few feet of the lower white Medina sandstone at wells No. 20, 28 and 62. The gas in that sandstone is generally found three feet in from the top of it, but often, also, another vein is found nine to ten feet in.

HOW LOCATED—ORIGIN.

In the opening remarks of this paper, I referred briefly to the discovery of the only two gas fields yet found in Ontario, and I may add in Canada, not so much as a matter of record or history, but more as an introduction to the discussion of the much more interesting and important point, scientifically and economically, which led me to make these discoveries and which is no less than the question of origin of the natural gas and petroleum.

Had I not entertained the firm conviction against the generally accepted theory in this country, in the United States and in England that the origin of natural gas, of petroleum and of bitumens in general, is volcanic instead of organic, I would have been unable to point out as likely to become natural gas fields these two localities in Essex and in Welland counties, 200 miles apart one from the other, and each about 100 miles from any other oil or gas field known at that time. It is indeed quite clear that one believing in the organic theory of the origin of natural gas and petroleum would naturally consider that there might be natural gas or petroleum deposits under any parts of the peninsula of south-western Ontario, between the Georgian Bay, Lake Huron, and Lake St. Clair to the north-west and Lake Erie and Lake Ontario to the south-east, as the whole of that large section of the country is underlaid with Devonian and Silurian sedimentary strata more or less fossiliferous; and it would be and has been impossible to anyone following that organic origin theory to localize any particular district of that vast peninsula where these hydrocarbon products should be found by drilling. In fact, according to that theory, if found in one place, these products should be found in almost any other part of the peninsula. On the other hand, for one accepting, as I did, the volcanic origin of these products as gaseous emanations from the interior of the earth along certain fissured and fractured zones of the crust of the earth, it was possible to select, in south-western Ontario, several likely new gas fields by mapping out the probable continuation in Canada of these fissured and fractured zones from other gas and oil fields already located and developed on the same zones in the United States. This was done by me, as stated above, with the result that our only two gas fields in Ontario were at once discovered, and this result is in itself a strong proof of the soundness of the theory I accepted of the volcanic origin of natural gas. Especially so when it is considered that in each of these two Ontario new fields the gas was found in formations, not before known, anywhere, to contain natural gas in large quantities, viz., as before stated:—the white Medina sandstone, just above the thick body of the Medina red shales in Welland County and the upper bed of the Guelph dolomitic limestone in Essex County. Thus the volcanic theory allowed me not only to localize with precision two new and entirely unsuspected gas fields, but also to find the gas in entirely new horizons, showing conclusively that when these new fields were selected, it was not simply to try and reach by drilling certain formations known elsewhere to be rich in oil and gas, but, on the contrary, that they were selected with the conviction imparted by the volcanic theory of origin, that wherever found, natural gas and petroleum are simply emanations from below into a porous rock or into a drift, sand or gravel, and that that rock, drift, sand or gravel plays only the role of a tank or reservoir, and, therefore, that natural gas or oil, or both, might be found in any or all of the porous rocks or strata drilled through, no matter what their geological name or age might be, or whether they had or not a past record as producers of oil or gas.

This is exactly what was found to be the case in the drilling of the 142 wells we have now drilled in Welland County, as we have to-day there, and have had for years, wells connected on the lines getting their gas from each of the following different strata:—

3. From three different horizons in the upper beds of the Guelph dolomite. } at depths of 500, 530 and 580 feet.

4. From one horizon in the first ten feet of the Clinton limestone.	Which is about 200 feet deeper than the lower gas horizon just mentioned in the Guelph.
5. From one horizon in the upper part of the red Medina sandstone.	About forty feet below the preceding horizon in the Clinton.
6. From one horizon in the upper white Medina sandstone.	About seventy feet below the preceding horizon in the Medina.
8. From two horizons in the lower white Medina sandstone.	About twenty and thirty feet below the preceding horizon in the upper white Medina sandstone.
9. From one horizon in the Trenton limestone, 600 feet below the top of it, at a depth of 2940 feet.	About 2220 feet below the preceding horizon in the lower white Medina sandstone.

To these nine different "sands" (this term means any gas or oil rock in the parlance of a driller, whether it is a sandstone, a limestone, or any other rock) producing gas in Welland County several others could be added, in which smaller quantities of gas were found, especially in the big interval of shales, 1700 feet thick, between the lower Medina white sandstone and the Trenton limestone, where gas was encountered several times in "shells" or small shaly limestone layers.

At a well at St. Catharines, about twenty miles north-west from our wells, in Welland County, yet another and lower "sand" was found to contain gas and some large wells have been obtained in this same "sand" at different localities in Oswego and Onondaga Counties, New York State. This "sand" is a white yellowish sandstone under the Trenton limestone and immediately above the Archaean formation.

Here then is a series of Silurian sedimentary rocks in Welland County, some 3000 feet thick, resting directly on the Archaean rocks, and containing gas in every one of its porous portion or stratum from the one immediately above the Archaean to the surface. Is not that a proof that the source of the gas is still lower and below the Archaean? But let us now look over the results of the thousands upon thousands of oil and gas wells drilled in the States of West Virginia, Ohio, Indiana, Pennsylvania and New York. There we have altogether a series of sedimentary strata some 10,000 feet thick, ranging from the Archaean to the Upper Barren Coal Measures of the Carboniferous, and here, also, every sandstone or porous limestone or other rock of that thick series of rocks has, in one locality or another in these States or in Ontario, produced either oil or gas, or both, in commercial quantities. Starting from the most southern of the oil and gas fields in West Virginia, where the newer rocks of the Carboniferous outcrop, and going north-west to Indiana and south-western Ontario and north-eastward across Pennsylvania and New York States as far as the Adirondack region where the Archaean rocks outcrop, the oil and the gas are found geologically deeper and deeper as the measures rise to the surface in the following principal "sands" in descending order:—

Pittsburg sandstone just above the Pittsburg coal.		
Fifty foot Macksburg sandstone.	160 feet below the Pittsburg coal	Lower Carboniferous and Subcarboniferous.
First Cow Run or Joy Sand....	240 " " "	
Mahoning sandstone..........	300 " " "	
Middle Cow Run or Freeport sandstone	410 " " "	
Upper Second Cow Run sandstone	600 " " "	
Lower Second Cow Run sandstone	650 " " "	
Tionesta, Homewood or 700 feet Macksburg sandstone	810 " " "	
Upper Connoquenessing or 800 feet Macksburg sandstone....	910 " " "	
Lower Connoquenessing or upper salt sand	1000 " " "	
Lower salt sand or Sharon Conglomerate or Olean Conglomerate or Maxon sand	1050 " " "	
Keener sandstone	1200 " " "	
Big Injun sand...............	1280 " " "	
Squaw sand	1350 " " "	
Berea grit	1700 " " "	

Upper Devonian white sands:

- First sand or Butler Second sand or Gantz
- 100 foot rock
- 50 foot rock
- Second sand or thirty foot rock
- Blue Monday sand or Gordon
- Boulder sand or Hickory
- Stray third sand
- Third sand
- Fourth sand
- Fifth sand

Middle Devonian:

- Elizabeth sand
- Warren slush oil sand
- Warren third sand
- Clarendon third sand
- Speechley sand
- Cherry Grove and Sheffield sand
- Cooper oil sand
- Bradford oil sand
- Lower Waugh and Porter sand
- Elk County group of sands, two or three in number

Hamilton limestone	The Petrolia and Oil Springs, Ont., upper show	Lower Devonian
Corniferous sandstone	Oil Springs and Petrolia fields	Lower Devonian
Oriskany sandstone	Euphemia Field, Ont.	
Guelph sandstone	At least three different horizons in Essex and Welland Counties	Silurian
Niagara limestone	Seneca Falls, Alden, New York State and in Indiana	Silurian
Clinton limestone	At Lancaster, Ohio and Welland Co., Ont.	Silurian
Medina red sandstone	Two different horizons in Welland Co. and in New York State	Silurian
Medina upper white sand Medina lower white sand	Welland Co., Buffalo, Alden, Oswego and Onondaga Counties	Silurian
Trenton limestone, upper part	Several horizons in Ohio and Indiana	Silurian
Trenton limestone, lower part	Several horizons in Welland Co. and Oswego and Onondaga Counties, N.Y.	Silurian
Calciferous sandstone	St. Catharines, Ont., Oswego and Onondaga Cities, N.Y.	Silurian

To this list of about fifty different porous rocks, rich in oil and gas, quite a number of other horizons could be added by a more careful study of the subject; and the Cambrian rocks of the Quebec group, now furnishing oil in Newfoundland, can also be added. This fact that so many porous rocks, one upon the top of the other, and all through the 10,000 feet of sedimentary measures, from the Archaean floor to the surface of this region, are in places filled with oil or gas, should serve not only as a strong evidence, but in our opinion as a most convincing proof that these hydrocarbon products are not indigenous but adventitious to every one of these "sands," and, therefore, that they came through fissures in the Archaean below and have penetrated and imbibed every porous rock they encountered in their ascent. We cannot indeed admit a different and new organic source under each one of these formations, especially when we come down to rocks of the lower Silurian and Cambrian ages, during which time the development of vegetable or animal life was most certainly entirely inadequate to explain, by some decomposition of organic remains, the enormous quantities of petroleum and natural gas, for instance, in the Trenton or lower Silurian limestone of Ohio and Indiana. This ancient formation, we might here remark, has been the most prolific one on the North American Continent in hydrocarbon products.

But we have still a more direct proof that these hydrocarbon products are due to gaseous emanations from below. This proof is the rock pressure of natural gas. As is well known, when first tapped in any of the wells, the natural gas rushes out of the hole impelled by a great force, which, when the gas is closed in and confined records on a gauge in some fields up to 1500 lbs. to the square inch, but is, generally, between 200 and 1000 lbs. And here comes the most important point in this relation:—in every field when gas is found in several strata, the highest pressure is always recorded in the lowest or deepest stratum. For instance, in the Welland County field, the rock pressure of the gas was 300 lbs. in the Guelph dolomite; 400 lbs in the Clinton; 525 lbs. in the Medina white sand; and, 1000 lbs. in the Trenton limestone. These enormous pressures decreasing as the gas travels up from below by friction through the small fissures and the small pores of the "sands," we submit, cannot be explained any other way than by a volcanic source from below.

It certainly is not to be argued that the expansive nature of the resulting gas from the decomposition or distillation of organic remains, will show 1000 or 1500 lbs. pressure, as it sometimes does in a certain rock, while in another rock, or in the same rock nearer the surface, the pressure resulting from a similar expansion due to an organic decomposition or distillation will only be a few pounds.

Neither is it to be argued seriously that the weight of the superincumbent rocks is the cause of the high pressure of natural gas in its reservoir and of the increase of that pressure in depth; for the gas is in the pores of firm cohesive rocks, which no more weigh on it than the walls of a cavern would on the water in that cavern.

Neither is the theory of hydrostatic or artesian water pressure advanced and strongly advocated by Professor I. C. White, of West Virginia, and by the late Professor Orton, of Ohio, in their interesting papers and reports on natural gas and petroleum, ablo to explain how organic made gas came to its rock pressure; for the simple reason that the oil and gas rocks of Nortb America are not permeable or pervious rocks, though they are porous in places, as everyone who has made a study of these rocks will admit.

But if, for tho sake of argument, we admit that they are pervious rocks, then this hydrostatic theory is at once condemned again, absolutely, by the well-known fact, so often strongly illustrated by Professor Orton himself, that the rock pressure of all gas fields constantly diminishes as the gas is taken out and used from the field, and the similar fact that an oil field furnishes flowing wells only for a short time when first discovered. Indeed an artesian water pressure communicated through a pervious rock, from tbe outcrops of it would of course furnish a constant hydrostatic head, and, conseqnently, the last cubic foot of gas from a gas field would come out of it with tbe same pressure as the first cubic foot, and flowing oil wells, impelled by this constant force, would continue to flow and would not have to be pumped. Especially so, if it is admitted, as Professor Orton did (Bulletin of the Geol. Society of America, Vol. I, pp. 91, 92 and 93, Marcb 1st, 1890; also Geol. of Ohio, Vol. I Third Organization, pp. 102), that tbe porosity is so perfect in the gas rock, between the outcrops of it and tho gas field, that the water pressure suffers absolutely no loss by friction; then surely, with such a free communication, the imparted pressure to the gas or to the oil, by this water head, should be absolutely constant. Instead of tbat the rock pressure of the gas in the North Findlay field is now only a few pounds at many points instead of 450 as at first, and thousands of flowing oil wells in north-western Ohio have had to be pumped for years; and this has been the case in every field. If it is held that the porosity through which the communication of the gas field with tbe outcrop of the rock is maintained is so small and defective that only the help of long geological time has allowed the water from the outcrops to slowly penetrate and to finally give to the gas its high rock pressure, while, on the other hand, now that the gas is being used so rapidly from the field, it is impossible for the long and tortuous water column to react promptly enough to prevent the well-known, rapid and great recorded diminuation of the gas pressure; then, to those presenting this argument it is only necessary to answer that this great want of porosity would of necessity wear off the pressure, and tberefore, that in such a case the rock pressure of the natural gas would be very small, as it is with natural gas found in shales (so-called shale gas), where a good example is at hand to show how the minuteness of the pores of the shales and the want of porosity has destroyed the original strong rock pressure of the gas permeating through these shales from below.

To show by a direct example that the artesian water pressure theory is inadmissible, we will consider the original rock pressure of the Medina lower white "sand," in the Welland County field, which at No. 1 well was 525 lbs.; there, the gas was found in that sandstone at 218 below tide, and as this sandstone outcrops (some fifteen miles north, at Queenstown and Lewiston, below Niagara Falls), at an altitude of 400 feet A. T., the hydrostatic head would be 618 feet. Therefore, such a column of salt water, weighing 0.476 lb. per square inch for every foot in height, would exert a pressure of 294 lbs. (that is, supposing a perfectly free and easy communication and no loss of pressure) as against 525 lbs., the actual rock pressure recorded. If we now consider the minuteness of the pores of that White Medina sandstone and the necessary loss by friction which water entering the outcrops of it at Queenstown would suffer in its long travel to No. 1 well, we can readily see that water entering the outcrops there never would get to No. 1 well, and, therefore, that not a single pound of that supposed water head would be available in the gas field to impart pressure to the gas. We see, then, that it is impossible to explain, through an organic origin of the gas, its rock pressure, and especially the increase in depth of that pressure; while the volcanic theory, on the contrary, accounts for these facts at once.

We now propose to show that through the volcanic theory all the other conditions of the oil and gas fields are most readily explained. Firstly:—We will recall the well-known geological fact that the volcanic action is, and has been during all geological ages, shifting and intermittent along the fractured zones of the earth crust, that is to say, that while a volcanic activity manifests itself intermittently in a certain region during a certain geological age, in subsequent ages it dies out and becomes entirely quiescent in that particular region to break out anew in other portions of the earth; and this explains why we find that natural gas and oil, though volcanic products, are also stored products, and why their rock pressure and quantity gradually decrease as we take these products out of their deposit. The volcanic action which brought them there was active, as it always is, only for a time, and is now dead and unable to refill the reservoirs; just as it is in most mining regions of the earth, where a similar volcanic activity once was filling with quartz and other veinstones more or less mineralized, fissures, veins and lodes now long ago solidified. Secondly:—Though many new oil and gas fields and new districts remain yet to be discovered, still enough is known to-day of the distribution of these products in certain regions to show how localized and accidental their deposits are. For instance, in the State of Ohio, where so many wells have been drilled all over the State, it is only from a very limited area in the north-western part of the State that 200 million barrels of oil and enormous quantities of gas have been produced in the last twelve years, yet in many other counties of the State we have the same fossiliferous and porous strata, presenting also numerous anticlinal and other folds; but they nevertheless have been proven to be barren of hydrocarbon products. Similarly the oil region of Pennsylvania is altogether confined to a belt in the western part of the State from Greene County to McKean County and all the central part and north eastern part of the State, also underlaid with porous and sedimentary strata, are barren of hydrocarbon; and, the disturbed condition and the high inclination of the strata cannot be advanced to explain it, as other oil and gas regions produce from much more disturbed and inclined strata, as for instance, California. The same localization can be pointed to in Ontario and New York State, where the oil and gas fields cover an exceedingly small percentage of the porous and fossiliferous areas, though there is no doubt that further discoveries will somewhat increase this small percentage in both Ontario and New York State; but where this localization is most striking, is in the famous oil fields of the volcanic peninsula of Apcheron, near Baku, in Russia, where, from a small area of not over eight square miles, a production of oil of over 700,000,000 barrels has now been obtained. We could give a much fuller illustration of this local distribution of the oil and gas deposits in small fields along the fissured and fractured zones of the crust of the earth, in connection with the big orogenic movements of that crust; but we will have to leave this to a further occasion. We have, however, referred to this point here to show how this local and accidental distribution is unlike what would be expected from deposits of organic origin, which, like the coal beds, would naturally spread out uninterrupted over wide regions. On the other hand, a volcanic product is *a priori* found localized along the lines of volcanic activity, and there in large quantities, while the neighboring localities or districts not subjected to this volcanic action are barren.

Thirdly:—In all the oil and gas fields, either above or below, or in the producing sands themselves, a bitter, strong, salt water, very often sulphurous, is found. Sulphur is also found in some of the oils, as in the Ontario and Lima oils, and often in the natural gas under the form of hydrogen sulphide. In the Welland County field of Ontario the upper gas in the Guelph dolomite has a very pronounced odor due to the hydrogen sulphide it contains, and so has the gas from north-western Ohio, Indiana and Essex County, Ontario. An analysis by Professor Francis C. Phillips, of Allegheny University, of the Guelph dolomite gas of Point Abinc, Welland County, gave the following composition:—

Hydrogen Sulphide	0.74
Nitrogen	2.69
Hydrocarbons of the paraffin series	96.57
	100.00

Another analysis gave 0.82 of hydrogen sulphide. Now why is this water so strongly saturated with chlorides of sodium, calcium and magnesium, and where is this hydrogen sulphide and nitrogen coming from? While the late Professor Orton, who was a firm exponent of the organic theory of origin of natural gas and oil, has, to our knowledge, never explained how rain water entering the outcrops of the Trenton, in Lake Huron, and travelling so freely through this rock as to lose no head by friction in the long transit to Ohio and Indiana, ever became such a bitter sulphurous brine in the oil and gas fields of these States, we, on the contrary, have in the theory of volcanic emanations a ready answer to the above questions, and a most simple and direct explanation of the presence of these other elements in the oil and gas fields, such as water, chlorides, nitrogen and hydrogen sulphide. Indeed, besides the emission of lavas, the volcanic activity in all the numerous volcanic regions of the earth where it is now active or only lately quiescent, or even at many places where it has long been dormant, is also the cause of the escape of large quantities of steam vapors and of gaseous emanations forming the well-known "fumaroles," "solfataras," "suffionis," "salzes" and "moffettes" of the volcanic districts. The careful study of these gaseous emanations made by many reputed scientists has proven beyond a doubt that they are largely composed of alkaline and other chlorides, including ammonium chloride, hydrogen sulphide and hydrocarbons. Here is a direct indisputable analogy between the products of the present volcanic activity so widely distributed over the entire globe and between the products we find in the different oil and gas fields. Surely this is a much stronger analogy to compare to the products of the oil and gas fields than the fact often advanced that marsh gas is produced in the swamps and marshy grounds of to-day by the decay of vegetation. If that be taken as analogous, then where is the coal or other carbonized residue in the Devonian and Silurian gas and oil rocks of North America, for to follow this supposed analogy, the decaying vegetation of the swamps must continue to decompose into peat or lignite, and finally into coal? If it is claimed that the process of decomposition or destructive distillation has been so complete as to leave no residue, then how can there be such large undisturbed coal fields associated with the upper gas and oil rocks of Pennsylvania, West Virginia and South Eastern Ohio?

This association, of course, would on that supposition be impossible, and all these coal fields would also be distilled into liquid and gaseous bitumens. Therefore, from every point of view, it can certainly be said that the organic theory of origin does not account for the facts, phenomena and conditions of our oil and gas fields; and, if this theory is held by so many, it appears to us that it is simply because they consider it as an axiom that everything constituted with carbon must be an organism or result from an organism, forgetting not only that they should not use "axioms" in geology, but also that to exist and to subsist an organism must first derive carbon from the mineral world, where it must therefore be in large quantities, under many forms, and the hydrocarbons of the oil and gas fields are only a few of these mineral forms of carbon brought into their present deposits, as most minerals have been under the influence of the volcanic agency, which has left so many marks on the constitution of so many parts of this globe, from the oldest geological age to this day.

TORONTO, February, 1900. EUGENE COSTE, M.E.