THE DUNCAN GAS FIELD, STEPHENS COUNTY, OKLAHOMA.

By CARROLL H. WEGEMANN.

INTRODUCTION.

The Duncan gas field, sometimes known as the Hope field, lies in Stephens County, Okla., near the post office of Cruce, about 10 miles northeast of the town of Duncan. (See Pl. VIII and fig. 3.)

The first well in the field was drilled about 1907, in the NW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W., and is reported to have obtained some gas and oil but was abandoned. The Skelly Drilling Co. a few years later drilled three gas wells in the E. ½ sec. 12, T. 1 N., R. 6 W., and two dry holes, one a few rods west of the center of the same section and another in the NW. ¼ sec. 7, T. 1 N., R. 5 W. It is understood that these wells have since been taken over by the Washita Gas & Fuel Co., which itself began drilling in the field on March 20, 1912. The company's first well, which was a "gasser," was drilled in the NW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W. The company has drilled one other gas well in the same quarter section and two dry holes, one in the SW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W., and one near the middle of sec. 1, T. 1 N., R. 6 W.

A dry hole was drilled by the Stephens County Oil & Development Co. in the SE. ¼ SW. ¼ sec. 20, T. 1 N., R. 5 W., and a dry hole has been drilled by another company in the SW. ¼ SE. ¼ sec. 30, T. 1 N., R. 5 W.

The principal flow of gas in the wells is obtained at about 850 feet, and the wells vary in production from 3,000,000 to almost 18,000,000 cubic feet a day. A pipe line has been laid from the field to Duncan and supplies that town with gas.

The present report has been prepared by the United States Geological Survey under a cooperative agreement with the Oklahoma Geological Survey, according to which each organization furnished a part of the funds necessary for the work.

The field work for the report was done in September, 1914, the writer being assisted by Mr. Ralph W. Howell, of whose careful work he desires to express his appreciation. Thanks are due to Mr. B. A. Barnes, a resident of Duncan, for much information in regard to the

field; also to the Washita Gas & Fuel Co., the Stephens County Oil & Development Co., and Mr. W. G. Skelly, for logs of wells drilled in the field.

DRAINAGE AND TOPOGRAPHY.

The Duncan field lies just south of the divide between Wild Horse and Brush creeks, both of which are branches of Washita River. The relief in the field is not over 250 feet, the most prominent topographic feature being an escarpment formed by a bed of sandstone which partially encircles the field. The region is for the most part covered with post-oak timber.

STRATIGRAPHY.

The surface rocks in the Duncan field are red beds of Permian age. They consist of shale, sandstone, calcareous sandstone and shale conglomerate. The shale is red or bluish gray in color. The sandstone is predominantly white or buff but is in some places red. The cement of the sandstone is calcareous and in some beds the lime content increases in amount until the rock is a calcareous sandstone. At the bases of certain of the sandstone strata, or embedded in them, are thin beds of conglomerate, the pebbles of which consist of fragments of shale. The fragments are more or less angular and do not appear to have been transported far from their place of origin, being of the same material as the ordinary Permian shale.

The most important bed or group of beds in the Duncan field structurally and stratigraphically is a series of sandstones and interbedded shale about 40 feet in thickness, which forms an escarpment that partly encircles the field. The surface of the bed is in most places timber-covered, and the line of wooded hills produced by its outcrop is a conspicuous topographic feature. The individual beds of the group are variable in thickness and extent but the group as a whole covers a broad area and has been traced for about 60 miles from a point north of Foster, a small settlement 18 miles east of the Duncan field, to the north flank of the Wichita Mountains. The sandstone in the Duncan field is white, but that in part of the adjoining area is pink or red, and there are places where the change from pink to red may be observed in a single outcrop. This sandstone group forms the best horizon marker in the region and it is by means of it that a considerable part of the structure in the Duncan field has been determined.

Below the sandstone lies about 100 feet of shale containing near its middle one or more thin beds of white sandstone, which are inconspicuous in outcrop. The shale is underlain by beds of sandstone interstratified with shale, the whole being about 300 feet thick. Where the sandstone beds reach the surface they form rounded knolls or ridges, which, however, are inconspicuous as compared with

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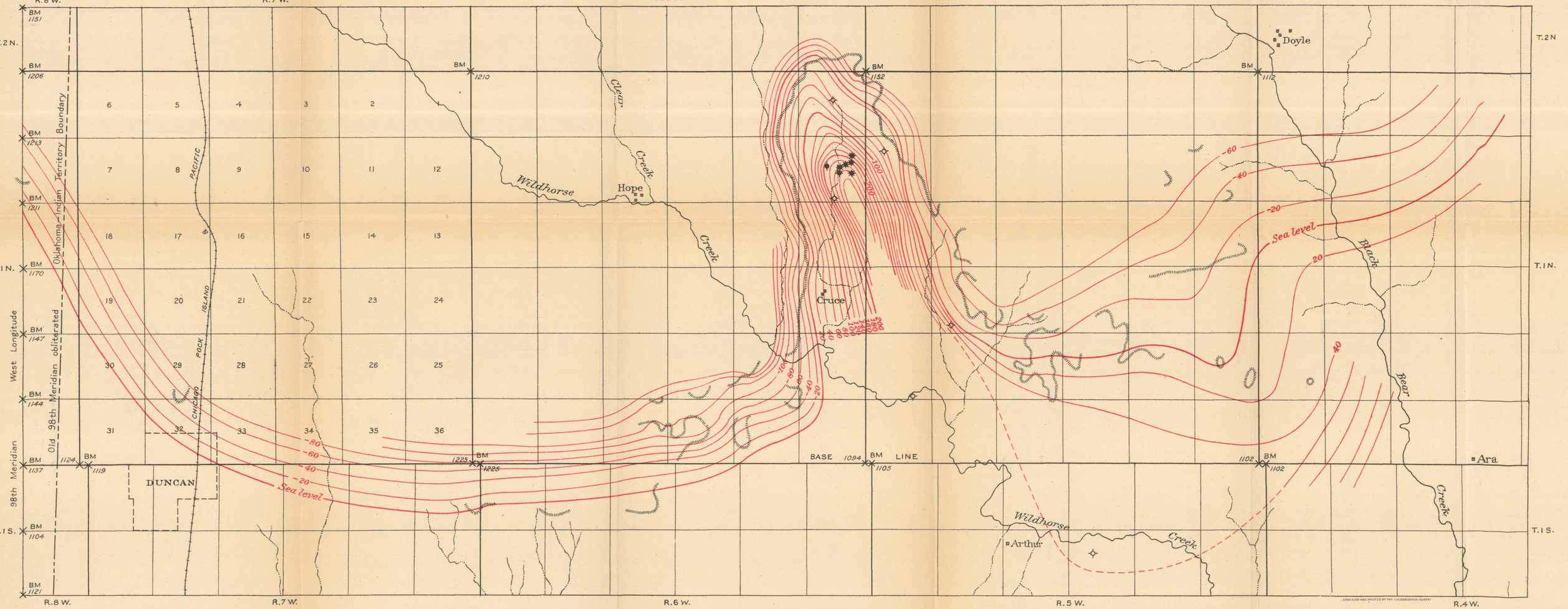

MAP OF THE DUNCAN GAS FIELD, STEPHENS COUNTY, OKLAHOMA

By Carroll H. Wegemann and Ralph W. Howell

Scale 1/63,360

1 ½ 0 1 2 3 4 5 Miles

1915

Show of oil

Gas well

Show of oil and gas

Dry hole

Structure contours
Contour interval 20 feet

Outcrop of sandstone beds forming escarpment

U. S. G. S. bench mark showing altitude in feet

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the escarpment of the higher group of sandstone beds. Below the soft sandstone and shale beds or about 400 to 500 feet below the base of the escarpment-forming sandstone, is a group of beds in which sandstone predominates and which, where it reaches the surface, produces hills and ridges of considerable height. The soil formed by this group of sandstones supports a thick growth of post oak like that of the higher escarpment-forming sandstone.

The nature of the strata which underlie the Duncan field is shown by the logs of the gas wells, the deepest of which is in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W. In this well red, brown, and bluish shale alternate with thinner beds of white sandstone to a depth of 1,825 feet, but below this depth the shale is prevailingly blue. At 1,900 feet a 20-foot bed of limestone is recorded. From observations in adjacent fields, it is believed that the red color in this region is confined to the Permian and that thick beds of limestone are not found in that formation. It therefore seems probable that the unconformity between the Permian and the underlying Pennsylvanian lies in the well mentioned above, between the red shale and the limestone, probably at the base of the 25-foot bed of "yellow quicksand" recorded at 1,825 feet. As none of the other wells in the field reached this depth it is impossible to demonstrate the presence of the unconformity by a comparison of logs. Its presence can be shown, however, in the Healdton and Loco fields, and the unconformity may be observed in surface exposures along the west end of the Arbuckle Mountains. Here the unconformity between the Permian and the underlying Carboniferous is well exposed east of the town of Poolsville, where steeply dipping Paleozoic beds, ranging in age from Ordovician to Pennsylvanian, are overlain unconformably by flat-lying deposits of Permian age.

Fossils are comparatively rare in the Permian. About 25 miles southwest of the Duncan field, in Cotton County, the bones of primitive amphibians have been found, and fossil leaves of Permian age have been collected in the Healdton field and near Dixie and Poolsville, southeast of the Duncan field. In the field itself certain of the sandstone beds bear the marks of plant stems, but the impressions are so indistinct that the nature of the plants can not be determined. They are perhaps algæ. Some of the thin beds of calcareous sandstone contain also very much broken fragments of shells, among which bits of crinoid stem were recognized.

INTERPRETATION OF STRUCTURE CONTOURS.

The structure contours shown on Plate VIII are drawn on the surface of the main gas sand (indicated on Pl. IX by correlation lines between plotted logs) and represent the slope of the folded surface of that bed. Every point along any given contour is at the same

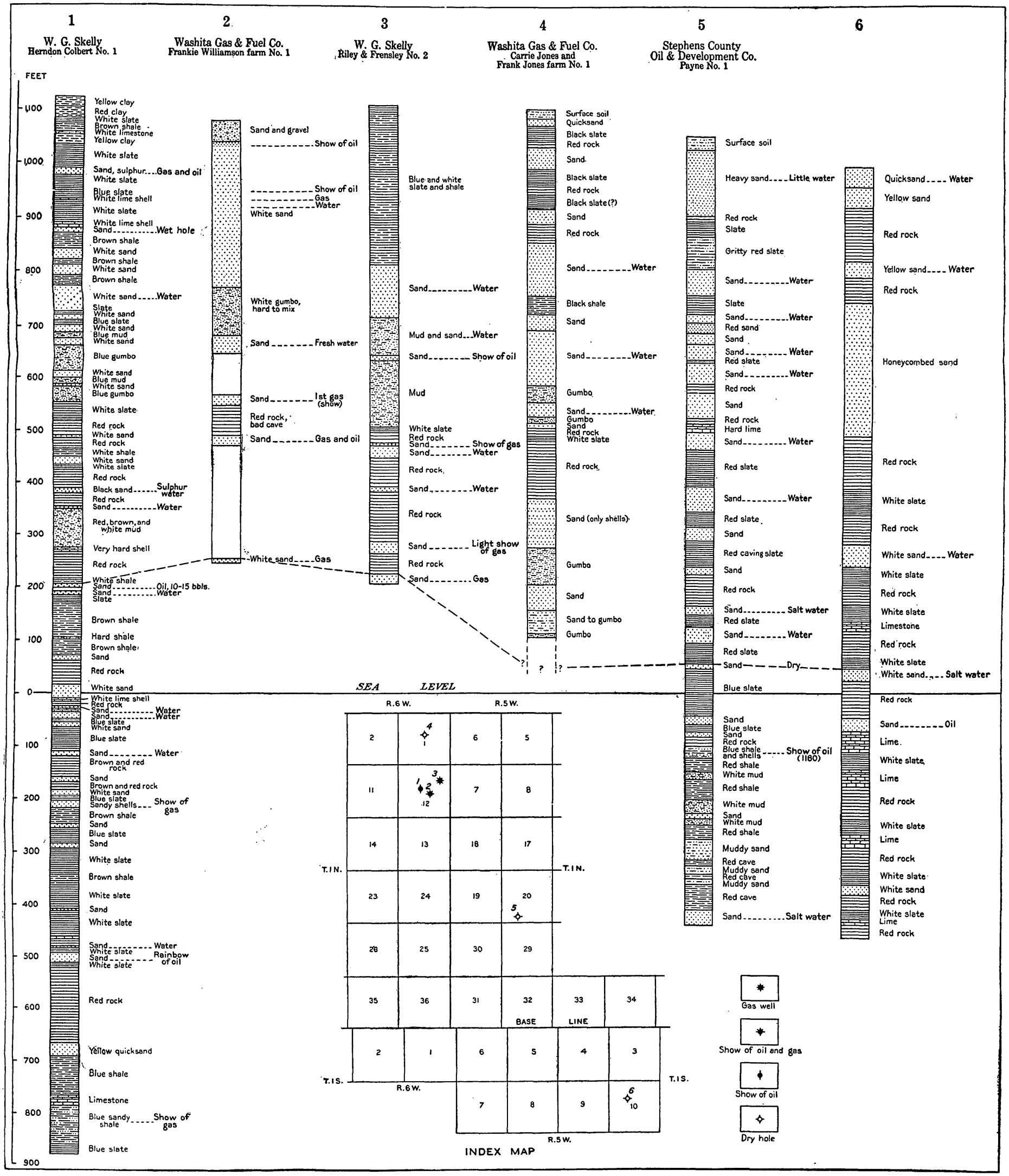
elevation above or below sea level, the lines being drawn at intervals of 20 feet. To one unfamiliar with the interpretation of contours the following somewhat fanciful conception may be of assistance.

Were it possible to remove all the overlying strata and to walk about on the surface of the oil sand, the course followed by one who endeavored to walk always at an elevation of 200 feet above the level of the sea, never stepping up or down but walking always at the one level, would be that indicated by the 200-foot contour on the map. When the pedestrian came to a knoll or jutting point, he would be compelled, in order to keep at the same level, to walk around its side. When he reached the valley which lay between this knoll and the next he would be obliged to walk up the valley to a point where its floor was level with that of the hillside that he had just left. In other words, his course, were it represented by a line, would outline the form of the hills and valleys or their contour. A series of lines drawn at given intervals above sea level will represent very clearly to one accustomed to the reading of contours the form of the surface represented by them.

STRUCTURE.

The Duncan anticline proper is about 2 miles broad by 5 miles long, its axis trending a few degrees west of north. About 15 miles south by southeast of this fold, in line with its axis lies the Loco gas field, which is 10 miles northwest of the great Healdton field of Carter County. (See fig. 3.) Roughly speaking the three fields lie on a curve which partially encircles the west end of the Arbuckle Mountains. The mountains lie 25 miles east by south of the Duncan field. About 30 miles west of the Duncan field is the Lawton field, at the eastern extremity of the Wichita Mountains, and between the Wichita and Arbuckle uplifts there is a low arch, the north flank of which is outlined by the escarpment which is so prominent in the Duncan field. This escarpment may be traced from a point in sec. 23, T. 2 N., R. 3 W., north of Foster post office, southwestward to and around the Duncan gas field and thence to an exposure on the north side of sec. 32, T. 1 N., R. 7 W., 1 mile north of the town of Duncan. From this place it may be traced northwestward in a straight line to the NE. ¼ sec. 24, T. 4 N., R. 11 W., northeast of the Wichita Mountains. It doubtless extends farther northwest along the mountain flank. The dips along this escarpment are comparatively low, not exceeding 1°, except in the vicinity of the Duncan field.

The southern limb of the low fold between the two mountain uplifts can not be defined because of lack of exposures, and hence the exact position of the axis of this fold is unknown. The cross fold which forms the Duncan anticline lies north of the axis, and the domes of Loco and Healdton lie south of it. The three fields are in no sense



LOGS OF WELLS IN THE DUNCAN GAS FIELD, OKLAHOMA, AND INDEX MAP SHOWING LOCATION OF WELLS.

along the axis of a continuous cross fold. They are in fact distinct structures but are so situated with reference to the Arbuckle uplift that they appear to have been originally formed at the same time by stresses acting between the rigid mass of the mountains and the strata of the plains. The Duncan field does not, however, like the fields south of the mountain axis, give evidence of two periods of folding. Its structure is more regular than that of the other oil or gas fields mentioned. As shown on Plate VIII, the axis lies midway between the sandstone escarpments on either side, and the beds dip from the axis at angles of about 3°. The anticline plunges rather steeply at its north end, and at its south end the escarpments formed by the outcropping edges of the sandstone beds diverge in a direction almost at right angles to the axis of the fold, the structure itself appearing to merge into that of the low arch above mentioned, connecting the two mountain uplifts. In the E. ½ sec. 6 and in sec. 5, T. 1 S., R. 5 W., a line of timbered hills is formed by the lowest group of sandstone beds exposed in the vicinity of the field. This line of hills may be traced southeastward to sec. 6, T. 2 S., R. 4 W., at which place grahamite deposits have been mined in the sandstone strata which form the ridge. As this ridge lies in approximate alignment with the axis of the Duncan fold, it may be to a certain extent anticlinal, although observations in the neighborhood of the grahamite mines, as well as in sec. 6, T. 1 S., R. 5 W., indicate that the beds in these two localities are horizontal. In sec. 32, T. 1 S., R. 4 W., about 1½ miles west of the town of Alma, sandstone beds exposed in a gulch north of the road appear to dip northward with the grade of the stream. This dip may in fact be to the northeast, away from the possible anticlinal axis on which the grahamite mines are situated. Because of the lack of definite beds which can be traced from place to place in this region, the exact nature of the structure is very difficult to determine.

OIL AND GAS.

The principal gas horizon in the Duncan field, a sand from 7 to 19 feet thick, lies at a depth of 800 to 900 feet below the surface and about 900 feet above the base of the Permian as the formation is here developed. Showings of gas and heavy oil in small quantity are obtained in some of the wells in shallower sands, and it is reported that the gas sand on the limbs of the anticline below the gas pool in one well (in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W.) carries heavy oil in small amount.

None of the wells in the productive area in the Duncan pool extend far below the principal gas horizon, and hence the sands in the 900 feet of Permian beds which underlie this horizon have not been tested in the best part of the field. The deep well already mentioned,

in the SE. ¼ NW: ¼ sec. 12, T. 1 N., R. 6 W., encountered showings of gas at a depth of 1,300 feet and a "rainbow" of oil at 1,625 feet, but whether or not these two beds would be productive on the crest of the anticline it is impossible to say in advance of drilling.

From a comparison of well logs as well as from studies of the surface rocks in the Duncan, Lawton, Loco, and Healdton fields, the following tentative correlations of the oil and gas sands may be made: The principal gas sand at Duncan is probably the same as the "400-foot sand" in the Lawton field, in which case the sand with showings of gas struck at 1,335 feet in the deep test well in the NW. ¼ sec. 12, T. 1 N., R. 6 W., of the Duncan field is the probable equivalent of the "800-foot sand" in the Lawton field. The gas sands at Loco probably lie at or a little above the same horizon, and the productive sands of Healdton some 300 or 400 feet lower, corresponding in a general way to the sand carrying showings of oil which was struck in the deep well at Duncan at 1,625 feet.

The extent of the gas pool to the southeast and the possible presence of oil in commercial quantity in the Duncan field are subjects on which no positive statements can be made. It appears probable that the axis of the anticline for at least a mile southeast of the gas wells should prove good gas territory. The well of the Stephens County Oil & Development Co. in the SW. ¼ sec. 20, T. 1 N., R. 5 W., was drilled too far east to test the possibilities of the anticline in this locality. The dry hole, however, in the SE. ¼ sec. 30, T. 1 N., R. 5 W., is in a good location. Its log was not obtained, but if it reached a depth of 1,000 feet without encountering oil or gas in commercial quantity it is probable that the anticline is barren in this part of the field, at least as regards the sands now producing in the Duncan field.

As the sandstones exposed in sec. 5 and the E. ½ sec. 6, T. 1 S., R. 5 W., are lower than any of the beds exposed in the vicinity of the gas wells, it is evident that the gas sand must be nearer the surface and hence the structure higher in secs. 5 and 6, T. 1 S., R. 5 W., than farther to the north. The dips in this locality are, however, very small, and so little is known of the exact shape of the fold that it is impossible to make predictions in regard to it. The well in NW. ¼ sec. 10, T. 1 S., R. 5 W., appears to have been drilled too far east to have been a fair test. The plunging end of an anticline like that on which the gas wells are situated is always a very favorable place for the accumulation of oil or gas, but it may be questioned whether in the more gentle folds, such as the fold which appears to be indicated by the sandstone ridge above mentioned in secs. 5 and 6, T. 1 S., R. 5 W., oil or gas are as likely to accumulate, even if the beds on the crest of the fold are in reality higher than those on the point of the anticline.

Prospecting for gas in the Duncan field should be carried on along the crest of the anticline as indicated on Plate VIII, the first well being placed about half a mile south of the present productive wells. If the first well is successful other wells may be drilled at intervals of about half a mile along the axis to the southeast until the limit of the pool in this direction is reached.

The gas probably extends also about half a mile northwestward along the axis from the present productive wells.

The chances for obtaining oil in large quantity in the immediate vicinity of the gas wells would appear to be poor, inasmuch as the deep well in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W., was unproductive. Oil may possibly be found beyond the limits of the gas pool to the southeast along the anticlinal axis as indicated on Plate VIII, but this possibility can be tested only by systematic exploration of the gas pool in that direction as indicated above.

As the gas-bearing sand now known in the Duncan field lies 900 feet above the base of the Permian, and as lower Permian sands produce oil and gas in neighboring fields, the field can not be considered as thoroughly tested until the base of the Permian on the crest of the anticline is reached by the drill. The approximate depth to the base of the Permian at any given point, the elevation of the surface being known, may be estimated from the structure contour lines given on Plate VIII as follows: If at any given point the elevation of the surface is 1,100 feet and the elevation of the gas sand as indicated by the contours on Plate VIII is 280 feet, the gas sand is 1,100 feet minus 280 feet, or 820 feet below the surface. As the base of the Permian is about 900 feet below the gas sand, it is 820 feet plus 700 feet, or 1,720 feet below the surface at the given point.

If the Permian sands below the gas sand be found unproductive in the most favorable part of the Duncan anticline—that is, in the vicinity of the wells already drilled or just southeast of them—they will probably be barren in other parts of the field. If, however, they are found to carry oil or gas in paying quantity test wells in other parts of the field should reach them.

COMPOSITION OF GAS IN THE DUNCAN FIELD.

Below is a report of an analysis made by the Bureau of Mines of a sample of gas, collected in the Duncan field by the author of this report.

The sample was taken September 25, 1914, from a well drilled by W. G. Skelly in the NE. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W.

Analysis of gas from the Duncan field, Oklahoma.

[Laboratory No. 5862.]

CO_2	0.4
CH_4	91.9
C_2H_6	4.1
N_2	3.6
Total	100.0

Specific gravity (air=1), 0.59.
Heating value at 0° C. and 760 millimeters pressure, 1,055 British thermal units.