CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1912.

PART II. MINERAL FUELS.

MARIUS R. CAMPBELL, *Geologist in charge.*

INTRODUCTION.

This volume is the seventh of a series that includes Bulletins 316, 341, 381, 431, 471, 531, and 541, "Contributions to economic geology (Part II)" for 1906, 1907, 1908, 1909, 1910, 1911, and 1912, respectively. Previous to 1906 the annual "Contributions" consisted of one part only and papers on mineral fuels were included with the papers on metals and nonmetals except fuels in a single volume. These earlier volumes are Bulletins 213, 225, 260, and 285, for 1902, 1903, 1904, and 1905, respectively.

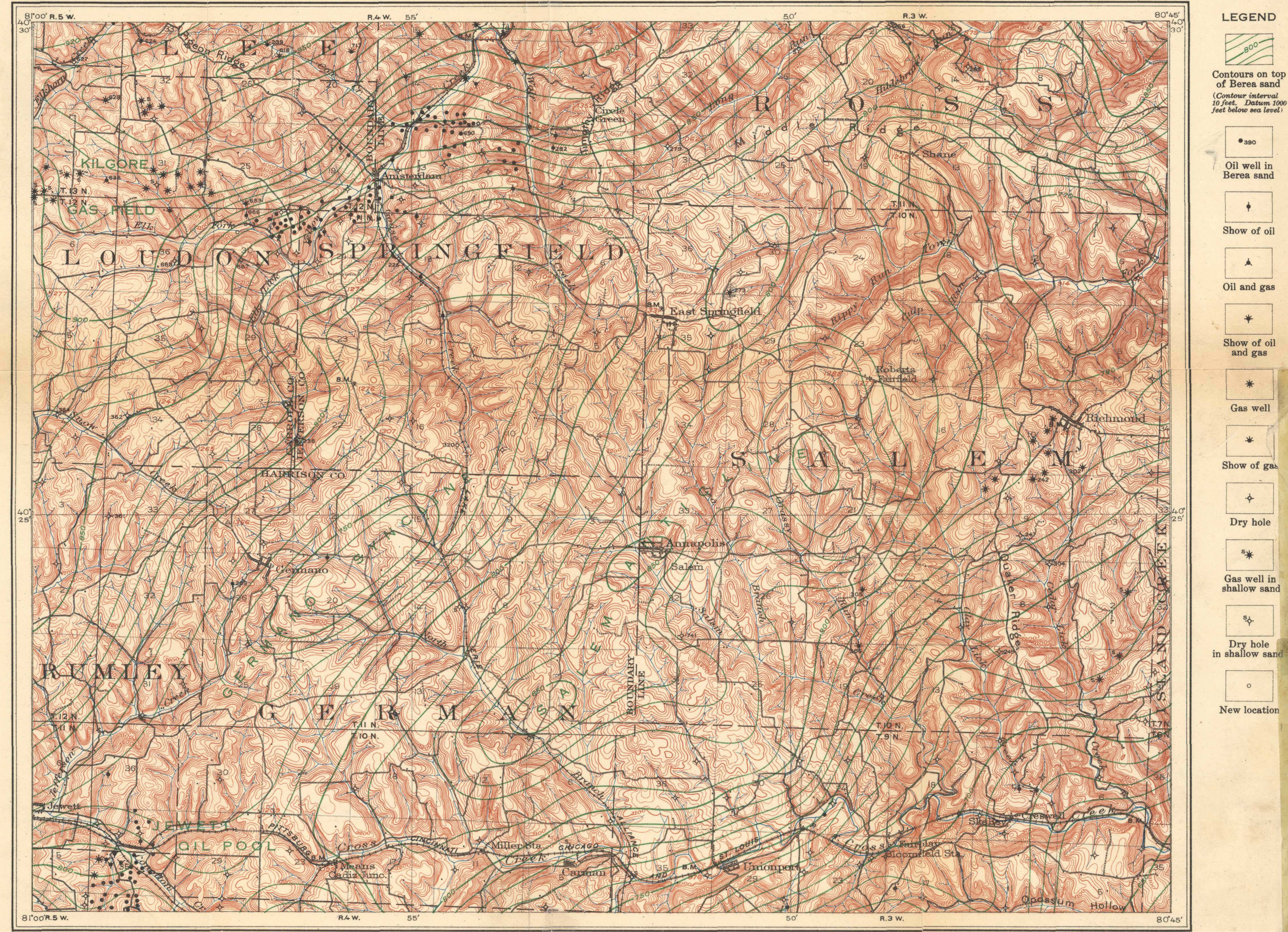
As the subtitle indicates, the papers included are of two classes—(1) short papers giving comparatively detailed descriptions of occurrences that have economic interests but are not of sufficient importance to warrant a more extended description; (2) preliminary reports on economic investigations the results of which are to be published later in more detailed form. These papers are such only as have a direct economic bearing, all topics of purely scientific interest being excluded. They have been grouped according to subjects or general regions and each group has been issued as an advance chapter as soon as it was ready.

Brief abstracts of the Survey's publications of the year are given in the annual report of the Director. The complete list of Survey publications affords, by means of finding lists of subjects and of authors, further aid in ascertaining the extent of the Survey's work in economic geology.

540-541

U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 541 PLATE I



H. M. Wilson, Geographer in charge.
Triangulation and topography by W. T. Griswold.
Surveyed in 1901 in cooperation with the State of Ohio.

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

MAP OF THE NORTHERN PART OF THE CADIZ QUADRANGLE, OHIO

Showing structure contours on top of the Berea sand

By D. Dale Condit

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

PETROLEUM AND NATURAL GAS.

OIL AND GAS IN THE NORTHERN PART OF THE CADIZ QUADRANGLE, OHIO.

By D. DALE CONDIT.

INVESTIGATIONS IN THE AREA.

The Cadiz quadrangle lies in eastern Ohio and includes parts of Harrison, Carroll, and Jefferson counties. In 1902 the region was examined by W. T. Griswold, then of the United States Geological Survey,[1] who published a report that included a structural contour map of the Berea sand. A few years later the same author, associated with M. J. Munn, made a study of the Steubenville quadrangle, adjoining the Cadiz on the east, and of the Burgettstown and Claysville quadrangles of Pennsylvania.[2] These reports, the first in which an attempt was made to show accurately the attitude of deep oil sands by means of contours, have led to the extension of fields already known, the discovery of several new oil pools, and, what is equally important, have been of great educational value.

The present author during the later part of 1912 spent several months in field work in the Steubenville-Cadiz region, with the primary object of collecting data for a geologic folio. Considerable information concerning oil and gas was obtained with a view to determining, if possible, favorable areas for future prospecting. Detailed discussion of the geology of both the Cadiz and Steubenville quadrangles is reserved for a later report, this preliminary paper being published to bring immediately to the attention of oil operators and drillers the more important results of the work. Only the northern two-thirds of the Cadiz quadrangle is shown on the map (Pl. I), as only that area receives attention in this paper.

---

[1] Griswold, W. T., The Berea grit oil sand in the Cadiz quadrangle, Ohio: U. S. Geol. Survey Bull. 198, 43 pp., 1902.

[2] Griswold, W. T., and Munn, M. J., Geology of oil and gas fields in Steubenville, Burgettstown, and Claysville quadrangles: U. S. Geol. Survey Bull. 318, 196 pp., 1907.

GEOLOGY.

STRATIGRAPHY.

The stratigraphy of the area has been discussed in detail in previous reports and only a brief outline is needed here. The surface rocks belong in the Conemaugh and Monongahela formations of the Carboniferous system. The Pittsburgh coal, which is the basal bed of the Monongahela formation, appears near the top of the hills at Richmond, East Springfield, and Germano, and is the principal source of fuel for the country people.

Beneath the Pittsburgh coal lies the Conemaugh formation, which comprises about 470 feet of sandstone, sandy shale, and clay, much of which is brick red, and a few coal and limestone beds of little economic importance. The most noteworthy stratum is the Ames or "Crinoidal" limestone member, which lies 210 to 225 feet below the Pittsburgh coal. It consists of one or more layers, having a total thickness of 2 to 10 feet, and can easily be recognized by the abundance of crinoid stems it contains.

The Allegheny formation, underlying the Conemaugh, is known only from drill records in the Cadiz quadrangle, but its upper part may be seen in outcrop along the valley of Yellow Creek a little north of the area mapped. It is the great coal-bearing formation of the Appalachian coal basin, and, although only a little more than 250 feet thick in eastern Ohio, it includes numerous coal and clay beds of great economic importance. One of these coal beds is extensively mined at Amsterdam by shafting.

The knowledge of deeper strata is derived from well records. The Allegheny formation is underlain by the Pottsville formation, which comprises about 150 feet of sandstone and sandy shale, including a few coal and clay beds. The Pottsville is the basal formation of the Pennsylvanian series ("Coal Measures") and rests upon Mississippian (lower Carboniferous) strata.

The Mississippian strata in the region are probably somewhat less than 700 feet thick and consist of sandy shale and several porous sandstone beds, which constitute reservoirs for petroleum and natural gas. Near their top is a thick, coarse sandstone best known among drillers as the Big Injun sand, and about 350 feet lower is the Berea sand, which is the great oil sand of eastern Ohio. It is believed to be the same as the famous Berea sandstone quarried at Cleveland. Few wells have been drilled deeper than the Berea sand and knowledge of lower rocks of the region is slight.

The distance from the Berea sand to the Pittsburgh coal varies rather widely, ranging from 1,450 to 1,530 feet in the area mapped to over 1,600 feet a few miles beyond the southeastern border. This irregularity is due, in part, at least, to an unconformity at the base of the Pennsylvanian strata. Near the end of Mississippian time the surface was exposed to erosion for an indefinite period, developing an uneven surface upon which the Pottsville formation of the Pennsylvanian was laid down. This ancient land surface has been recognized at numerous places along the outcrop of these beds in central Ohio and northwestern Pennsylvania.

Two well records are given to illustrate the general succession of rocks as reported by the driller.

Well No. 273, on the L. D. Rhinehart farm, one-half mile from East Springfield, starts 71 feet below the Pittsburg coal, which outcrops along the road a few rods to the north.

Log of well No. 273 (No. 1 on L. D. Rhinehart farm at East Springfield).

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	10	
Sand, gray	145	1
Limestone, blue, hard	10	1
Fire clay	20	1
Shale, red and gray	115	300
Show of coal	....	....
Shale	50	350
Sand, white, soft	40	390
Shale, dark	35	425
Coal	4	429
Shale, gray	16	445
Sand, white	20	465
Shale, black	10	475
Coal	....	....
Fire clay	30	505
Shale, black	70	575
Sand, gray, hard (Second Cow Run)	30	605
Shale, black, soft	50	655
Show of coal	....	....
Fire clay, white, soft	20	675
Shale, black	45	720
Sand, dark, hard	25	745
Shale and sand	40	785
Sand, white, soft (Salt sand)	70	855
Shale and sand, dark, hard	115	970
Sand, Big Injun, yellowish, soft	100	1,070
Sand, gray, soft	40	1,110
Shale, and blue rock, hard	270	1,380
Shale, black, soft	35	1,415
Sand, Berea, bluish, hard, slight show of oil and gas	45	1,460
Shale, bluish, soft	37	1,497

The record of well No. 690 (No. 7 on the J. Rutledge farm in sec. 13, Springfield Township) is not complete, but it is given to show the position of the Berea sand with reference to the Salt sand and Big Injun sand, both of which are in eastern Ohio locally oil and gas bearing, although of far less importance than the Berea.

Log of well No. 690 (No. 7 on the J. Rutledge farm, sec. 13, Springfield Township).

	Depth to top.	Depth to bottom.
	Feet.	*Feet.*
Conductor	0	12
Coal	390	....
Coal	415	....
Salt sand (gas)	680	....
Big Injun sand	855	970
Berea sand:		
Lime cap	1,342	1,368
First pay (oil)	1,368	1,378
Break (shale)	1,378	1,386
Second pay (gas)	1,386	1,392
Total depth	....	1,395

OIL AND GAS SANDS.

The region included in the Cadiz quadrangle and the adjacent area in eastern Ohio is really a "one-sand" country, for practically all of the oil comes from the Berea sand. Other sands of local importance are the Second Cow Run, the Salt, and the Big Injun. Their positions with reference to the Berea sand are shown in the two well records given above. The Big Injun sand contains a small amount of oil and is productive at Osage in the northwestern part of the Steubenville quadrangle. The Salt sand yields gas a few miles south of Richmond. The Second Cow Run sand is supposed to contain a small oil pool near Unionport and is said to yield considerable gas in the Kilgore field, about 4 miles west of Amsterdam.

The Berea sand, as shown in the record of well No. 690, consists of several parts. At the top is the hard impervious "lime cap" of drillers, which has a variable thickness, measuring 5 to 10 feet at Richmond and 20 to 30 feet at the Amsterdam, Kilgore, and Jewett pools. Beneath the lime cap is the First sand—a white, even-grained sandstone 4 to 12 feet thick in producing wells. In many "dry" holes no pay sand is found, the entire Berea, 30 to 60 feet thick, consisting of dense, dark, impervious rock similar to the lime cap.

Throughout a considerable portion of the western half of the area mapped the Berea has two pay sands, which are designated First and Second by drillers and are separated by a shale "break" several feet thick. The Second sand, which lies about 45 feet below the top of the Berea, is much less persistent than the First sand, but has proved to be equally or even more productive where present. It is found in most of the wells in the vicinity of Amsterdam, is fairly persistent in the greater part of Springfield and Loudon townships, and has been found as far south as the Harrison-Carroll county line.

The development of the great Scio oil field, situated a few miles west of the area mapped, is of interest in this connection. At first oil was obtained there solely from the First sand, and the existence of the Second sand was unknown. Gradually the flow diminished, and in the hope of restoring it a number of the holes were cleaned, drilled a few feet deeper, and reshot. To the great surprise of the drillers the production was greatly increased, in some wells to an amount greater than ever before. Thus the existence of a second pay sand in the Berea became known.

It is possible that an undiscovered Second pay sand may exist in the Cadiz quadrangle also, even in areas where considerable drilling has been done. Scarcely a single well south of the Harrison-Carroll county line penetrates deeply enough into the Berea to prove the presence or absence of the Second sand; and it is significant that the Second sand is productive in the Maxwell pool near the town of Cadiz, about 12 miles south of the Carroll County line.

STRUCTURE.

By geologic structure is meant the attitude of the strata or their position with reference to a datum plane. The best method of showing the structure of coal beds and of oil or gas sands is by a map on which are drawn lines representing contours connecting points of equal altitude. The structure of the Berea sand is shown in Plate I by contours having intervals of 10 feet, the datum being a surface 1,000 feet below and parallel with sea level.

At many points in the Cadiz quadrangle the altitude of the Pittsburgh coal above sea level was determined by spirit leveling. In areas where this coal is not present, as where it has been removed by erosion along the structural arch known as the Salem anticline, its position is calculated from that of the Ames limestone, which outcrops about 220 feet lower. Altogether, its altitude was determined at hundreds of places and its structure or "lay" shown by contour lines drawn through points of equal altitude. From this structural map the structure of strata at and near the surface in this region may be inferred with considerable accuracy, because all of them lie approximately parallel to it. The Berea sand, however, lies so deep and its distance below the Pittsburgh coal varies so widely from place to place that its structure map of the coal will not apply to the sand directly. By taking account, however, of the ever-varying interval between the Berea and the Pittsburgh, as shown by well records, an accurate structural map of the oil sand differing considerably from that of the coal may be deduced. The difference in the position of the contours on Plate I and on Griswold's map[1] is due largely to corrections made possible by new well records.

The Appalachian coal field is a great canoe-shaped basin into which the rocks slope from all sides. Eastern Ohio lies on the west side of this basin, hence the prevailing dip is southeastward. Numerous wrinkles or folds in the strata along the slopes of the basin give anticlines and synclines which cause local flattenings and even reversals of the dip, but whose effects are very insignificant when the basin is considered as a whole. Their influence, however, in the accumulation of petroleum and natural gas has long been known and for this reason their accurate mapping is important to the oil operator.

In the Cadiz quadrangle the most important structures so far as oil is concerned are the Germano synclinal basin and the broad Salem anticline which occupies much of the central portion of the area mapped. These folds trend approximately northeast and southwest, thus according with the general direction of folds in the Appalachian region. The flank of the Salem anticline dips southeastward with fair regularity for many miles, being interrupted only by undu-

[1] The Berea grit oil sand in the Cadiz quadrangle, Ohio: U. S. Geol. Survey Bull. 198, Pl. I, 1902.

lations that suggest cross folding. Along the crest rise several minor domes, the highest of which is near the village of Salem. A promontory-like area extends eastward beyond Richmond, immediately north of which lies a shallow depression, adjacent to a low "saddle" in the Salem anticline.

The Germano basin lies west of the Salem anticline and is a canoe-shaped depression whose axis lies near the village of Germano. Its southwestern portion is constricted by a westward extension of the Salem arch, along which lies the Jewett oil pool. Northwestward from the basin the rocks rise rapidly to the crest of another arch about 2 miles beyond Amsterdam.

SALT-WATER SATURATION.

It is generally conceded that the structure of the rocks is an important factor in the accumulation of oil and gas and that a contour map showing the anticlinal and synclinal folds of a region is indispensable for the intelligent selection of favorable territory for drilling. But the extent to which the sand is saturated with salt water is also important and should be known to anyone making a location. It has been found that there is an upper limit of saturation of the various sands and that there has been a widespread accumulation of oil at this water line. In the Berea sand the water line varies considerably in altitude from place to place. Well No. 249 near Richmond, which struck the Berea a little above the 740-foot contour (260 feet below sea level) is reported to be water bearing. But well No. 242, which found the Berea a little above the 790-foot contour, gives gas. In the Hopedale field, 3 miles southeast of Cadiz Junction and beyond the area represented on the map, a strong flow of salt water is encountered in the wells reaching the Berea sand at the 730-foot contour and gas appears in wells reaching it at the 775-foot contour. In the Jewett pool the water line is somewhat higher, salt water being found at the 780-foot contour and gas at the 800-foot contour. Evidently the upper limit of salt water rises northward across the Germano basin, for well No. 225 (near Amsterdam), in which the top of the Berea sand lies near the 800-foot contour, yielded much salt water.

The altitude of the water line in the Berea sand thus varies considerably from place to place, but becomes progressively higher northward. Its rise is gradual along both sides of the Salem anticline, but differs considerably on the two.

The importance of knowing definitely the extent of saturation of the oil sand is demonstrated by the oil pools in the Cadiz and Steubenville quadrangles. Many of these, including the Island Creek, Pekin, Knoxville, and Osage, follow more or less closely the strike of the rocks and maintain a definite relation to the water-bearing portion of the Berea sand. Were it not for the impervious areas in the oil sand which prevent free circulation, the depth to the water line would be an almost unerring guide to the depth at which the pools should be sought. Unfortunately, however, the condition of the sand governs in part the location of the pools and must be considered in seeking them.

Many pools occur both above and below the water table, as is illustrated by a number of producing areas in the Steubenville quadrangle and elsewhere. It is noteworthy, however, that even in areas where the oil sand lies below the level of saturation, many oil pools closely follow the strike of the rocks for several miles. Such occurrences suggest that the water level fluctuated during former geologic ages, and that each hydrostatic condition was accompanied by the accumulation of oil.

From evidence obtained in areas not shown on Plate I the following generalizations can be made: (1) In areas where the sand lies well above the water line, the oil occurs in very irregular pools, the shapes and dimensions of which are controlled by the porosity of the sand rather than by the direction of dip. It is well known that the Berea sand is for the most part only slightly permeable and that the oil pools lie at favored places where it is locally of more open texture. Occurrences on anticlinal slopes above the water line represent permeable areas in which the oil is retained by an adjoining impermeable sand. (2) The greater number of oil pools found at or near water line lie in "embayments" along the flanks of anticlines rather than on anticlinal "noses" or promontory-like structures. This fact has an important bearing on prospecting and is also of considerable interest as suggesting that the water line has in comparatively recent geologic time receded from a higher level. (3) In pools below the water line the oil as a rule follows more or less closely the strike of the rocks for some distance, suggesting that the pools are the result of one or more ancient and lower water levels, each of which produced a corresponding accumulation of oil.

POOLS OF THE AREA.

AMSTERDAM AND VICINITY.

The Amsterdam pools are the most recently discovered in the Cadiz quadrangle, and the prospects for important extensions and new developments are good. Both the First and Second sands of the Berea are productive, some wells producing from both. The maximum production of wells in the First sand is about 30 barrels a day, but several in the Second sand are reported to yield 150 to 200 barrels.

The wells along the Yellow Creek valley southwest of Amsterdam are in the First sand, but some in the northwest corner of sec. 24, Springfield Township, draw from both sands. Nearly all of the oil produced in sec. 30, London Township, comes from the Second sand. The same is true of the gas wells to the northwest in secs. 25, 31, and 32, and also farther west near the village of Kilgore, which lies just beyond the edge of the area mapped. About one-fourth mile beyond Kilgore is another oil pool.

Much of the gas in the Kilgore field comes from the Second Cow Run sand.

The Second sand of the Berea has been noted in wells 2 miles south of the gas field in secs. 25 and 31, London Township. A slight "showing" of gas and oil was found in well No. 362. The Second sand was recorded in well No. 361, but was not found in well No. 364. Northward from the gas field the occurrence of the Second sand is uncertain. It is productive in well No. 628, in sec. 2, but is missing in well No. 627. Some gas has been found in wells Nos. 624, 239, 618, and 717, near the north edge of the quadrangle, but is said to come from the First sand of the Berea in all of them.

South of the above-mentioned gas field lies an untested area which appears structurally favorable for yielding both oil and gas. The sand in the Kilgore oil pool lies at about the 870-foot contour. The productive area is located on the west flank of the anticlinal "nose," which separates it from the Amsterdam pool. An extension of the Amsterdam pool along the same level would lead southwestward between the dry holes Nos. 667 and 668. Wells Nos. 643, 653, and 666 are said to have a good development of the First sand in the Berea; hence there is a possibility of production from it as well as from the Second sand. Well No. 636, although lying considerably higher on the anticline than the oil wells to the east and west, is reported to yield considerable oil along with the gas. The valley of Elk Fork in sec. 36 and the northern part of sec. 6 to the west are suggested as favorable territory for the search for both oil and gas. Gas may also be expected in sec. 25, provided the sand is good.

All the wells in the immediate vicinity of Amsterdam, as well as those a mile northeastward along the valley of Yellow Creek, probably draw from the First sand of the Berea. All are moderate producers, and start at 2 to 10 barrels. A good development of the Second sand, which is gas bearing, was found in well No. 690 and in several others near by. In the oil wells to the southeast, near Wolf Run, the Second sand likewise has gas, but is also oil bearing, and is said to furnish much of the yield. Apparently it is only a matter of time until the Wolf Run area is joined with that to the northwest by a continuous line of producing wells. The structure in the territory toward the east in sec. 1 appears favorable for prospecting, and may yield from both sands. Well No. 282 was drilled only to the First sand, and gave a showing of oil. Much untested territory lies farther east. Well No. 279 found a hard sand. Well No. 266 is dry in the Berea, but gave a showing of oil in the Big Injun sand. Well No. 269, in sec. 14, Ross Township, gave a showing of oil 28 feet below the top of the Berea.

RICHMOND AND VICINITY.

The pay sand of the Berea in the gas wells at Richmond is less than 4 feet thick, and lies 5 to 10 feet below the top of the Berea. The structure to the south appears the most favorable for oil, but a poor sand is reported in the several dry holes that have been drilled. Well No. 302 gave a showing of oil and gas, and Nos. 305 and 306 a showing of gas. Well No. 247, of which no record was obtained, was drilled at a location theoretically good, but penetrated a sand reported as dense and impervious, and found no oil. Considerable drilling has been done recently on the Kilgore and neighboring farms east of Richmond and just beyond the edge of the area mapped, and both oil and gas have been found. On the Kilgore farm a 2-barrel oil well, from which 2 barrels of salt water were also pumped daily, found the sand at about the 730-foot contour. Oil and gas are associated in a well half a mile north and a little higher structurally. The failure to obtain oil or gas in holes drilled a little southwest of this well is attributed to the hardness of the sand. These facts give little encouragement for the finding of much oil in the vicinity of Richmond.

Drilling near East Springfield and Salem has given uniformly unfavorable results, disclosing at best only a slight showing of oil or gas. Well No. 741, recently completed near Salem, is added to the long list of dry holes in that region, and the sand is reported as very inferior and compact. It seems improbable that either oil or gas will be found in the higher portion of the Salem anticline. The east and west slopes of the Germano basin are suggested as more likely territory for prospecting, although locations can not be definitely specified. There should, however, be an accumulation of oil at the upper limit of salt water, which is at or near the 800-foot contour. A showing of oil has been reported in wells Nos. 209, 236, and 320.

GAS FROM MUD LUMPS AT THE MOUTHS OF THE MISSISSIPPI.

By E. W. Shaw.

MUD LUMPS.

The development of "mud lumps" at the mouths of the Mississippi is generally, if not always, accompanied by the formation of mud springs, from which considerable quantities of combustible gas escape, suggesting that gas is the primary agent of mud-lump upheaval and that it may exist in large and valuable pools beneath the surface. Several companies have considered sinking test wells, and one company has sunk a well designed as a test to a depth of about 2,000 feet at "The Jump," a few miles above the Head of the Passes. Small amounts of gas were found at several different depths in this well, but not in commercially important quantities. However, the well was not located on a recently active lump and perhaps not even on or near an old one.

The present report, which is based on a preliminary examination of the mud lumps, made by the writer in November, 1912, sets forth the principal facts which seem to have a bearing on the possible existence in these places of valuable accumulations of gas.

The mud lumps of the Mississippi are great swellings of soft bluish-gray clay which rise in the shallow water near the mouths of the river, commonly forming islands with a surface extent of an acre or more and a height of 5 to 10 feet. The lumps are rounded or elliptical at first, but are soon carved into irregularity and are sometimes cut in twain by wave action. Their period of growth ranges from a few hours to several years and is commonly irregular. Generally a mud lump rises in a few weeks or months to a height of 4 or 5 feet above the surface of the water. Then it remains quiescent and is beaten down by the waves in the course of a few years. Those which rise slowly are, of course, considerably worn before they stop growing. Those which rise more rapidly and in protected places bear a cap of laminated silt having a maximum thickness of 10 or 15 feet.

The structure of the mud lumps appears to be comparable to that of bysmaliths. A dark bluish-gray clay of medium stiffness and great stickiness forms the central core. Upon and around this core is a series of faulted and folded strata of sand and silt which have been carried up from the sea bottom and deformed in the upheaval. Fissures are numerous and faults are normal, beautiful examples of block faults being common. A peculiarity of many of the new mud lumps is that the surface resembles a plowed field with irregular furrows in every direction. This effect, which has excited much wonder, appears to be the result of slight erosion of an extensively fissured surface.

MUD SPRINGS.

Among the most conspicuous and impressive features of the lumps are the mud springs, which are active on many, though not on all, of the lumps. The discharge from these springs consists of salt, watery mud (sludge) and gas. The amount of sludge discharged is very small and the flow of gas is less than 10 cubic feet an hour. The mud accumulates around the vents and forms cones ranging from a few inches to several feet in height and having a rather striking resemblance both in form and explosiveness to miniature volcanoes.

Careful examination reveals the fact that many and perhaps all of the gas-mud springs are closely associated with fissures. Commonly the fissures are so obliterated that it is difficult to make sure of this fact, but on the freshest lumps both the association and the absence of mud springs between fissures are evident. It seems, therefore, that when a lump is pushed up, the upper part, especially the sand and silt cap, is somewhat extensively fissured. Water rises in the fissures at least to the level of the sea, and gas bubbles rise through the water, causing erosion of the sides of the fissure. In certain favorable locations, along fissures where conditions are just right, the rise of gas bubbles through the water causes sufficient erosion to keep a vent open long after the remainder of the fissure closes entirely. The delta materials contain a large amount of both marsh gas and water, so that wherever a hole a few feet deep is made it almost immediately fills with water and bubbles with gas.

COMPOSITION OF THE GAS.

Two samples of gas were collected from mud springs and on analysis were found to consist principally of marsh gas (CH_4) with some oxygen, nitrogen, and carbon dioxide.

Analyses of gas from mud lumps at mouth of Mississippi River.

[George A. Burrell, Bureau of Mines, analyst.]

	Laboratory No. 3149. 2½ miles southeast of Pass a Loutre lighthouse. Size of sample at atmospheric pressure about 0.1 cubic foot.		Laboratory No. 3150. 3 miles west of Burrwood, La. Size of sample at atmospheric pressure about 0.5 cubic foot.	
	As received.	Air free.[1]	As received.	Air free.
CO_2	4.98	5.22	2.14	2.42
O_2	1.38	.00	2.70	.00
CO	.00	.00	.00	.00
CH_4	77.05	82.50	84.50	97.02
N_2	16.59	12.28	10.66	.56
	100.00	100.00	100.00	100.00
Heating value per cubic foot at 0° C. and 760 mm. British thermal units		879		1,033

[1] Assuming that the O and part of the N got into the sample in the form of air, either before or after the sample was collected.

The samples were collected with considerable care by displacement of water from a large bottle, which was held inverted over the vent with the mouth just below the water surface. A 6-inch funnel was used to guide the gas into the bottle.

Sample No. 3149 was taken from a spring about the middle of the south half of the eighth lump southeast of Pass a Loutre lighthouse. The surface of the sludge in the spring was about 4 feet above mean tide. The other sample, No. 3150, was taken on the west side of Big Cactus lump from a vent which is barely covered at low tide. No water or mud seemed to be flowing from this vent.

The results of the analyses are believed to show correctly the general composition of the gas at the particular vents where the samples were taken. It should be borne in mind, however, that gas from other vents may possibly have a very different composition. Even in the analyses given it may be that owing to the fact that different gases have different degrees of solubility in water the amounts stated are not exactly correct. Water under ordinary conditions of temperature and pressure dissolves about 2 per cent of nitrogen, 4 per cent of oxygen, and 179 per cent of carbon dioxide. For this reason the bottles were filled with water from the throats of the vents, for that was probably nearly saturated with gas, particularly the water used in collecting sample No. 3149. If pure water had been used, the results, especially for those gases present in relatively small amount, would, no doubt, have been very different.

The analyses seem to indicate that the gas is not of deep-seated origin, but has developed within a few feet of the surface, for certain hydrocarbons commonly present in gases found deep in the earth are lacking. The principal constituent, methane (CH_4), emanates from most if not all marshes and generally carries with it minor and variable amounts of nitrogen, oxygen, and carbon dioxide, all of which are produced in the decay of vegetable matter. Natural gas associated with petroleum generally contains other hydrocarbons, particularly ethane, the amount of which ranges from a trace up to 15 per cent or more. Some gases found in deep wells are, however, practically pure methane. Ethane and ethylene, on the other hand, have rarely if ever been found in marshes. Hence, it appears probable, though not certain, that the gas from the mud lumps is produced in the ordinary reduction process, which affects plant material in marshes.

CONCLUSIONS.

It seems improbable that the mud lumps are forced up by natural gas for the following reasons:

(1) As Lyell and Hilgard long ago pointed out, the amount of gas given off seems too small to accomplish such results. There is no reliable report of a flow more rapid than about 10 cubic feet an hour.

(2) If the mud lumps were forced up by gas one might expect the rate of growth to increase rapidly and explosions to be common.

(3) The lumps are composed largely of clay, which seems to be present nowhere else in the delta in such thick beds. If their upheaval were due to natural gas the more fluid beds, such as clay, would probably be thinned instead of thickened.

(4) The lumps seem to have a close relation to the mouths of the river, being most common to the west and within 2 or 3 miles of the end of a pass. They are also more active at and following times of high water.

Though the mud lumps and gases probably can not be taken as indicating valuable pools of gas below, neither they nor any other known circumstance in the region can be taken as contrary evidence. It is very probable that only a part of the marsh gas escapes and that some is entrapped in the silt which is continually accumulating on the delta. The gas which has thus been buried in the thousands of years during which the delta has been growing seems to be now in part disseminated and in part collected into more or less definite pools. Several deep wells have been sunk in the lower end of the delta 70 to 125 miles west of the Passes and most of them have found considerable amounts of gas. One well in sec. 51, T. 19 S., R. 19 E., became uncontrollable from gas found at a depth of about 1,700 feet. Gas escapements of considerable size are numerous, particularly in Terrebonne Parish. Prospecting is difficult because of the softness of the materials, which make the control of gas under any considerable pressure a serious task. Perhaps an economical way will be found to collect the marsh gas from many shallow wells, each yielding only a few hundred cubic feet a day.