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THE STRUCTURAL CONDITIONS OF THE CRESCENT POOL, LOGAN COUNTY, OKLAHOMA

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BY

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The Phillips Petroleum Company

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CHAPTER I

INTRODUCTION

It was called to the attention of the writer that the Crescent oil pool had gone unnoticed insofar as concerns the published geologic literature. This seemed to be an opportunity for one especially interested in subsurface geology to make a contribution.

The various oil companies with holdings in the pool were visited. Without exception, every concern very generously turned over to the writer the sample log and scout ticket information which it had on file. No electric logs were available for this work.

This information was then assembled into six geologic cross sections, four subsurface maps and one isochor map.

CHAPTER II

MAPS AND CROSS SECTIONS

The maps which are included in this work are numbered as follows:

Map No. 1 Structural Contour Map on Top of the 1st Wilcox Sand

Map No. 2 Structural Contour Map on Top of the Viola Limestone

Map No. 3 Structural Contour Map on Top of the Oswego Limestone

Map No. 4 Structural Contour Map on Top of the Layton Sand

Map No. 5 Isochor Map of the Interval Between the Layton Sand and the Viola Limestone

The lines showing the respective locations of the six cross sections have been placed on Map No. 4. They have been labeled according to the following plan:

West-East Cross Section Along Line AA', Map No. 4,

North-South Cross Section Along Line FF', Map No. 4,

etc.

No attempt was made to show detailed features of a limestone or of any other unit in the cross sections. For example, the Oswego limestone is represented by the common limestone symbols without regard for the shale zones toward the base. Neither were the sand zones of the Cherokee shale represented.

The section which occurs from the Oswego limestone up, with the exception of the layton sand, was left entirely blank. This section was not deemed necessary to illustrate the structure.

CHAPTER III

LOCATION

The Crescent Oil Pool is located in sections 21, 27, 28, 33, and 34, T. 17 N., R. 4 W., Logan County, Oklahoma. One well, a dry hole, is located farther south in section 10, T. 16 N., R. 4 W.

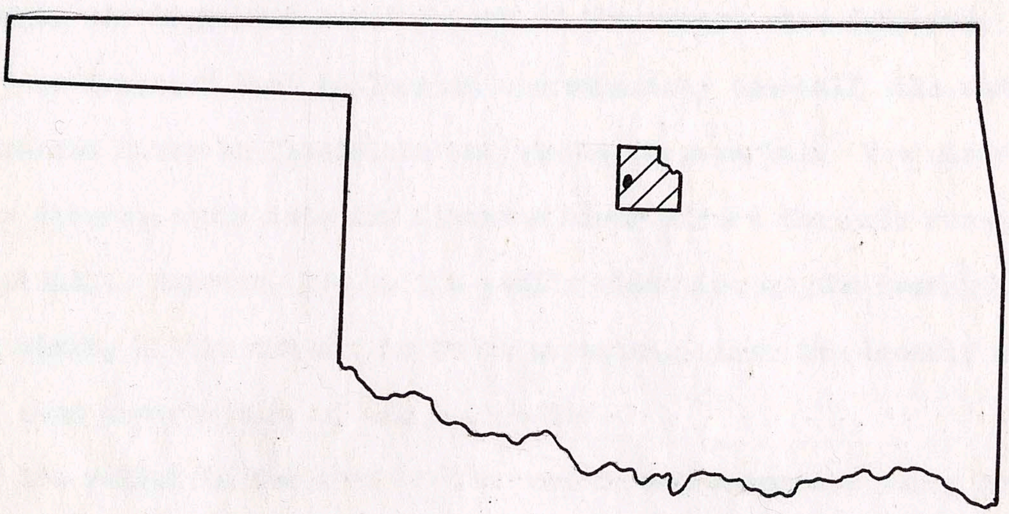

Fig. 1 Map Showing Location of Crescent Oil Pool.

The pool has essentially a north-south trend. It is approximately two miles long and one-half to one mile wide. The northern edge is defined by the Carter Oil Co.-Gulf Oil Company No. 1 Middleton in C SE SE section 28, T. 17 N., R. 4 W.; the south edge by the Carter Oil Co. and others No. 1 Herren in NE NW NE section 4, T. 16 N., R. 4 W.; the west edge by the Gulf Oil Co. No. 1 McDermott in SE SW SE section 28, T. 17 N., R. 4 W.; and the east edge by three wells extending north and south, one of which is the Continental Oil Co. et al No. 4 Ferguson in SW SE SE section 27, T. 17 N., R. 4 W.

CHAPTER IV

TOPOGRAPHY

Unless indicated otherwise, the quotations appearing under the discussion of topography, areal geology, and stratigraphy are taken from Bale's report on Logan County. The areal map of Logan County and the same major stratigraphic subdivisions of the report were followed.

The Crescent Pool is located approximately one-half mile north of the Cimarron River on floodplain and windblown material. Two minor streams flowing south into the Cimarron River afford the only run-off of the vicinity. However, due to the pool's situation on the Recent deposits of the river, little run-off is to be expected, since the loosely consolidated sand absorbs most of the rain water.

The relief in the area of the pool is approximately forty feet. The elevation ranges from 1,130 to 1,170 feet above sea level.

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[1]Hubert E. Bale, "Oil and Gas Geology of Logan County," Oklahoma Geological Survey Bulletin 40-GG (1928), 5-18.

CHAPTER V

AREAL GEOLOGY

The areal geology of the surface in the area of the pool is relatively simple. It is covered over entirely by the Recent floodplain and windblown material of the Cimarron River.

The Garber sandstone of Permian age probably directly underlies this floodplain material throughout the extent of the pool. The deposits are resting on the Garber in the Carter Oil Co.-Gypsy Oil Co. No. 1 Miller in C NE SE section 28, T. 17 N., R. 4 W.

"In general, the structural geology of the surface formations in Logan County is monoclinal with a dip of about 40 feet per mile to the northwest."

CHAPTER VI

STRATIGRAPHY

The succession of formations encountered in drilling is well illustrated by the stratigraphic log of the Carter Oil Co.-Gypsy Oil Co. No. 1 Miller in C NE SE section 28, T. 17 N., R 4 W. The Mississippi limestone which normally lies between the Chattanooga shale below and the Cherokee shale above is missing in this well.

	Top	Base
Recent		
Floodplain deposits	0 to	150'?
Permian (Enid group)	150 to	1955?
Garber Sandstone (Hayward member)	150	310
Wellington formation	310	695
Stillwater formation	695	1955
Herington limestone	1420	1440
Ft. Riley limestone	1660	1665
Wreford limestone	1770	1775
Cottonwood limestone	1950	1955
Pennsylvanian		
Neva-Foraker Lime Series	2040	2210
Neva Limestone	2040	2060
Foraker Limestone	2280	2310
Garber Elgin Series	2310	3630
Pawhuska Limestone	3080	3130
Deer Creek Limestone	3290	3295
Carmichael Limestone	3480	3500
Oread Limestone	3630	3640
Endicott-Tonkawa Sand Series	3640	4830
Lovell Limestone	4070	4090
Avant Limestone	4270	4290

	Top	Base
Layton Sand Series	4830	4890
Layton Limestone	4830	4850
Layton Sand	4850	4890
Hogshooter Limestone	4990	5000
Checkerboard Limestone	5080	5100
1st Oolitic Limestone	5190	5210
2nd Oolitic Limestone	5340	5355
Osewgo Limestone	5490	5650
Cherokee Shale	5650	5820
Mississippi		
Chattanooga Shale	5815	5820
Siluro-Devonian		
Hunton Limestone	5820	5858
Ordovician		
Sylvan Shale	5858	5962
Viola Limestone	5962	6018
Simpson Formation	6018	?
1st Wilcox Sand	6112	T.D. 6141

Floodplain Deposits:

As has been previously stated, the entire Crescent Pool is situated on floodplain and windblown material approximately one-half mile north of the Cimarron River. This material may be as much as 150 feet thick. The samples of the Carter Oil Co.-Gypsy Oil Co. No. 1 Miller in C NE SE section 28, T. 17 N., R. 4 W., begin at a depth of 150 feet in the Garber sandstone. It is not known by the writer just how far below the surface the floodplain material may extend.

Enid Group:

a. Garber Sandstone:

The Garber sandstone is the uppermost member of the Enid group which is encountered in the Crescent Pool. In the No. 1 Miller it consists of 160 feet of subangular, iron-stained, quartz fragments, which are loosely cemented together to form clusters. The upper sixty feet contain a minor amount of somewhat calcerous cementing material.

b. Wellington Formation:

The top of the Wellington formation was determined by an abrupt change from sand clusters to a red, slightly arenaceous, shale with interspersed sand cluster streaks or beds. It is 385 feet thick in the No. 1 Miller.

c. Stillwater Formation:

The top of the Stillwater was determined by the appearance of the "purple shale zone." The base of the Cottonwood limestone, as used by Aurin, Officer, and Gould,[1] determines the base of the Stillwater or the base of the Permian section. The formation is made up of red, purple, chocolate, and gray shales (in descending order), sand layers, and minor gypsum and limestone.

Herington Limestone - The Herington is twenty feet thick in the type well. It is a medium grained, white to light gray limestone, in which appears the first pyrite of the section.

Ft. Riley Limestone - The Ft. Riley is a limestone approximately five feet thick in the No. 1 Miller. It is dark gray to black in color and is medium grained.

Wreford Limestone - The Wreford is only five feet thick in the type well. The limestone is medium grained, and white

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[1]F. L. Aurin, H. G. Officer, and C. N. Gould, "The Subdivisions of the Enid Formation," Bulletin American Association of Petroleum Geologists, IX, No. 8 (1926), 791.

to light gray in color.

Cottonwood Limestone - The Cottonwood greatly resembles the Wreford and is also approximately five feet thick.

Neva-Foraker Lime Series:

This series consists of the Neva limestone, and the underlying Foraker limestone separated by a gray shale section with minor sand streaks present. The Neva is a dense, gray to white limestone, twenty feet thick; the Foraker is a medium grained, gray to dark limestone, thirty feet thick.

Garber Elgin Series:

The beds from the base of the Foraker limestone to the top of the Oread limestone are included in this section. In the No. 1 Miller the series is made up essentially of shales and limestones with a few thin interspersed sand beds.

Pawhuska Limestone - The Pawhuska is medium grained and white to gray in color. It is fifty feet thick.

Deer Creek Limestone - The Deer Creek (five feet thick) is medium grained and is light to gray in color.

Carmichael Limestone - The Carmichael (twenty feet thick) is medium grained and light to gray in color.

Oread Limestone:

The Oread is a light gray limestone only ten feet thick in the type well. It is distinct enough to be a horizon suitable for mapping.

Endicott-Tonkawa Sand Series:

Bale[1] groups all the beds between the Oread limestone and the

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[1]Bale, op. cit., 9.

Layton sand series and calls them the Endicott-Tonkawa sand series. In the type section, this zone runs slightly over 1,100 feet in thickness. It is made up of gray shale and sand zones with some thin lime streaks present.

The Lovell Limestone (twenty feet thick) and the underlying Avant Limestone (twenty feet thick) are included in this section.

Layton Sand Series:

This consists of sands and shales, lenticular in character. The top of the sand zone which was mapped in this work is overlain by a thin limestone zone some ten to fifteen feet thick and also by a thin conglomeratic zone.

"The lenticular character of the sands is often responsible for good shows of oil and gas but these do not seem to bear any definite relation to subsurface structure, hence are misleading."

In the No. 1 Miller the Layton sand is thirty-five feet thick; it grades into shale at the base so that it is difficult to ascertain the base of the sand with any degree of certainty. Also toward the base, the sand becomes extremely micaceous, grading into a micaceous shale and becoming looser than the upper part of the sand which is somewhat tight and compact. The sand grains (quartz) are subangular, sometimes found as clusters and sometimes cemented into a tight sandstone.

Hogshooter Limestone:

The Hogshooter is found to be only ten feet thick here. It is very similar to the Lovell and Avant limestones.

Checkerboard Limestone:

The Checkerboard is a twenty foot limestone resembling the

Hogshooter limestone. It underlies forty feet of black shale.

1st and 2nd Oolitic Limestones:

The names of these two limestones are self-explanatory. They are rather coarse-grained.

Oswego Limestone:

The Oswego limestone or Oswego-Big Lime Series is medium to coarse-grained and white to grayish in color. It averages from 150 to 200 feet thick in the Crescent Pool. The base grades into the Cherokee shale in such a manner that it is difficult to determine the Oswego-Cherokee contact closer than twenty to forty feet. "It is one of the important key beds for subsurface mapping and often a part of the series is sandy and has good shows of oil and gas."[1]

Cherokee Shale:

The Cherokee is a dark gray shale averagine 150 feet in thickness in the pool. Sand streaks or layers are common from the middle of the shale section toward the base. The sand near the middle "is no doubt a near equivalent of the Bartlesville sand known to the east of this area."

The Cherokee forms the lowest member of the Pennsylvanian series in the Crescent Pool, lying nonconformably on the Mississippi limestone below.

It is lower Des Moines[2] in age: the Morrow is not represented.

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[1]"Service on New Fields," Oil and Gas Journal, vol. 32, No. 11 (August 3, 1933), 67.

[2]F. L. Aurin, G. C. Clark, and F. A. Trager, "Notes on the Subsurface pre-Pennsylvanian Stratigraphy of the Northern Mid-Continent Oil Fields," Bulletin American Association of Petroleum Geologists, V, No. 2 (March-April, 1921), 123.

Mississippi Limestone:

The Mississippi limestone varies in thickness from zero to approximately 800 feet. It is nonconformable to the overlying Pennsylvanian Cherokee shale and

Is conformable to the Chattanooga shale below. The Mississippi lime is brown to black in color and often cherty at the top. This horizon, commonly known as 'chat,' produces oil and gas to the north in Garfield and Kay counties.

Radler[1] states that the dark Mississippi limestone correlates with the Mayes limestone member of the Caney formation in western Lincoln County.

Chattanooga Shale:

The Chattanooga is a black shale containing considerable organic material. It averages a little over one hundred feet in thickness on the downthrow side of the north-south fault. The shale ranges from zero to ninety feet in thickness on the upthrow side of the pool where post-Mississippian pre-Pennsylvanian erosion removed it completely from the crest of the structure and partially removed it down the flank of the structure.

The shale is conformable to the overlying Mississippi limestone and is unconformable to the underlying Hunton. It is equivalent to the Woodford chert of the Arbuckle Mountains section.[2]

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[1] Dollie Radler, "Lincoln County," Oklahoma Geological Survey Bulletin 40 - VV (1930), 8.

[2] Ibid.

Hunton Limestone:

The Hunton is a medium to coarse grained, white to light gray, sub-translucent limestone. It ranges in thickness from zero to fifty feet.

It is unconformable to the overlying Chattanooga shale and is probably conformable to the underlying Sylvan shale. Only a part of the Chimneyhill limestone member of the Hunton is present in the Carter Oil Co.-Gypsy Oil Company No. 1 Miller. No glauconite was found by the writer when running samples on this well but "pink crinoidal limestone" was abundant, indicating that the zone present was the lower "pink crinoid zone" of the Chimneyhill limestone.

The Hunton in this pool probably is not a suitable horizon for subsurface mapping, since post-Hunton pre-Chattanooga erosion has so differentially removed the Hunton that a map on this formation would no doubt show false structures.

Sylvan Shale:

The Sylvan is a blue-green to green-black shale varying from 90 to 100 feet in thickness. It is probably the most reliable unit from the standpoint of constant thickness to be found in Oklahoma.

It is no doubt conformable to the Hunton limestone above and to the Viola limestone below.

Viola Limestone:

The Viola is a rather coarse-grained white limestone averaging fifty feet in thickness.

Although it is difficult to determine the base of the "Dense" upper limestone of the Simpson formation, the information obtained by the writer shows this limestone to remain rather constant in thickness. The writer has no knowledge of any well in the pool which shows the upper "Dense" to be missing except in three cases where it was faulted out. This indicates that the Viola is probably conformable to the underlying Simpson formation in the area of the pool.

Simpson Formation:

The uppermost member of the Simpson is fine-grained white limestone referred to as the "Dense." Underlying the "Dense" is some fifty feet of dolomite and shale. The prolific 1st Wilcox sand lies directly underneath the dolomite and shale section just mentioned. The 1st Wilcox is made up of subangular to rounded, frosted quartz grains which are loosely compacted.

Below the 1st Wilcox and above the 2nd Wilcox is the Marshall zone. It is composed of dolomite and shale and averages fifty feet in thickness.

The 2nd Wilcox sand is a loosely compacted quartz sand zone ranging ten to twenty feet thicker than the 1st Wilcox sand.

The Carter Oil Co.-Gypsy Oil Co. No. 3 Knowles in SW SW NW section 34, T. 17 N., R. 4 W., penetrated approximately one hundred feet of shale and dolomite with minor amounts of sand before going into the Arbuckle limestone. This is the only well in the Crescent Pool which reached the Arbuckle limestone.

CHAPTER VII

STRUCTURE

Regional Geology:

The Crescent Oil Pool is located near the center of the state on the west to northwest dipping homocline. Ignoring the Recent stream and river deposits, the surface rocks of Logan County are Permian in age.

Clark and Cooper[1] speak of the movements at the close of Mississippian time resulting in two major lines or trends of folding in the area of Kay, Grant, Garfield, and Noble counties, Oklahoma. Their accompanying map of structural features in this area shows one of these uplifts to be the Blackwell anticline trending north to northwest from Garber through Blackwell and continuous with the Granite Ridge farther north. Located along this anticline are the Garber, Thomas, Hubbard, and Blackwell local structures.

The same map shows the Ponca anticline farther east running essentially parallel to the Blackwell anticline through Ponca City and continuous to the north with the Beaumont anticline of Kansas. On the Ponca anticline are located the Ponca City and Mervine oil pools.

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[1]G. C. Clark and C. L. Cooper, "Oil and Gas Geology of Kay, Grant, Garfield, and Noble Counties," Oklahoma Geological Survey Bulletin 40 - H (Mar. 1927), 21.

Between these two dominant uplifts and parallel to them are shown two shorter lines of folding which include the Billings and Tonkawa pools.

The question arises as to whether the Crescent pool is a southern extension of the Blackwell anticline, of the Ponca uplift, or of neither.

If the Ponca anticline were extended southwest without change of direction, Crescent would lie directly in its path. However, Clark and Cooper's map[1] shows the Blackwell anticline as taking an abrupt southerly course in the Garber pool. If the Blackwell axis holds this southerly course, it will pass directly through Crescent.

Clark and Cooper[2] state that the Ponca anticline may be younger than the Blackwell anticline because erosion has not removed the Mississippi limestone from the former. Since the Crescent Pool has Mississippi limestone present, this suggests that it is an extension of the Ponca trend. However, if the pool is located well down the flank of the Blackwell uplift, the Mississippi limestone would no doubt be present.

Mr. C. M. Harris[3] seems to think that the pool is associated with the granite ridge of Kansas. This intimates that it is an extension of the Blackwell anticline which, according to Clark and Cooper, is probably an extension of the granite ridge of Kansas.[4]

In either case, the Crescent Pool is probably associated with the

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[1] _Ibid_, map.

[2] _Ibid_, 21.

[3] Personal Communication.

[4] Clark and Cooper, _op. cit._

southwestern extension of those positive elements, although no well in the pool has penetrated to the basement granite. The writer knows of no evidence strong enough to warrant a statement making the pool an extension of any one specific major trend.

Folding:

At or toward the close of the Mississippian time, the area was subjected to uplift and emergence, accompanied or followed by a buckling up of the Crescent anticline, including at least the formations from the Simpson up through the Mississippi limestone. Following this uplift and folding was a period of erosion which removed all but about 150 feet of the Mississippi limestone on the downthrow side of the long north-south trending fault which cuts the structure into an east and a west part. On the upthrow side of this same fault, everything from the Mississippi limestone down through the Sylvan shale was removed, exposing the Viola on the crest of the structure. The Viola limestone was the oldest bed exposed on the anticline as a result of the erosion.

Following this period of erosion, the Pennsylvanian and Permian shales, sands, and limestone were deposited.

For a clearer picture of the nonconformable relation between the Pennsylvanian and pre-Pennsylvanian rocks, reference is made to the west-east cross sections. Note also the marked similarity in structure between the Layton sand and the Oswego limestone and the pre-Pennsylvanian formations.

The folding in the Crescent pool is anticlinal. The writer is using Clapp's[1] definition of an anticline when he writes,

> In the writer's structural classification an anticline was considered an upward arch that is considerably longer than wide and that is 'closed' horizontally in all directions. . . . Anticlines and domes may collectively be called 'closed structures' and the writer prefers to limit these terms to structures that are closed, unless qualifying words are affixed.

The folding or general structure of this pool may be compared to a deck of cards which is bent in the middle. The cards on the inner side of the curve are bent more abruptly than the cards on the outer side of the curve. So it is with the Crescent anticline. The beds have a greater angle of dip or a more pronounced flexure with depth than do the uppermost layers which may be compared to the cards of the outer side of the curve.

In making this comparison, the writer by no means intends to imply that the entire stratigraphic section of this area was suddenly bent up or bowed up with one sudden quick movement.

The result of the folding was a north, slightly northwest trending closed structure ranging two to two and one-half miles in length and one-half to one mile in width. The closure ranges from 50 feet on the Layton sand to over 500 feet on the Viola limestone. Theoretically, the closure of the 1st Wilcox sand should be greater than that of the Viola limestone, but due to lack of 1st Wilcox control on the edge of the pool, this cannot be determined accurately. The folding becomes more pronounced with depth and plays out toward the surface. This characteristic is in accordance with the other pools in this general area; for example, the Thomas, Garber, Retta, and Blackwell pools discussed by

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[1]F. G. Clapp, "Role of Geologic Structure in the Accumulation of Petroleum," in Structure of Typical American Oil Fields, II, (Tulsa: American Association of Petroleum Geologists, 1929), 673-674.

Clark and Cooper.[1]

The isochor map of the interval between the Layton sand and the Viola limestone greatly resembles both the 1st Wilcox and the Viola structural contour maps. This is reasonable, since the greatest degree of folding was in pre-Pennsylvanian time. The Layton structure is more nearly flat-lying.

It will be noted on the structural contour maps, particularly map No. 1 and map No. 2, that the crest of the anticline shows two rather distinct structures or structurally high areas with a minor syncline or chute separating them. The anticline might even be called a "double structure," although that term might imply a greater or more pronounced chute than is present between the two local highs. This "double structure" is reflected even in the Layton sand on map No. 4, becoming less pronounced with a decrease in depth. Several other pools associated with the Nemaha uplift show this characteristic.

An interesting feature is made evident by comparing map No. 1 with map No. 4. It is seen that as the depth is increased in the pool, the crest of the structure is gradually shifted to the west. The crest of the very gentle Layton sand structure is located some 600 feet horizontally farther east than that of the 1st Wilcox sand or the Viola limestone. The crests of the 1st Wilcox and the Viola are essentially in the same position. The Oswego structure and the Layton structure show a shift to the east. Map No. 4 shows the crest of the Layton

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[1]Clark and Cooper, op. cit., 7-44.

structure to be located farther to the east than Oswego.

Maps No. 1 and No. 2 show very plainly a steepening of the dip on the east side of the structure as one goes from north to south. The Ramsey-Eason et al No. 1 McGuire Trustee, section 10, T. 16 N., R. 4 W., shut down in the Sylvan shale. The writer, in order to obtain approximate control, estimated the top of the Viola limestone as being one-hundred feet below the top of the Sylvan shale, and contoured between this well and the wells to the north by the equal-spacing method. This shows a minor decrease in the angle of dip and shows the Viola is becoming structurally lower--probably passing into the syncline of which Wilson[1] has made mention.

Because of the lack of control on the west side of the anticline and because of the north-south trending fault which divides the anticline into two parts, the exact conditions on the west side of the pool are difficult to ascertain. It seems, however, that minus the faults, the west side would be very similar to the east, except that the former has a slightly steeper dip and is somewhat more irregular in character. See the west-east cross sections and also the north-south cross section, FF'. The writer believes in a speculative sense, that were it not for the faults, the closed structure would appear almost as a symmetrical fold.

From the structural contour maps and also from the cross sections, it can be seen that the Pennsylvanian beds have a structure which is

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[1] W. B. Wilson, "Evidence of Oil and Gas Migration Crescent Pool," an abstract, Tulsa Geological Society Digest (1935), 29.

similar in the mathematical sense to the underlying pre-Pennsylvanian beds.

This may indicate one or all of several possibilities:

1. It may indicate continued folding along the same pre-Pennsylvanian axes in the Pennsylvanian and Permian time.

2. It may mean merely adjustment of the underlying pre-Pennsylvanian rocks.

3. It may suggest differential settling and compaction of the Pennsylvanian and Permian sediments coupled with differential deposition over the uneven pre-Pennsylvanian surface.

Certainly no possibility can be entirely ruled out. The writer, however, is inclined to agree with Clark and Cooper:

> The character of the rocks at the surface during this pre-Pennsylvanian erosion interval was such that anticlinal valleys were not formed. Had the Mississippian been composed of thick shales and interbedded hard, resistant limestones and sandstones, it is probable that anticlinal valleys would have resulted. The section, being made up of large thicknesses of resistant shales resulted in anticlinal hills. These hills in turn reflected themselves in the subsequent formations resulting in the present surface structures. The possibility of subsequent folding in the formation of surface structure should be considered, as it is not probable that all of the surface structure is due to the reflection of these buried hills. However, the most important factor in the formation of surface structure is the differential deposition and settling of the Pennsylvanian and younger sediments on this old topography.[1]

After examining a considerable number of the logs in the pool, it was noted that the Permo-Pennsylvanian sediments consist of a great percentage of shale and sand. Both lend themselves readily to settling and compaction.

This fact and the fact that no evidence of faulting was found in

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[1]Clark and Cooper, *op. cit.*, 21-22.

the Permo-Pennsylvanian sediments seem to be factors in favor of the differential deposition-compaction on an eroded surface idea for the similarity of structure of the Pennsylvanian-pre-Pennsylvanian rocks.

Minor features are present on the maps and cross sections; for example, the gentle terrace structure shown at the south extension of the anticline on map No. 3, but they are considered to be only natural features associated with the diastrophic movements. No explanation is offered for these minor irregularities. An explanation would be entirely within the realm of theory, based upon the principles of differential competency of the rocks, or differential stresses, the evidence for either of which is entirely lacking.

Faulting:

Contemporaneous with or subsequent to post-Mississippian-pre-Pennsylvanian uplift and folding, a north, slightly northwest, trending normal fault was initiated which divided the anticline into two segments, an east segment and a west segment. The fault has a throw as measured on the west-east cross sections of at least 250 to 300 feet.

As to the age of this fault, there can be only little room for argument. The Mississippi limestone is cut by the fault. It is debatable whether or not a part of the lower Cherokee shale is faulted. The writer is of the opinion that the lower Cherokee shale is not faulted but that it is "affected" by it, due to subsequent adjustment along the fault plane and differential deposition and settling of the Cherokee shale over the fault scarp. It will be referred to in this thesis as post-Mississipian-pre-Pennsylvanian in age.

Several lines of evidence serve to confirm the idea that the principal fault is a normal fault:

1. In the Texas No. 5 Denny, SE NW SE 33, T. 17 N., R. 4 W., the 1st Wilcox is completely faulted out in the normal section as well as the Sylvan shale. This unmistakable evidence of a missing section, particularly the Sylvan shale which is conformable above and below, indicates normal faulting. See cross section, DD'.

2. In the Mid-Continent No. 5 Campbell, NE NW NE section 33, T. 17 N., R. 4 W., the Viola section is completely missing; this indicates a normal fault.

3. In the Continental No. 5 McConnell, SE SW SE 28, T. 17 N., R. 4 W., the upper Simpson, down to and including a part of the Marshall zone, is completely missing; again denoting a normal fault.

4. Referring to cross section BB' it is seen that the Sinclair No. 1 Shaffer NE NE SW section 28, T. 17 N., R. 4 W., and the Carter-Gypsy No. 4 Miller NW NW SE 28, T. 17 N., R. 4 W., are only 660 feet apart and that neither shows evidence of faulting. Yet the 1st Wilcox in the No. 4 Miller is 450 feet higher than the 1st Wilcox in the No. 1 Shaffer. The subsea elevations of the entire pre-Pennsylvanian section correspond to those just mentioned for the 1st Wilcox sand. This indicates faulting. Since a fault must be present between the two wells, it must necessarily be at a rather high angle in order not to cut either well. Normal faults are generally considered to be high angle faults, at least within the range of forty-five degrees in either direction from the vertical.

The question may arise as to why the Oswego limestone and the Layton sand, both having steeper dips over the fault zone, (see west-east

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cross sections) were not considered as faulted rather than as locally steepened. The cause of this local steepening is very evident when the cross sections are studied. It will be noted that a very definite fault scarp remained on the post-Mississippian-pre-Pennsylvanian erosional surface.

> Extensive folding and faulting took place and erosion attacked the topographic 'highs' thus created, reducing the height by some several hundred feet. But as the erosion was not sufficiently prolonged to bring about a peneplanation of the area, the topography was still rather rugged at the beginning of Pennsylvanian time, many of the hills exceeding 500 feet in height.[1]

Wilson[2] states that the faulting in the Crescent pool was practically completed by Oswego time.

This "high" produced by the incompletely eroded fault scarp is considered sufficient evidence to account for the local steepening of the dip without resorting to faulting as an explanation.

By comparing the thickness of the Mississippi limestone in the Carter Oil Co. No. 1 Herron, NE NW NE section 4, T. 16 N., R. 4 W., (approximately 800 feet) with the thickness of the Mississippi limestone in the Texas No. 5 Denny, NE NW SE 33, T. 17 N., R. 4 W., (approximately 100 feet) it is seen that a fault must be present between the two wells. Sufficient wells have not been drilled in this particular locality to

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[1]Stuart K. Clark and J. I. Daniels, "Relation Between Structure and Production in the Mervin, Ponca, Blackwell, and South Blackwell Oil Fields, Kay County, Oklahoma," Structure of Typical American Oil Fields, I, a symposium, (Tulsa: American Association of Petroleum Geologists, 1929), 160.

[2]W. B. Wilson, *op. cit.*

determine the dip direction, the exact location, or even the linear direction of the fault. It was merely drawn in on the maps partially dashed; it is theoretically considered to be normal and as a part or branch of the north-south trending fault.

The fault or faults responsible for the omission of the Viola limestone and the Sylvan shale in the two wells previously mentioned are considered to be merely branches or as a part of the major north-south fault zone.

The structure is a good example of faulting at depth which plays out into a fold with a decrease of depth.

In the Texas No. 5 Denny SE NW SE section 33, T. 17 N., R. 4 W., repetition of section is noted from the Sylvan shale down to total depth in the 1st Wilcox sand. A zone of some twenty feet is logged "fault zone" by the Texas Company. Underlying this "fault zone" is the second section beginning with the Sylvan shale.

This is interpreted as a reverse fault on cross section DD' because of the repetition of section which is so unmistakable. Since no other wells record this repetition of section, control is nil. However, it is probable that the fault underlies the entire pool because as the cross sections are compared it is noted that all the formations are found at subsea elevations which are in conformity with one another. This indicates that all the wells are on the upthrown side of this reverse fault.

From cross section DD' it is determined that the reverse fault is relatively older than the normal north-south fault zone. By comparing the normal section below the reverse fault in the No. 5 Denny with the faulted section above the reverse fault, it is apparent that the section above the fault must have been shoved up as a normal section: the Sylvan shale and the upper Simpson formation were then faulted out by normal faults.

The age of this reverse fault is questionable. It is at least post-Sylvan since it cuts No. 5 Denny just above the Sylvan. Probably it is post-Mississippian-pre-Pennsylvanian, since the Mississippi limestone is normal to the other structure. This is not proved by the evidence at hand, however.

Summarizing, the faulting is interpreted as follows:

1. The reverse fault was initiated, probably making the area of the entire pool on its upthrow side.

2. Later the long north-south trending fault and its associated branch faults were initiated with the east side of the anticline being its upthrow side. This divided the structure "in two separate reservoirs, since gas and oil are found at lower subsea elevations in the 'Wilcox sand' on the west side than the water level established in this sand east of the fault."[1]

Relation of Structure to Accumulation:

Production is found on both sides of the major fault. It is found to be on an average of 400 feet higher on the east or upthrow side.

Wilson's[2] ideas of oil and gas migration at Crescent are outlined

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[1]Ibid.

[2]Ibid.

below.

The process of upfolding was slow enough to allow accumulation of oil and gas over the entire structure. Following the process of accumulation, the buckling had become of sufficient intensity as to result in the north-south fault. This split the structure into two reservoirs, one of which was structurally higher than the other. No evidence of migration at the fault zone is known to the writer.

Wilson accounts for the oil on the west being two degrees lower than that on the east side by the fact that the regional dip is to the west: this would leave the west side open to migration. An addition, then, of heavy oil from the west would cause a lowering of the gravity.

The writer agrees that this is one possibility but until further work is done along the line of migration and accumulation, no definite conclusion can be reached.

CHAPTER VIII

GEOLOGIC HISTORY

The first definite information which is brought out is found in the Simpson formation of Ordovician age. The lower limit of the Simpson or the upper contact of the Arbuckle limestone is not definitely known. One well, the Gypsy Oil Co.-Carter Oil Co. No. 3 Knowles, SW SW NW section 34, T. 17 N., R. 4 W., penetrated the Arbuckle formation, but the writer was unable to obtain the exact depth of the contact or which member of the Arbuckle formation was penetrated.

Anderson,[1] in his discussion of the geology of Cleveland and McClain counties, Oklahoma, states, "Following deposition of the Arbuckle limestone the area was uplifted during the St. Peter retreat of the sea. The upper surface of the Arbuckle was eroded."

Presuming this erosion period, an advance of the sea then caused the deposition of the Simpson formation, consisting of sands, shales, dolomites, and limestones. From the information obtained, it is problematical as to whether the Simpson is conformable to the overlying Viola limestone. The thickness of the zone overlying the 1st Wilcox sand varies somewhat as plotted on the cross sections, but on the other hand, no

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[1]Anderson, G. E., "Geology of Cleveland and McClain Counties," Oklahoma Geological Survey Bulletin 40 - N, (1927), 14.

information was obtained which showed the upper "Dense" limestone varying more than fifteen to twenty feet in thickness or which showed the "Dense" to be absent except in three wells: in these three wells evidence points to faulting rather than to erosion as the cause of the removal. This seems to indicate a conformable relationship between the Simpson formation and the Viola limestone.

The following quotations show the diversification of opinion on this point:

> At the end of the deposition of the upper Simpson a retreat of the sea resulted in the erosion of a part of the upper Simpson. This break is not clearly defined in the Oklahoma City area. In the Seminole area Levorsen states: 'Locally the Viola limestone is apparently conformable on the underlying Simpson formation but over broad areas it overlaps the entire middle and lower Viola and the upper Simpson section.'[1]

Clark and Daniels[2] in writing on the Mervine, Ponca, Blackwell, and South Blackwell oil pools in Kay County, Oklahoma, state that the history of north-central Oklahoma, from Cambrian to Permian time falls into five major subdivisions one of which is: "A period of deposition extending from the Cambrian presumably until the close of the Hunton time. . . . ."

> The deposition of the first sediments laid down upon the granite occurred from Cambrian to the close of Hunton time, and includes the upper Arbuckle, Simpson, Viola, Sylvan, and Hunton formations. This period of sedimentation was followed

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[1]A. Travis, "Oklahoma County," Oklahoma Geological Survey Bulletin 40 - 55 (1930), 21.

[2]Clark and Daniels, op. cit., 159.

by a period of emergence when the above formations were tilted and eroded.[1]

At any rate, the Viola limestone, the Sylvan shale, and the Hunton limestone were deposited without evidence of intervening erosion. This is illustrated on the cross sections by the uniformity of thickness of the Viola and Sylvan throughout the pool. No suggestion of unconformity at the base or top of the Sylvan is recorded on the sample logs.

Travis[2] states that following Simpson deposition, the Richmond sea invaded Oklahoma from the southeast, causing the deposition of the Viola and Sylvan. He also states that the Hunton was deposited following a deepening of the Sylvan sea.

Anderson[3] says, "A shoaling of the sea caused the deposition of the Sylvan shale. This was followed by submergence and deposition of the Hunton."

Following the close of the Hunton (Siluro-Devonian) sedimentation, a period or time of emergence and erosion ensued. In tracing the Hunton across any of the cross sections of the Crescent pool it is seen to vary from zero feet to sixty feet in thickness--ample evidence of unconformity.

As has been previously stated, the writer found the Hunton to consist of the "pink crinoid" zone of the Chimneyhill limestone member of the Hunton formation.

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[1]Clark and Cooper, op. cit., 20

[2]Travis, op. cit., 21-22.

[3]Anderson, op. cit., 14-15.

Clark and Cooper[1] consider this pre-Chattanooga movement to have been caused by the Ozark uplift which gave the pre-Chattanooga rocks a regional dip to the southwest of some forty to fifty feet per mile.

A submergence and advance of the Mississippian sea caused the Chattanooga shale and the Mississippi limestone to be laid down, following which was a time of uplift, folding, faulting and erosion. It was during post-Mississippian-pre-Pennsylvanian time that the Crescent anticline was buckled up, faulted, and truncated by erosion forming local? nonconformity with the overlying Pennsylvanian sediments over the anticline.

The diastrophic movement in the pool was such as to cause a thrust or reverse fault which may now possibly underly the entire pool. Later, buckling was so intense as to exceed the competency of the rocks and a normal fault or normal fault zone resulted which cuts the pool into two parts. Erosion was contemporaneous with or subsequent to the faulting, resulting in the truncation of the uplift.

After a period of erosion which was not sufficiently long to erode the anticline to a topographically flat surface, "Came the period of deposition during which all of the Pennsylvanian and Permian sediments were deposited."[2] This irregularity of the pre-Pennsylvanian surface accounts for the varying thickness of the Cherokee shale on the cross sections.

Although this work only involved itself with two mappable

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[1]Clark and Cooper, op. cit.

[2]Ibid., 22.

Pennsylvanian formations, the Oswego-Big Lime Series and the Layton sand, it is reasonable to conclude that the intervening and possibly the overlying rocks retain the same marked similarity of structure as these two units possess; this conclusion appears more reasonable when the Crescent pool is compared with the surrounding pools; e.g., the Garber, Tonkawa, etc., in which this condition exists.

> In fact, so far as the fields under consideration are concerned, their entire subsequent history appears to have been remarkably free from such disturbances, with the exception of some faulting of late Permian or post-Permian age. The anticlines of the post-Mississippian rocks evidently are simply modified impressions of the resistant pre-Pennsylvanian hills underlying them.[1]

[1]Clark and Daniels, *op. cit.*, 160-161.

CHAPTER IX

HISTORY OF DEVELOPMENT

The following information was taken from Dalrymple's[1] article on the Crescent pool.

On the fifteenth day of October, 1930, the Eason Oil Company brought in the No. 1 Katschor, SW NE SW section 34, T. 17 N., R. 4 W., with an initial production of 650 barrels daily from the Layton sand at 4,919 to 4,942 feet, total depth. This discovery paved the way for the development of the field which later created excitement with its Continental Oil Co. No. 2 McConnell, NW SE SE section 28, T. 17 N., R. 4 W. This well had a potential rating of 33,928 barrels of oil daily--Oklahoma's biggest producer up to 1936.

A short while later the offset to the Eason Oil Co. No. 1 Katschor was drilled in NE NE SW section 34, T. 17 N., R. 4 W. Both wells in 1936 were running nineteen barrels daily.

The Eason Oil Company's discovery well resulted in considerable activity. Due to the depression, interest slowed up and Crescent almost died out before it actually began.

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[1]Dal Dalrymple, "Crescent, Opened in 1930, Has Biggest Producer of 1936 to Date," Oil and Gas Journal vol. 35, No. 7. (July 2, 1936), 21.

In 1933, after sending a seismograph outfit into the field, the Carter Oil Company decided to test the acreage which it had assembled in 1930 after the Eason Oil Company brought in the discovery well. As a result the Carter Oil Co.-Gypsy Oil Company No. 1 Miller in the C NE NE section 28, T. 17 N., R. 4 W., was completed on July 26, 1933 as the Wilcox sand discovery in the pool. The No. 1 Miller reached the Wilcox sand at 6,120 to 6,141 feet with a flow of 5,726 barrels of oil and 5,000,000 feet of gas the first twenty-four hours.

The second well to penetrate the Wilcox sand was the Carter Oil Company-Gypsy Oil Company No. 1 Walker in C NE NE section 33, T. 17 N., R. 4 W. It penetrated the Wilcox sand at 6,078 to 6,091 feet and, although it was higher on the structure, the production was less, being some 2,000 barrels of oil and 6,000,000 feet of gas during the first twenty-four hours.

Naturally, following the discovery of the prolific Wilcox sand, activity increased and by 1935, forty-two of the seventy-five wells in the pool had been drilled and were producing: the remaining thirty-four wells have been drilled slowly in the succeeding years. Out of a total of seventy-five wells only seven dry holes have been drilled. Crescent did not suffer the mass confusion and lawlessness so characteristic of wild-cat pools at that time, but had a very systematic and serene development in comparison.

At the present time the following companies are leaseholders in the immediate pool:

1. The Carter Oil Company
2. The Continental Oil Company
3. The Davon Oil Company

4. The Eason Oil Company
5. The Gulf Oil Company (Gypsy Division)
6. Mid-Continent Petroleum Corporation
7. Sinclair-Prairie Oil Company
8. Phillips Petroleum Company

TABLE I

PRODUCTION DATA*

Gravity of Oil, A.P.I. at 60° F.	41.8 to 43.3
Sulphur per cent	0.2
Oil Base	Mixed
Average Oil Production per well daily, Nov., 1935	165 Bbls.
Initial Pressure, Lb. per Sq. In.	2,920
Total Gas Production, Millions Cu. Ft., to end of 1935	8,386
Wells Producing Oil Only to End of 1935 . .	0
Wells Producing Oil and Gas to End of 1935	32
Wells Producing Gas Only to End of 1935 . .	1
Wells Completed to End of 1935	33
Equipment	Rotary and/or Cable Tool

*Source: H. E. Rorschach and E. G. Dalgren, "Petroleum Development in Oklahoma in 1935," American Institute of Mining and Metallurgical Engineers, Petroleum Division (1936), 330-333.

CHAPTER X

CONCLUSIONS

1. The Crescent pool is a faulted anticline.

2. The structure was formed following Mississippian sedimentation and prior to Pennsylvanian sedimentation.

3. The accumulation is due to structure rather than to lenticularity except in the case of the Layton sand, in which case both structure and lenticularity are present.

4. The faulting occurred contemporaneously with or subsequent to folding in the post-Mississippian-pre-Pennsylvanian time.

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