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Oil possibilities in Western Kansas and North Central Wyoming

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Department:

OIL POSSIBILITIES IN WESTERN KANSAS
AND
NORTH CENTRAL WYOMING

by

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A

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ILLUSTRATIONS

OIL POSSIBILITIES IN WESTERN KANSAS

The reported discovery of oil in the McNabb well in the northwest corner of Trego County, Kansas, has attracted attention to that region as possible oil producing territory. The offer of certain blocks of leases on several so-called "oil structures" occasioned the reconnaissance made by the writer. The prospects were examined during the period, September 28 to October 14, 1921.

LOCATION. The area examined lies in southern Logan and Gove Counties Kansas, along the valleys of Smoky Hill River and Twin Buttes Creek.

The main line of the Union Pacific Railroad lies 12 to 20 miles north of the prospects while the main line of the Missouri Pacific Railroad lies 5 to 15 miles south of the prospects.

Scott City on the Missouri Pacific Railroad is the station from which the drilling well of the Plateau Oil Corporation is best reached. The distance is 22 miles.

STRATIGRAPHY. The western portion of Kansas is covered by an approximately flat-lying mantle of sand, gravel and limy clays of late Tertiary age, up to 300 feet thick. Some of the larger streams have cut through and removed this Tertiary material from the underlying strata of Cretaceous age, and it is in these Cretaceous areas that the prospects under discussion are located.

The exposed strata are largely limy shales and chalky limestones known as the Niobrara formation. In a few isolated, small areas, however, the dark shales of the Pierre formation are present, lying conformably upon the Niobrara. The white, drab, and orange-colored, chalky character of the Niobrara, and abundant fossils, Inoceramus and Ostrea congesta, serve to distinguish this formation from the overlying dark gray Pierre shale.

The succession of formations together with their character and average thickness is given on the following page in tabular form.

TABLE OF FORMATIONS

AGE	GROUP OR FORMATION	CHARACTER	THICKNESS
Tertiary	Ogallala	Sand and gravel	0 - 300 feet
Cretaceous	Pierre	Shale, dark gray	200 feet
	Niobrara	Chalky limestone & shale	350 - 650 feet
	Benton: Carlile	Shale, dark	450 feet
	Benton: Greenhorn	Limestone	
	Benton: Graneros	Shale, dark	
	Dakota	Sandstone, water bearing	200 - 300 feet
Comanchean	Washita group: Kiowa	Shale	55 feet
	Washita group: Cheyenne	Sandstone	130 feet
Permian	Cimarron group	"Red Beds", sand, shale, gypsum, salt	1300 feet
	Big Blue group	Gray shale and limestone	1050 feet
Pennsylvanian	Missouri group	Gray shale and limestone	1500 feet
	Des Moines group	Limestone, shale and sandstone	600 - 800 feet
		Oil sands of Mid-Continent fields in lower part of Pennsylvanian.	

Unconformities occur between the Tertiary and Cretaceous, between the Cretaceous and Comanchean, between the Comanchean and Permian and within the Permian Red Beds.

STRUCTURE. (a) Major Features. The structure of parts of the central Great Plains has been worked out by N.H.Darton in a very general way from the records of deep borings[1]. The general structure is represented by structure contours which show the altitude of the top of the Dakota sandstone above or below sea level. This map shows that the area examined for this report is at the point of origin of an extensive low arch which extends northward through Kansas and northwestward through Nebraska and South Dakota toward the Black Hills. The pitch of the axis of this broad low uplift is to the north and northwest. A number of wells drilled at various places on this arch seem to indicate that it has not, as a whole, caused the accumulation of hydrocarbons. Minor folds on this large structural feature would, however, have prospective value so far as the consideration of structure alone is concerned. The object of a geological examination in this region would, therefore, be to locate such minor folds.

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[1] Darton,N.H., Bull. No.691- A., U.S. Geol. Survey.

The normal dip produced by the major structure is generally northward to slightly east of northward in Logan County, northward to slightly west of northward in western Gove County, and northeastward in eastern Gove County. The rate of dip is, however, so slight, being only 5 to 7 feet per mile, that for any one locality the normal attitude of the beds may be considered flat.

(b) Local Structural Features. Throughout the area examined, the Niobrara beds exihibit widespread variation from the approximately flat, normal attitude. Two processes, namely folding and differential settling could, either alone or in conjunction with each other, have produced the deformation that has occurred and it is believed that the field evidence indicates that both have been effective in this region. There is a marked tendency for the axes of the better defined uplifts to have trends which vary from north-south to northeast-southwest. Since the axis of the major structural arch in this area trends slightly east of north, the axes of the minor structures may be said to be approximately parallel to the axis of the major uplift. Such an arrangement of structural features can be reasonably believed to be the result of

folding caused by forces acting from the east and the west. But while there is some general orderly arrangement of the better defined uplifts to be noted, it is probably fair to say that the most widespread deformation is apparently without orderly arrangement and may be due primarily to a process of differential settling, or differential compacting of sediments, such as is typically represented in southeastern Kansas and in Osage County, Oklahoma. It is true that if the Cretaceous beds were laid down upon a topography which reflected an earlier folding in its ridges and valleys, that the structures produced by differential settling would possess an arrangement similar to that due to folding alone, but these structures would then reflect folds of prospective value in the pre-Cretaceous strata. It seems probable then, that both folding and differential settling have produced the deformation observed.

Many faults, all of the normal type, exist in the region. They are apparently of no considerable magnitude, judging from the appearance of the observable fault criteria and from the fact that the beds on either side of the fault planes are in nearly every instance Niobrara.

The strata are seldom found to be flat-lying,

but dip in various directions at angles of from 1° to 20°,- dips from 1° to 2° being the most common. It seems likely that dips of 5° or more are due to faulting rather than to folding.

The main object of the field work in this region was to determine the existence, shape, size, and location of structural features, such as anticlines and domes, which would indicate the most favorable places to prospect for oil. Since there are practically no horizon markers in the Niobrara beds, it was necessary to determine the structure almost entirely from strike and dip observations. Obviously, such a method of determination of structure is liable to considerable error, since the dip must be assumed to remain constant in those areas where there are no outcrops, while it is evident, where observable, that the dip changes erratically within short distances. Too great reliance must not, therefore, be placed upon the structural efficacy of the folds represented by strike and dip symbols on the accompanying plats, Series III. The strikes and dips indicated are reliable in themselves, but uplifts inferred from such data can not be claimed to be more than a possible interpretation. The fact remains that there is evi-

dence of considerable deformation, and some of this deformation may have been effective in causing the accumulation of oil and gas.

As will be explained in a later paragraph, the chief prospective oil and gas bearing horizon in this region is the upper, red portion of the Permian system. Now since "Red Beds" are, so far as known, inherently incapable of being a source of hydrocarbons, any oil that may be found to exist in the Red Beds will have presumably migrated to that position from another source, most likely the underlying Pennsylvanian. A faulted structure would, therefore, under the circumstances which obtain here, be preferable to an unfaulted one since a better opportunity for vertical migration might thus be provided.

It seems probable that the efficiency of folding in causing the formation and accumulation of oil varies inversely as the length of time elapsing between the deposition of the strata containing the petroleum-forming matter and the completion of the tectonic processes which caused the formation and accumulation of the oil. The reason for this may be briefly stated here as due to the fact that the older a formation be-

comes, and the deeper it is buried under superincumbent strata, the less porosity will be available for the migration of fluids through it because of the effects of compression and cementation. The age of the folding in a region, therefore, has an important bearing on the oil possibilities of that region.

The age of the folding may be inferred from the position of the important unconformities and from a consideration of the geologic history of this portion of the American continent. The folding apparent in the surface (Niobrara) beds probably occurred during the Rocky Mountain Revolution at the close of the Cretaceous period. The unconformity between the Cretaceous and the Tertiary systems is the result of this diastrophism. The folds produced at this time would be most effective in causing localization of hydrocarbons in the Cretaceous strata, namely, the Dakota, Benton, Niobrara and Pierre formations, and they would be least effective in causing localization of hydrocarbons in the Pennsylvanian and Permian strata. Since the general structure of the region represented on Darton's map[1] was determined on the upper surface of the Dakota sandstone, it is evident that the north-

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[1] op. cit.

eastward dipping homocline and the northward and northwestward pitching structural arch which comprise the major structure were given their present conformation during the post-Cretaceous folding.

Other periods of folding probably occurred between the Cretaceous and Comanchean periods, between the Comanchean and the Permian periods, and during the Permian period, as may be inferred from the unconfromities. Since, as will be pointed out under the heading "Possibilities for Oil", the upper portion of the Permian strata is the chief hope for oil production, the most important periods of folding in an economic discussion are those during, and immediately following the Permian period. Such folds would not be capable of detection at the surface except insofar as they may have provided localities of weakness upon which the post-Cretaceous folds grew.

Due to the unconformities that have been mentioned, the structure of the systems lying below the Cretaceous must vary more or less from that observable in the Niobrara (Cretaceous) beds at the surface. We can not, therefore, have any assurance that the domes, anticlines, and various irregular uplifts and depress-

ions which appear at the surface will have the same shape, dimensions, or position as those in the underlying Comanchean, Permian, and Pennsylvanian strata. Since the main hope for productive horizons is in the Permian strata, the impossibility of accurately determining the structure of these older beds with certainty introduces a serious difficulty. There is a tendency, however, for folds in older strata to express themselves, by continuous growth, in the overlying strata, when tectonic stresses continue or are repeated, hence, in the absence of sub-surface data, the uplifts in the surface beds should be selected as being more likely than other areas to indicate favorable structure in the buried strata. Acreage on, and close to the axes of uplifts is the most favorable in a comparative sense.

The geologic structure as it appears in the surface beds (Niobrara) is represented on the plats, Series III, by strike and dip symbols rather than by structure contours. It is realized that the manner of representation is not very definite, but it is believed that no greater definiteness is warranted by the available data.

Should oil in commercial quantities ever be found in this region, a very large area of Tertiary-covered strata, now impossible to prospect by means of surface examinations, could be systematically prospected by diamond drill holes to the base of the Niobrara formation. The necessary holes would be between 500 and 1000 feet deep. This method of determining structure is now being used in the glacial drift covered areas of Illinois.

(c) Individual Structures.

1. Hell Creek Structure. T.15 S., R. 31 W. The Hell Creek structure is one of the best defined folds of those submitted. The dip of the strata can be determined at frequent intervals over a considerable portion of the area, and these dips agree with sufficient consistency to indicate the strong probability of the existence of an uplift. There is, however, little or no evidence of closure on the northeast end of the axis. The elevation of the beds on the axis above the same horizon in the syncline on the southeast is estimated at about 200 feet, basing the estimate on the dip and length of the southeast limb of the fold. The vertical rise of the northwest limb amounts to about 220 feet, computed from the following data: The orange colored beds which appear to mark

the top of the Niobrara formation are 50 feet lower than the derrick floor of the Plateau Oil Corporation derrick, where they are prominently exposed northwest of the "Monuments" in Sec.28, T. 14 S., R. 31 W. The base of the Niobrara is reported at 480 feet in the log of the Plateau Oil Corporation well. Assuming that the thickness of the Niobrara is 650 feet the well started 170 feet below the top. The difference in elevation between the top of the Niobrara at the well, and in the major syncline northwest of the "Monuments" would, therefore, be approximately 220 feet.

The well of the Plateau Oil Corporation is properly located so far as the surface structure is concerned, but there is no means of knowing its situation with respect to the structure below the several unconformities. In the absence of sub-surface data the location is the best that could have been selected. The Permian Red Beds were entered at 1540 and penetrated 550 feet. The bottom of the hole is about 100 feet deeper in the Red Beds than the estimated depth of the horizon in which oil was reported in the Trego County (McNabb) well. The Plateau Oil Corporation well should reach the base of the Red Beds at about 2850 feet and the top of the Pennsylvanina at about 3900 feet.

2. Edith and Pence Structures. The Edith and Pence structures, lying largely in (location omitted) have better visible closure in the surface beds than any of the other structures submitted. These structures are small, but are worthy of as much, if not more consideration than any of the others.

3. The following structures appear to be more or less well defined uplifts on which, however, closure can not be proved:

Coin Structure, Location omitted (Private)
Elkader Structure, "
Jerome Structure, "
Southwest Extension of
Hell Creek Structure, "
Northeast Twin Buttes Structure, "
Twin Buttes Structure, "

4. Neither the Alanthus or Ben Allen structures are very well defined uplifts although there is considerable evidence of deformation of the strata in each locality.

DEVELOPMENT.

1. Plateau Oil Corporation. S.W. corner S.E.¼ of S.W.¼, Sec.27, T. 15 S.,R. 31 W. Drilled to 2090. Underreaming 8¼" casing at 1990.

Started in Niobrara.

Niobrara	0	to 480	
Benton	480	to 915	
Dakota	915	to 1130	a little water
Dark Comanchean shale	1130	to 1385	(Kiowa)
Comanchean Sandstone	1185	to 1540	(Cheyenne)
Permian Red Beds	1540	to 2090	bottom hole
Sand	1841	to 2025	
Shale	2025	to 2030	
Broken Sandstone		to 2090	

This well is favorably located on what is apparently the most favorable of the structures submitted.

2. Trego County (McNabb) well. N.W. corner of S.E. ¼ Sec.5, T.11 S., R. 25 W.

Started in Niobrara.

Reported to have entered Permian Red Beds at depth of 1450 feet.
Reported to have encountered oil at a depth of 1900 feet.
The company has not given out information.

Reported to have entered oil sand with water in the hole and that there was more than 300 feet of oil in the ten inch casing on top of the water. The writer saw heavy black oil floating on the water in the slush pit, but of course can not vouch for the fact that it was oil from the well and that it had not been poured into the well or on the pond. Coal and not oil was being used for fuel. The well was shut down at the time of the visit.

There is evidence of structural disturbance in the Niobrara beds near this well, but the number of outcrops and the time devoted to the examination were not sufficient to determine whether or not this well is favorably located with respect to the structure.

3. Utica well, Ness County. Sec. 1, T. 17 S., R. 26 W.

Niobrara	0 to 200
Benton	200 to 650
Dakota	650 to 770
Kiowa	770 to 995
Cheyenne	995 to 1190
Permian Red Beds	1200 to 2700
Salt at	2430.

Now being drilled deeper by local syndicate. Drilling around 3000 feet.

4. Vesper well, Lincoln County. Sec.10, T. 12 S., R. 9 W. Approximate base of Dakota at surface. Showing of oil at 210 feet. This showing would probably be in the Cheyenne sandstone above the unconformable contact between the Permian Red Beds and the overlying Comanchean.

Salt at 740 feet.
Showing of oil at 1130 feet.(Red Beds)
Council Grove formation reported at 1390 to 1450. The base of this formation is the top of the Pennsylvanian system in Kansas.
Pennsylvanian 1450 to 3575.

5. Garden City well, Finney County. Sec. 35, T. 21 S., R. 31 W.

Base of Niobrara at	100 feet
Benton	100 to 519
Dakota	519 to 840
Kiowa	840 to 1021
Cheyenne	1021 to 1221
Permian Red Beds	1221 to 2280 (showing of oil)
Oil at	2250.

6. Chappell well, Logan County. S.E. Corner Sec. 6, T. 14 S., R. 34 W. Drilling at 1200 or 1400 feet. Portable drilling machine.

POSSIBILITIES FOR OIL AND GAS.

Prospective Oil-bearing Horisons. The Niobrara formation is not properly constituted lithologically to serve as a reservoir for hydrocarbons since it is composed entirely of compact chalky limestone and shale. The Niobrara has been observed by the writer to yield a strong odor of hydrocarbons when struck or crushed, suggesting that it might contain more or less mother substance necessary to the formation of oil, but there are no beds either within or near the Niobrara that could serve as a reservoir. The formation has no possibilities. The Benton formation is without possibilities because of inadequate

reservoir members.

The Dakota sandstone is capable of serving as a reservoir for hydrocarbons. It has not, however, yielded anything but water in this region, even in wells located on more or less promising structures. It may, therefore, be regarded as a possible, but not very promising source of oil. The average depth of the Dakota is about 1000 feet.

The Cheyenne sandstone is capable of serving as a reservoir for oil and gas, but has never yielded anything of commercial value. The showing of oil at 210 feet in the Vesper well, Lincoln County, 130 miles to the eastward, is probably near the unconformable contact between the Cheyenne sandstone and Permian Red Beds. The Cheyenne formation may have possibilities as a reservoir for contact oil, but the results of drilling in western Kansas have thus far been unsuccessful. The formation is, therefore, unpromising. The average depth would be about 1400 feet.

The discovery of a small amount of oil in the McNabb, (Trego County well) in the Permian Red Beds at a depth of about 1900 feet suggests possibilities for the upper Permian as a source of oil. It is general-

ly believed that oil pools are not indigenous in strata of the nature of the Triassic, Permian, and Pennsylvanian Red Beds, but nevertheless commercial oil and gas pools have been found in Red Beds, notably at Electra, Pertolia, and Amarillo, Texas; at Healdton, Oklahoma; and in the Hamilton dome, Wyoming, where it is generally thought to have migrated to its present position from another source. The Permian Red Beds in this region may hence be considered a possible source of oil and gas. The top of the Permian Red Beds lies at depths of about 1400 to 1500 feet and the bottom would lie at depths of 2700 to 2850 feet.

The Pennsylvanian strata supposedly underlying this region would lie at such great depths that they will not be considered as a possible source of oil. It is estimated that that portion of the Pennsylvanian strata which carries the important oil pools of eastern Kansas and of Oklahoma, 180 miles and farther to the eastward, lies at a depth of some 5400 feet in this portion of western Kansas.

The outlook for productive oil and gas horizons in western Kansas is discouraging, but the sands of Cretaceous, Comanchean and upper Permian age have

some possibilities at depths ranging from 1000 to 3000 feet.

SUMMARY

1. The only localities in central western Kansas west of the 100th meridian where prospecting for oil, involving a study of the geologic structure, can be undertaken is along the valley of Smoky Hill River and its tributaries.

2. Considerable deformation of the gentle Mid-Continent type was observed in the Cretaceous beds, but due to the character of the exposed strata the structure can not be determined with a desirable degree of accuracy.

3. Prospective oil bearing sands are:

Dakota sandstone of Cretaceous age at about 1000 feet depth.
Cheyenne sandstone of Comanchean age at about 1400 feet depth.
Sands of the Permian Red Beds from 1400 to 3000 feet.

Scattered wildcat development has failed to discover any oil of importance in this region, but showings of oil reported in, and immediately above the Permian Red Beds, suggest that these strata are the most promising of the prospective sources which

can be reached at a depth of less than 5000 feet. The outlook for productive horizons is not encouraging.

4. A considerable number of the better defined structural uplifts in Gove and Logan Counties have been represented on the accompanying plats, Series III, by strike and dip symbols. The manner of determination and representation of the structure is not claimed to be definite and accurate, but is the best that could be done in view of the nature of the outcropping beds. Furthermore the structure of the buried Comanchean and Permian strata may not be like that observable at the surface due to unconformities, but, notwithstanding these difficulties, a location on or near the axes or crests of the uplifts, as represented on the plats, would be the most favorable place to make a test for oil.

5. It is apparent that the unfavorable features of the region far outweigh the favorable, but there is at least a possibility of finding oil of commercial value, and the suggestions contained in this report should aid in the discovery of oil and gas pools, if any exist.

October, 17, 1921.

GEOLOGICAL REPORT

ON

THE MURPHY CREEK DOME

Attention has recently been attracted to the Powder River dome and vicinity by the discovery of oil in the Dakota and Lakota sandstones in wells of the Trail Canyon and Sundance Syndicates. The occurrence of oil under considerable gas pressure, at the particular location and horizon where it was discovered, has not yet been satisfactorily explained since the oil-bearing horizons are exposed farther up the dip, between the new wells and the outcrop of the oil sands. On the other hand, three wells located near the crest of the dome found only great quantities of water in the Embar and Tensleep formations, which might have been expected to produce oil and gas.

The occurrence of oil on the Powder River dome, although under peculiar conditions, suggests that other structures in the vicinity have prospective value, and

seemed to warrant an examination.

Wegemann's structure map of the Powder River dome[1] indicates an anticlinal offshoot from the main dome on the northwest side, but his mapping was not carried beyond the limits of the Powder River dome itself. This anticlinal offshoot originates in section 30, T.42 N., R.81 W. and trends northwestward to a point six miles northwest of the village of Kaycee. A well-defined dome, known as the Kaycee dome, having its crest two and one-half miles west of Kaycee, forms the northern terminus of the anticline. Northwest of the point where the axis of the anticline is traversed by Murphy Creek a low dome was observed by the writer, lying largely in sections 2 and 11, T.42 N., R.82 W. This dome, hereinafter called the Murphy Creek dome, is the subject of this report.

LOCATION. The Murphy Creek dome is located in the northeast quarter of T.42N., R.82 W., Johnson County, Wyoming. Kaycee, a small village eight miles distant, is the nearest settlement. The distance to Salt Creek is thirty miles, to Buffalo sixty miles and

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[1]Wegemann, C.H., The Powder River Oil Field, Wyo. Bull. U.S. Geol. Survey No. 471, p. 56

to Casper via Salt Creek eighty miles. Buffalo is the nearest railroad point. The road from Buffalo to the dome is fairly good. The road from Casper is good as far as Salt Creek, but between Salt Creek and the dome travel over the road is very difficult in wet weather.

STRATIGRAPHY. In this area the Frontier member of the Benton formation is exposed. Two prominent sandstone beds known as the First Wall Creek and the Second Wall Creek sands respectively, form high rims on the flanks of the anticline. Below these two sandstone beds a third sandstone bed forms the surface over much of the structure. It is on the latter sandstone that the structure contours have been drawn.

The lower portion of the Benton formation, represented by the Mowry and Thermopolis members, are not exposed in the area represented on the map, but on the nearby Powder River dome erosion has proceeded into the Sundance formation.

The succession of geologic formations together with their age and characteristics is given in tabular form below:

TABLE OF FORMATIONS

AGE	GROUP OR FORMATION		CHARACTER AND THICKNESS
Cretaceous	Benton	Frontier	Sandstone and shale.
		Mowry	Shale 300 feet thick.
		Thermopolis	Shale and sandstone. Possible oil sands.
	Dakota sandstone		Total thickness of Dakota and Lakota(?) about 60 feet, variable. Contains water in upper part, oil in lower part on Powder River dome.
Comanchean	Lakota sandstone (?)		
	Morrison formation		Sand and shale 250 feet thick. Shows oil on Powder River dome.
Jurassic	Sundance formation		Sand and shale 275 feet thick. Shows oil on Powder River dome.
Triassic	Chugwater (Red Beds)		Red sandstone & shale, & gypsum. 1000 feet. Barren of oil everywhere except on the Hamilton dome, Hot Springs County, Wyo.
Permian	Embar formation		Possible source of heavy, black oil. Carries water only on Powder River dome.
Pennsylvanian	Tensleep formation		Sandstone and sandy limestone Possible source of heavy black oil.
	"	"	Carries water only on Powder River dome.
	Amsden formation		Limestone & red shale & sandstone. Oil at Soap Creek
Mississippian	Madison limestone		Source of part of oil at Soap Creek, Mont.

STRUCTURE. The structure of the Murphy Creek dome is represented on the map, Plate I, by structure contours on a sandstone layer of the Frontier formation which lies 260 feet below the top of the Second Wall Creek sand member, and approximately 850 feet above the top of the Dakota sandstone.

The highest point of the structure has an elevation of 5090 feet on the key horizon in the northwest quarter of section 11, the 5010 foot contour completely encircles the dome, and the 5000 foot contour may do so. The height of the closed portion of the dome is, therefore, as much as 80 feet and may be 90 feet. The area of the closed portion is approximately 1100 acres. This is admittedly a very small structure, both areally and in the amount of closure, but since the anticline on which the dome is located is a very large fold, with a large tributary collecting area on the northeast, some oil may have been entrapped in the sands of the Thermopolis shale, in the Dakota and the Lakota sands, and in the Morrison and Sundance formations. The prospects for discovering an oil pool of commercial value are not very bright and would not warrant the expenditure necessary to drill a deep hole, but since the main prospective horizon, the Dakota

sandstone, can be tested by a well less than 1000 feet deep, it would seem that the drilling of such a shallow, comparatively inexpensive well can be consistently recommended. Drilling below the base of the Sundance formation at a depth of approximately 1450 feet can not be recommended unless good wells are obtained in the formations above the Red Beds.

POSSIBILITIES FOR OIL. The formations containing sandstone layers in which oil or gas is known to occur elsewhere are the Thermopolis shale, and Dakota, Morrison, and Sundance formations. Sands in the Thermopolis shale contain the oil and gas obtained in the Trail Canyon Syndicate wells Nos. 1 and 2, lately drilled, and the Dakota sand is the oil bearing stratum in the Sundance Oil Syndicate well No. 1. All of these horizons would have possibilities on the Murphy Creek dome. Below the Sundance lie the Embar and Tensleep formations at drillable depths, but the possibility of finding oil in these horizons is remote. A large flow of water was encountered in the Embar on the main Powder River dome, therefore it would not be advisable to drill to the Embar unless exceptionally good wells are obtained in the higher horizons.

The recent oil and gas discovery on the main Powder River dome was made in the Dakota sand and in sand members of the overlying Thermopolis shale, notwithstanding the fact that these sands outcrop farther up the dip nearer the crest of the dome. The occurrence of oil under considerable gas pressure at this place is, therefore, unusual and can not yet be satisfactorily explained. It is true that the new wells are located on a minor wrinkle or anticlinal nose on the north flank of the main dome, but there is no known structural closure at this point. Other conditions that may have caused, or contributed to the accumulation and impounding of oil at this point are lenticular sand bodies, variable porosity of the sands, and height of the upper surface of the ground water. The same, or other peculiar conditions that caused the accumulation of oil on a pitching anticlinal nose in the Trail Canyon and Sundance Syndicate wells might possibly have a similar effect on the unclosed portion of the Murphy Creek anticline. Some acreage beyond the closure of the Murphy Creek dome has, therefore, been included with the acreage within the closure as having possible value in the sands above the Red Beds.

DEPTH. Wells starting on the key bed (surface on which contours are drawn) should reach the Dakota sand at a depth between 810 and 880 feet. The thickness of the Dakota sand on the Powder River dome is 56 feet. The variable and lenticular sands of the Thermopolis shale should be reached at depths from 500 to 850 feet. Possible oil bearing sands in the Morrison formation would lie at depths of from 900 to 1200 feet. Possible oil bearing sands in the Sundance formation would lie at depths of from 1130 to 1475 feet. The Red Beds are about 1000 feet thick in this vicinity, hence the top of the Embar formation would lie at a depth between 2400 and 2500 feet. All of these depths could be reduced by approximately 170 feet by drilling in the bottoms of the two draws near the crest of the dome.

At the suggested location in the N.W. ¼ Sec. 11, T.42 N., R.82 W., the drilling depths will be as follows:

Sands above Dakota	500	to	850 feet
Top of Dakota sand	850	to	900 feet
Morrison sands	900	to	1200 feet
Sundance sands	1200	to	1500 feet
Top of Embar	2400	to	2500 feet.

ABANDONED HOLE IN SECTION 23. The hole in the N.W. ¼ of Sec. 23, T.42 N., R. 62 W. is flowing a small stream of cold, non-saline, sulphide water from the 12 inch casing. No reliable information concerning this hole can be obtained since it was not drilled by a company, and the identity or whereabouts of the persons who drilled it are not known. The hole is said to be 770 feet deep. If this is so, it may have penetrated the Dakota sand. It is of interest to note in this connection that Mr. H.B.Andrus reports that the Benton, Trail Canyon, and Sundance Syndicate wells on the Powder River dome encountered fresh water in the upper part of the Dakota sand and oil in the lower 25 feet of the sand (Lakota). The fresh water was not under sufficient head to flow out of the hole. In these wells sulphide waters were encountered at shallow depths, above the Dakota. Evidently the sulphide water flowing from the abandoned hole in Sec. 23 is not from the Dakota, but this does not prove that the Dakota sand has not been penetrated. The possibility that this well may have entered the Dakota sand detracts from the prospective value of the area outside the closure of the Murphy Creek dome.

CHARACTER OF PROSPECTIVE OIL. A sample of

oil from Trail Canyon Syndicate's well No. 1 on the Powder River dome was obtained on Dec.15,1920. The oil was derived from the first sand of the Thermopolis member at a depth of 295 feet. It came in small amount along with much water and gas and was collected from the surface of an earthen tank.

The oil is dark brown to black in color and registered 25° Beaume' at 60° Fahrenheit. A distillation test gave the following results.

Distillation of Oil from Well No.1. Trail Canyon Syndicate.

Initial boiling point 130° F.

Temperature F.	Percent over	
130-200	2	
200-250	2	
250-300	4.5	Gravity of combined cuts up to 450° F=49° Bé.
300-350	4.5	
350-400	6	
400-450	7	
450-500	8	
500-550	9	
550-575	6	
575-600	3	
Above 600	39	
Total.....	91.	Residue and loss 9 percent.

The results indicate that 26percent of the oil can be utilized for gasoline, which is more than is usual in such a heavy crude oil. The heavier products of distillation showed but little wax, and considerable amounts of cylinder stocks suitable for lubricating oils.

SUMMARY

1. The Murphy Creek dome has a closure of at least eighty feet and may have as much as ninety feet. The area of the closed portion is about 1100 acres.

2. The prospects for oil production of importance are not encouraging, but on account of the shallow drilling (less than 1000 feet) necessary to reach the main prospective oil bearing horizons, the prospect seems worthy of a test at least to the Dakota sand. Since all the remaining prospective oil sands above the Red Beds could be tested by a hole less than 1500 feet deep it would probably be advisable to drill to the top of the Red Beds. Drilling to the Embar and Tensleep formations can not be recommended on account of the large flow of water obtained in this horizon in the Shiloh well on the Powder River dome.

March, 7, 1921.

GEOLOGICAL REPORT

ON

THE BILLY CREEK DOME

The discovery of a commercial oil pool on the Crow Indian Reservation, Montana, in February, 1921 aroused the interest of oil operators in the possibilities of the belt of country lying along the northeast flank of the Big Horn Mountains between the Soap Creek field on the north and the Powder River (Tisdale) and Salt Creek fields of Wyoming, on the south.

A number of localities in this belt were examined and mapped at intervals by the writer during the summer of 1921. Of those prospects which appeared to have more or less merit, the Billy Creek dome is one that still remains untested and it is therefore of interest at the present time.

Two wells were drilled on the Billy Creek dome a number of years ago, but they were not of sufficient depth to reach the important prospective oil-bearing horizons. The Carter Oil Company and other interests are now (February, 1922) drilling a well on this dome.

LOCATION. The Billy Creek dome is situated in T. 48 N., R. 82 W. Johnson County, Wyoming. It is traversed by the main highway between Casper, Salt Creek, Buffalo, and Sheridan, and is therefore easily accessible. Buffalo, the county seat of Johnson County, is sixteen miles distant and is the nearest railroad point. The Big Horn Mountains rise from 3 to 4 miles west of the Billy Creek dome and the great Powder River Basin lies to the eastward. Billy Creek, a permanent stream which flows from west to east across the structure, will furnish an adequate water supply for drilling and other purposes.

TOPOGRAPHY. A rim of Parkman sandstone, partially encircling the dome, and a central basin within the rim, are the dominant topographic features. The rim was formed by the planing off of the crest of the dome by erosion, and the removal of the soft shale above and below the rim-forming sandstone faster than the rim itself can be removed. The height of the rim above the basin within it varies from 40 to 100 feet.

The surface of the basin is comparatively smooth. South of Billy Creek a terrace of planation forms an extremely smooth surface over all that por-

tion of the basin. This terrace has a gradual slope downward to the east and is terminated abruptly on the north by Billy Creek, which stream has cut its bed some 70 feet below the general terrace level. North of Billy Creek the surface of the basin is slightly rolling and rises gradually from the creek toward the rim on the east, north, and west.

Three-fourths of a mile southwest of the axis of the dome the Parkman sandstone has resumed its normal northeastward dip and outcrops in a southwestward facing escarpment which parallels the Big Horn Mountain axis, and extends many miles northwestward and southeastward from this locality.

Four and one half miles southwest of the axis of the Billy Creek dome, the Carboniferous and older strata, rising toward the Big Horn axis, form the Big Horn Mountain uplift. Twelve miles still farther to the west the mountains culminate in granite peaks of which Cloud Peak having an elevation of 13,165 feet, and situated 30 miles north west of the Billy Creek dome, is the highest.

STRATIGRAPHY. The highest and youngest formation involved in the Billy Creek fold is the Park-

man sandstone which forms the rim of the dome. The underlying Pierre shale forms the surface of the basin within the rim. It is estimated that about 230 feet of the Pierre shale has been removed by erosion on the crest of the dome.

All of the Cretaceous strata, from the Parkman to the Cloverly, are exposed within the three mile belt, between the Billy Creek dome and the mountains, thereby presenting the opportunity to measure the thickness of the formations and to observe their characteristics. Two sections were measured by transit survey, one on Billy Creek, immediately west of the dome, and the other on Muddy Creek, about 5 miles northwest of the dome. The thicknesses obtained, and the general characteristics of the formations are indicated in the table of formations which follows, and in the columnar section on the map, PLATE II. A discussion of the prospective oil-bearing horizons appears under the heading "Prospective Oil-bearing Sands"

TABLE OF FORMATIONS

AGE	FORMATION	CHARACTER AND THICKNESS
Cretaceous	Parkman sandstone	Brown concretionary sandstone. 350 feet
	Pierre shale	Dark shale. 2700± feet thick. Shannon sandstone member 940 feet below top.
	Niobrara	Shale, gray. 200 feet
	Benton — Frontier	Shale, and thin sand & conglomerate members
	Benton — Mowry	Hard fissile shale. Thin sandy layers.
	Benton — Thermopolis	Dark carbonaceous shale containing the Muddy sand member. Benton 2000± feet thick
Comanchean	Cloverly	Sandstone and shale. 50± feet thick
	Morrison	Shale and sandstone. 200± feet thick
Jurassic	Sundance	Shale, sandstone and limestone. 400±
Triassic	Chugwater	Red shale, red & white sandstone, gypsum. 1200±
Permian	Embar	Limestone and shale. 0 to 50 feet thick.
Pennsylvanian	Tensleep	Sandstone and sandy limestone. 300±
	Amsden	Limestone, sandstone, red shale. 300±
Mississippian	Madison	Limestone. 1000 feet thick

STRUCTURE. The locality under discussion is situated on the northeast flank of the giant anticline of the Big Horn Mountains, therefore the regional dip is northeastward. The normal angle of dip is 10° to 25° northeastward, and the general strike is N. 22° W.

The Billy Creek dome is a small, symmetrical, oval shaped, subsidiary uplift on the northeast flank of the major Big Horn uplift. The dimensions and location of the dome were determined by a transit survey August, 17-19, 1921 and the results are indicated by structure contours which show the elevation of the base of the Parkman sandstone above sea-level. Wherever possible the position of the structure contours is controlled by the elevations on the key horizon (base of Parkman sandstone) or on beds which lie certain determined distances above the key horizon. In a few localities where the various horizons can not be recoginzed with certainty, the position of the contours is controlled by the dip. (See Plate II)

Sections A, B, and C indicate the vertical curves assumed by the strata, across the fold. The

curve itself, represents the position of the key horizon above sea level.

The structure was found to have a height of more than 400 feet and less than 500 feet above the lowest closing contour, in other words the " closure" is between 400 and 500 feet. The area within the closure is about three and one half square miles or about 2200 acres.

The tributary drainage, or gathering area from which hydrocarbons could be derived is uninterrupted for many miles to the northeast, east, and southeast, and should be adequate to fill the oil and gas reservoirs that may occur on this dome.

There is a strong probability that a normal fault exists on the reverse dip flank. Actual evidence of differential movement was not seen, but this and certain other criteria may have been erased by the erosional activities of Billy Creek which cuts through the rim near this place. Evidence suggesting the presence of a fault is: (a) the offset position of the butte on the north-south half section line of Sec.17 about midway between the South $\frac{1}{4}$ corner and the center

of the section; (b) the relative elevation of the beds on either side of the gap, between the previously mentioned butte and the outcrops to the northwest; (c) the gap mentioned under (b); and, (d) the variation in strike on either side of the gap. The fault, if it exists, is nearly normal to the strike and is, therefore a dip fault.

Experience has shown that faults of the nature and magnitude of that described, under the conditions here obtaining, do not usually have an adverse effect. The conditions under which normal faults of no very great throw (200 feet or less) are known not to affect oil accumulation adversely, are where a thick body of soft shale exists above the oil sands. Under such conditions the more or less plastic nature of the shale prevents the formation of open fissures which would permit the escape of oil and gas from the sands. This condition is notably illustrated at Salt Creek and Elk Basin where the effect of the numerous faults has been found to be beneficial rather than unfavorable. Since at Billy Creek the oil sands are overlain by great thicknesses of soft shale, the presence of a fault of the type described can not be considered unfavorable.

Whether or not the strata involved in a fold can be expected to be saturated with fluids depends upon the elevation of the outcrops of those strata as compared to their elevation on the fold in question. This consideration becomes especially important when the fold is, as in this case, situated very near the outcrop of the prospective oil sands. The outcrop of the main prospective oil sand, three miles west of the dome, is at an elevation of 5482, while on the crest of the Billy Creek dome this same sand lies at an elevation of about 650 feet. The apparent hydrostatic head tending to hold fluids in the reservoir is, therefore, over 4800 feet, a considerable portion of which should be effective, in view of the short distance of only three miles through which it must be transmitted.

The age of the folding which produced the Billy Creek dome is at least late Cretaceous and probably early Eocene since the very latest Cretaceous strata are involved in the folds. No unconformities exist in the Cretaceous strata in this region, hence the structure observable at the surface will be similar to that existing in the prospective oil sands, all of which are of Cretaceous age.

In view of the structural conditions recited, the Billy Creek dome is believed to be structurally favorable for the accumulation and retention of oil and gas. Other considerations, aside from structure, which are prerequisites for a productive structure will be taken up under the heading, "Prospective oil-bearing sands".

A location for a well is suggested at a point on the axis where the depths to the prospective oil sands would be the least possible. This location is in the bed of Billy Creek in the southeast quarter of Sec. 17, T.48 N.,R.82 W., 1050 feet west and 650 feet north of the southeast corner of the section. Approximate depths at the suggested location would be as follows:

First Frontier sand	3050 feet
Second Frontier sand	3100 feet
First sandy bed in Mowry shale	3760 feet
Second sandy bed in Mowry shale	3820 feet
The "Muddy"sand in Thermopolis shale	4280 feet
Cloverly sand	4600 feet.

PROSPECTIVE OIL-BEARING SANDS. The sands of the Frontier formation, known as the Wall Creek sands in the Salt Creek Oil Field in T.40 N.,R.79 W., where they are developed in thicknesses of from 50 to 125 feet and are so enormously productive, would be the

first prospective sand likely to suggest itself on the Billy Creek dome. An examination of the outcrops of the Frontier formation on Billy Creek and Muddy Creek, however, reveals the fact that the sand members have decreased in thickness until they give little promise of large production, if any, on the Billy Creek dome.

The thickness and character of the Frontier sands at their nearest outcrops to the Billy Creek dome are illustrated by the following sections:

Section of Frontier sand members on Billy Creek, 2½ miles west of dome.

	Feet
Sand (first Frontier), coarse, with streaks of brown limestone	6
Sandy shale.....	39
Sand, coarse, and conglomerate, fine, (second Frontier) with shale streaks.....	4
Sand and shale in alternating thin layers, base covered.....several feet.	

Only the sand and conglomerate, having an aggregate thickness of 10 feet appears to be sufficiently porous to serve as a reservoir for oil.

Section of Frontier sand members on Muddy Creek, 4 miles northwest of dome.

	Feet
Conglomerate (first Frontier sand) base covered	12 ±
Covered.....	40 ±
Conglomerate with 6 inch cone-in-cone limestone in middle (top member second Frontier sand).....	3½
Shale, soft sandy.....	9
Sand.....	4
Sandy shale.	

Only the sand and conglomerate layers having an aggregate thickness of about 20 feet appear to be capable of serving as a reservoir for oil and gas.

No mention whatever of sand members in the upper Colorado group of this locality is made by Darton[1] in the Professional Paper, Geology of the Big Horn Mountains. According to Darton,"in the region south of Mayoworth there develops in the upper part of the Colorado formation a bed of sandstone which attains considerable prominence in the Powder River district". The sandstone referred to is the Frontier sandstone member. Mayoworth is 18 miles south of the Billy Creek dome.

From a consideration of the sections measured by the writer, it appears that the Frontier sands offer but little promise of being productive. Very small wells, if any,are the best that could be expected from this horizon.

The Mowry member of the Benton formation underlying the Frontier member is the next possible source of oil. The Mowry beds here possess their usual, hard, fissile character and contain myriad fish scales. Sandy

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[1] Darton,N.H., Geology of the Big Horn Mountains: U. S. Geol. Survey, Prof. Paper No.51, pp., 53-57, 1906.

beds, in the Mowry, of the Big Horn Basin, Wyoming known as the "Kimball" and "Och Louie" sands are productive, and commercial production of oil is obtained directly from the shale in the Ferris and Lost Soldier fields and elsewhere in Wyoming. Production from the shale is probably made possible by a tendency of this hard, fissile shale to fracture and form open fissures on the crests of anticlines. Two sandy beds, each a few feet thick, were found in the Mowry shale in its Muddy Creek outcrop which adds to the prospective value of the Mowry shale on the Billy Creek dome. Only very small wells at best could be looked for, however, in strata of the nature of the Mowry.

Below the Mowry beds lie a series of dark shales called the Thermopolis shale. A sandstone bed within the Thermopolis shale is the main hope for oil on the Billy Creek dome. This sand has the approximate stratigraphic position of the "Muddy sand" of the Big Horn Basin, and will therefore, be called the Muddy sand in this report. As viewed at the outcrop on Billy Creek, three miles west of the dome, it had a thickness of 40 feet and was a true, finely granular sandstone, well fitted to serve as an oil and gas reservoir. Darton[2]

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[2] op. cit.

refers to a white sandstone in the lower part of the Benton formation, from 270 feet to 350 feet below the base of the Mowry, which outcrops at several places north and south of the Billy Creek dome. The thickness given is 8 to 15 feet. This sandstone would be that called the Muddy by the writer, but is considerably thinner than the development observed in the outcrops on Billy Creek and Muddy Creek.

Below the Thermopolis shale lies a thick massive sandstone stratum, the Cloverly formation of Darton.[3] The Cloverly is believed by Darton to represent the Dakota sandstone, Fuson formation, and Lakota sandstone of the Black Hills region and is therefore of later Comanchean and earliest Cretaceous age. The Cloverly is admirably adapted to serve as a reservoir for oil and gas on the Billy Creek dome and should certainly be tested. Its great depth, 4600 feet or more, is an objectionable feature.

The Morrison and Sundance formations will not be mentioned as prospective oil-bearing horizons, since they have never yielded important amounts of oil and are over 5000 feet deep on the Billy Creek dome.

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[3] op.cit. p.53

A sandstone in the Pierre shale, 940 feet below the base of the Parkman sandstone, appears on Muddy Creek. This sandstone is interpreted as the Shannon member. At the abandoned well in Sec. 17 the top of this sandstone should have an elevation of 4250, {5190 (elevation of base of Parkman) — 940 = 4250}. Water (probably from a sand) was reported in the well at a depth of 758 or an elevation of 4224, { 4892 (elevation of well) — 758 = 4224}. The water is therefore interpreted as coming from the Shannon sandstone member. There are, therefore, no prospects for oil in the Shannon sand.

Intervals between the base of the Parkman sandstone and important horizons below, as measured on Muddy Creek, follow:

	Depth below base of Parkman.
Shannon sand, water-bearing.....	940 feet
* First Frontier sand.....	3280 feet
* Second Frontier sand.....	3327 feet
* First sandy bed in Mowry.....	3990 feet
**Muddy sand.....	4512 feet
* Cloverly sand.....	4824 feet

* Prospective oil sand
**Main prospective oil sand

It is apparent, from a consideration of the prospective oil sands, that the thinness of the higher sands and the great depth of the moderately thick lower sands are the objectionable features of the Billy Creek dome. Oil production is to be expected, but it will require flowing wells of considerable size to pay at depths of from 4300 to 5000 feet. There can be no assurance, therefore of discovering an oil pool of commercial value on the Billy Creek dome, but it is certainly worthy of a test to the Cloverly sand, with the main hope for the best wells in the Muddy sand.

DEVELOPMENT. The two holes drilled on the Billy Creek dome some years ago were not deep enough to reach the principal prospective oil sands. The hole near the center of section 17 was drilled to a depth of 2260 feet, where a flow of gas was encountered. This depth was not deep enough to reach the First Frontier sand by about 800 feet. The first water was struck at 758 feet. This water is interpreted by the writer as coming from the Shannon sand. At present there is a small deep crater, at the site of the abandoned hole, filled with water through which gas is bubbling rather briskly. A very small amount of fresh

water is flowing out.

The hole in section 20 was only drilled to a depth of 750 feet when drilling was discontinued. The derrick was later blown down by the wind and the wreck still remains on the site.

The Carter Oil Company and associated interests are now, February, 1922, drilling in the southeast corner of Sec.17. This is a favorable location and the hole will, no doubt, be carried deep enough to test thoroughly the possibilities of the dome.

SUMMARY

1. The Billy Creek dome is structurally favorable for the accumulation of oil and gas.

2. The highest prospective oil sands, Frontier, would lie at a minimum depth of about 3050 feet and do not hold forth much promise of wells large enough to be profitable.

3. The largest wells would be expected in the Muddy sand at a minimum depth of 4280 feet. Flowing wells of considerable size would be required to be profitable at such a depth.

4. There is no assurance of obtaining wells

large enough to be profitable at the depths required, but the Billy Creek dome is, nevertheless, worthy of a deep test. Since a test well should be carried to the Muddy sand at a minimum depth of 4280, the Cloverly sand at a minimum depth of 4600 feet should also be included in the test.

August, 27, 1921.

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4. Condra, G. E., Geology and Water Resources of the Republican River Valley and Adjacent Areas, Nebraska: U.S. Geol. Survey Water Supply Paper 216, 1907.

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7. Darton, N. H., Geology of the Big Horn Mountains: U.S. Geol. Survey, Prof. Paper 51, 1906.

SERIES III
No. 1

HELL CREEK STRUCTURE

GOVE COUNTY, KANSAS.

Scale: 2 inches = 1 mile.

J. S. Irwin Geologist.

R. — W.

T. — S.

1 mile

MAJOR SYNCLINE

LEGEND

↘ Approximate dip.

+ Approximately flat.

NO EXPOSURES

UPLIFT

AXIS OF

Plateau Oil Corp. 2090'

Syncline

Probable

Fault

1½° Fault

1½° to 3°

2½° Fault

GOVE COUNTY

SCOTT COUNTY

PEERLESS PTG. & STATY. CO., DENVER

SERIES III
No. 2

Southwest Extension of HELL CREEK STRUCTURE

LOGAN COUNTY, KANSAS.

Scale:- 2 inches = 1 mile.

J. S. Irwin Geologist.

RANGE - WEST

← 1 mile →

TWP. - SOUTH

½° to 1°

7° to 20°

Fault

2½°

2½°

Highly faulted beds

3°

OAKLEY 30 miles

SCOTT CITY 17 miles

Fault

5°

5°

2°

2½°

AXIS OF UPLIFT

LOGAN COUNTY

SCOTT COUNTY

PEERLESS PTG. & STATY. CO., DENVER

SERIES III
No. 4

LEGEND

↳ Approximate dip

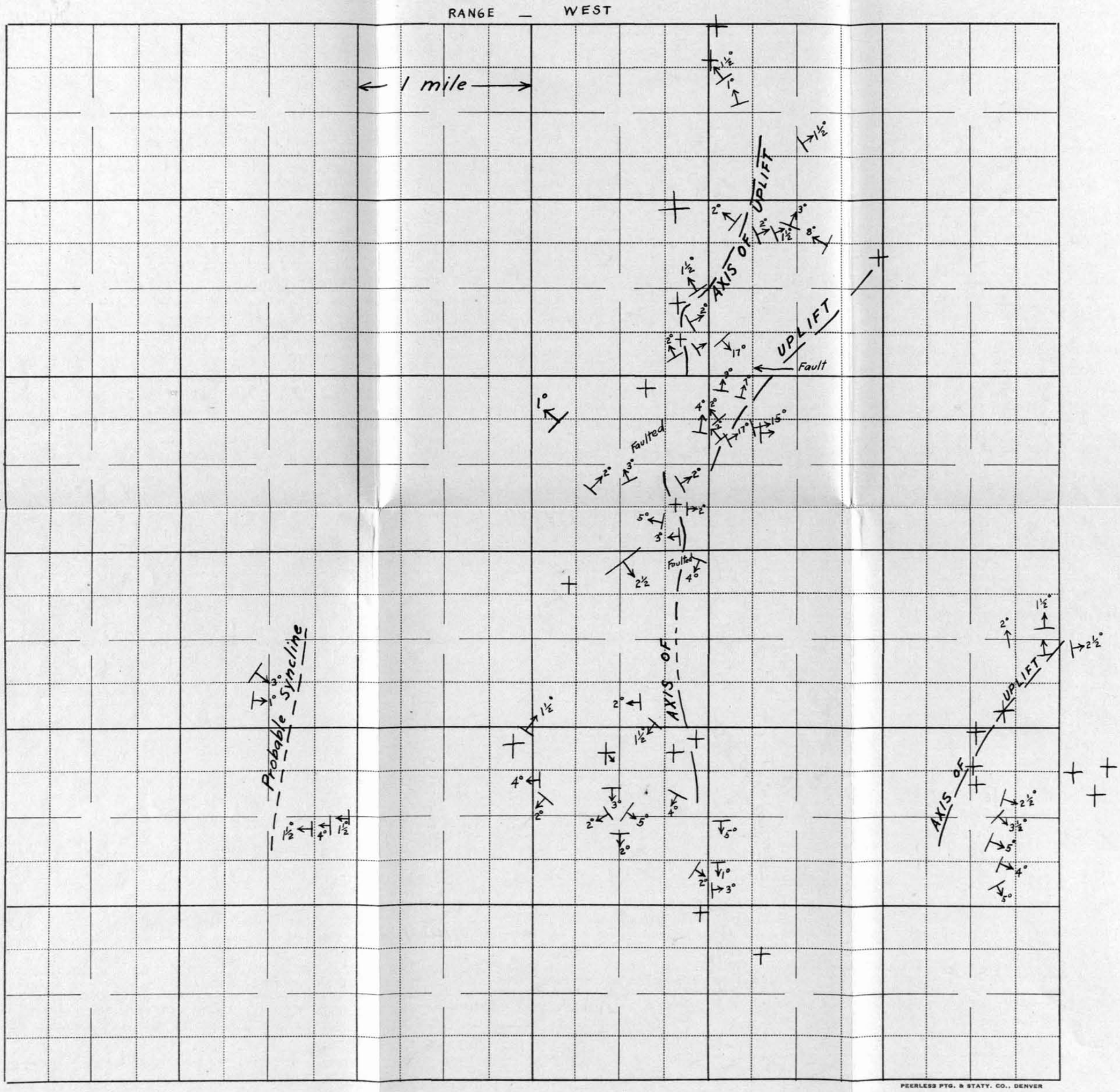
+ Approximately flat.

ELKADER STRUCTURE

LOGAN COUNTY, KANSAS

Scale :- 2 inches = 1 mile.

+ ↳2° J. S. Irwin, Geologist.



PEERLESS PTG. & STATY. CO., DENVER

SERIES III
No. 4

LEGEND

↳ Approximate dip

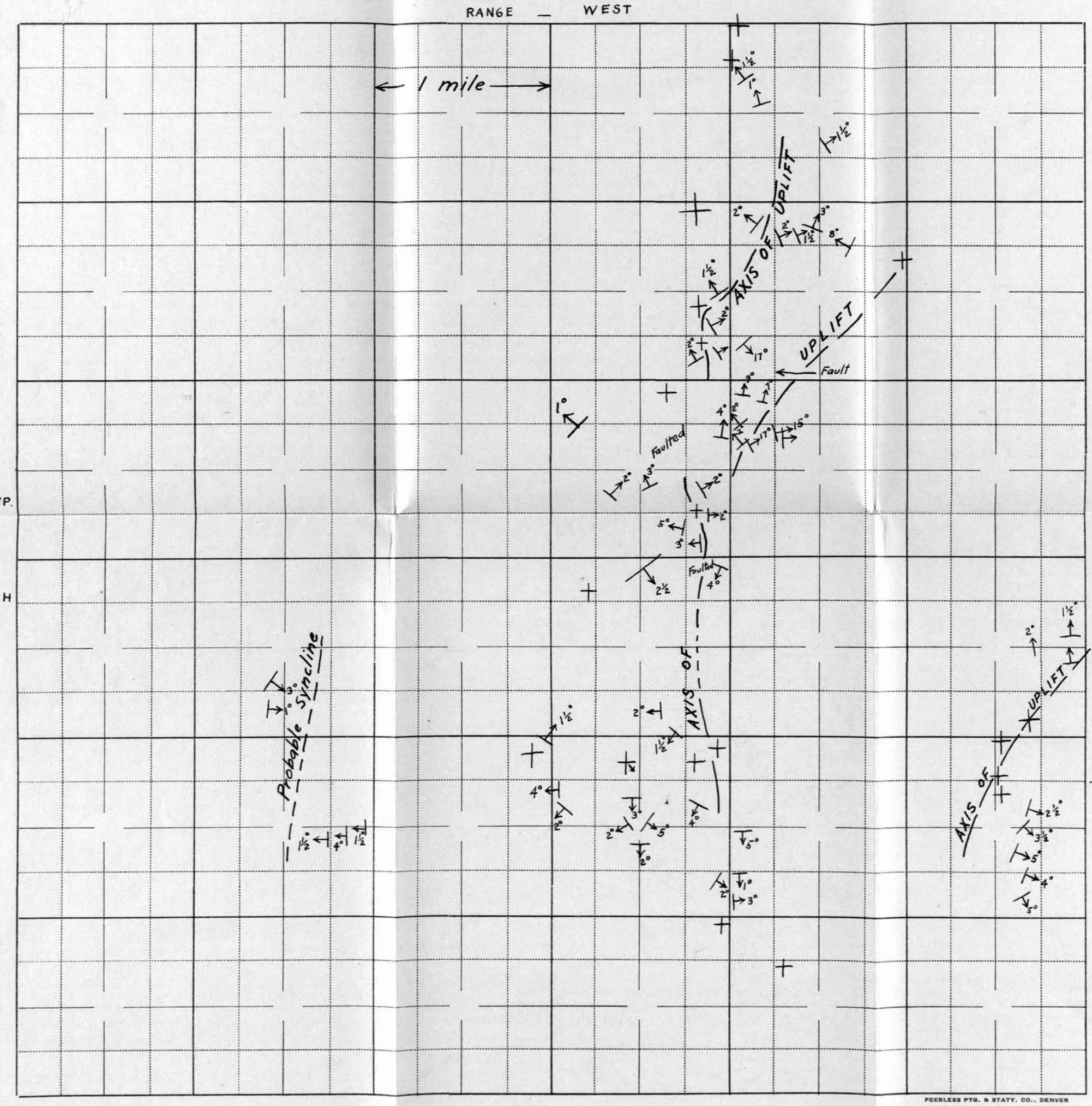
+ Approximately flat.

ELKADER STRUCTURE

LOGAN COUNTY, KANSAS

Scale :- 2 inches = 1 mile.

+ ↳2° J. S. Irwin, Geologist.



PEERLESS PTG. & STATY. CO., DENVER

SERIES III
No. 5

LEGEND

↘ Approximate dip.

\+ Approximately flat.

—

Scale:-2 inches = 1 mile.

LOGAN COUNTY, KANSAS

J. S. Irwin Geologist.

RANGE _ WEST

← 1 mile →

TWP. — SOUTH

EDITH STRUCTURE

UPLIFT

AXIS OF

PENCE STRUCTURE

AXIS

PEERLESS PTG. & STATY. CO., DENVER

SERIES III
No. 6

JEROME STRUCTURE

GOVE COUNTY KANSAS

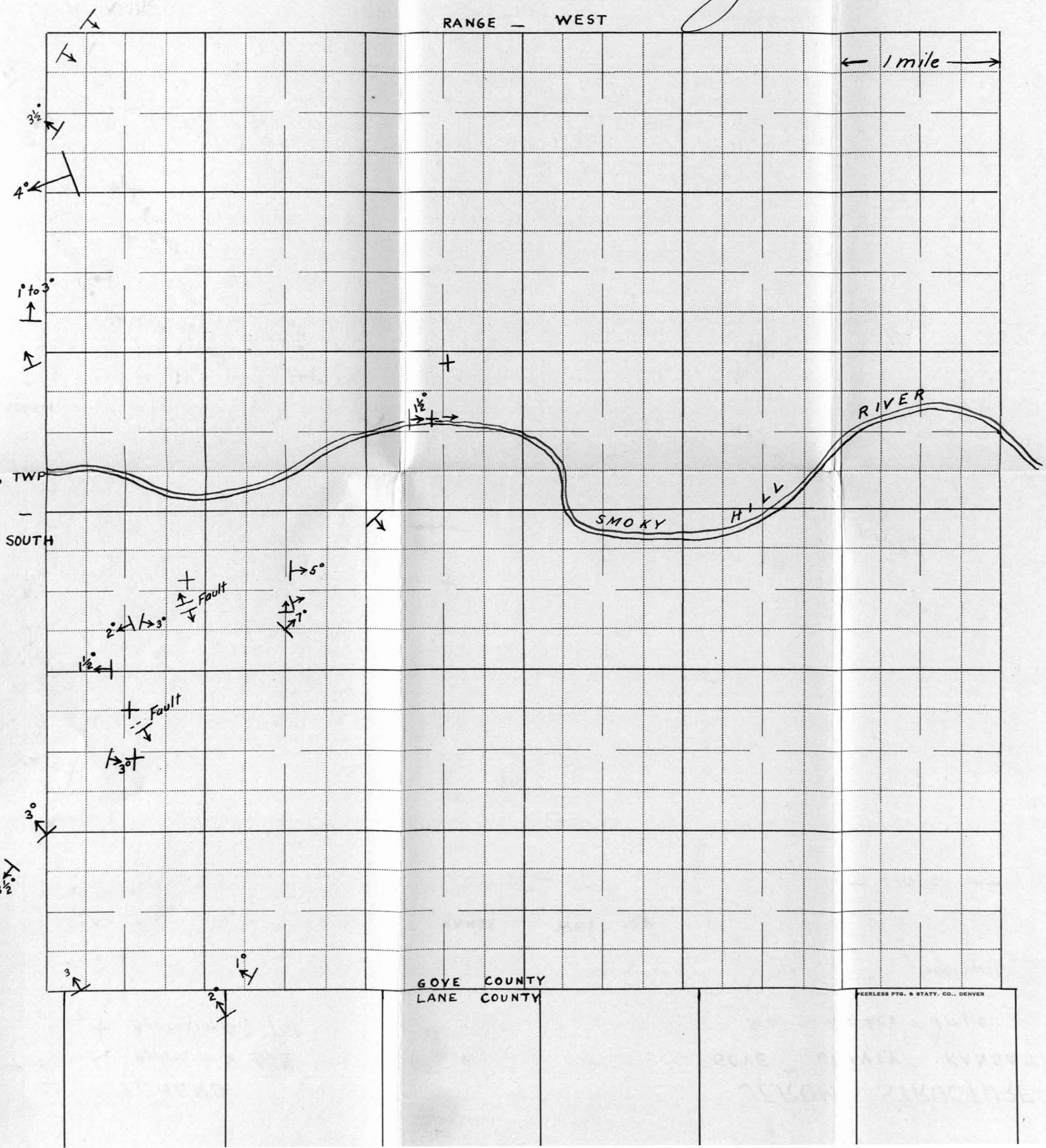
Scale :- 2 inches = 1 mile.

J. S. Irwin Geologist.

LEGEND

↘ Approximate dip.

\+ Approximately flat.



PEERLESS PTG. & STATY. CO., DENVER

SERIES III
No. 7.

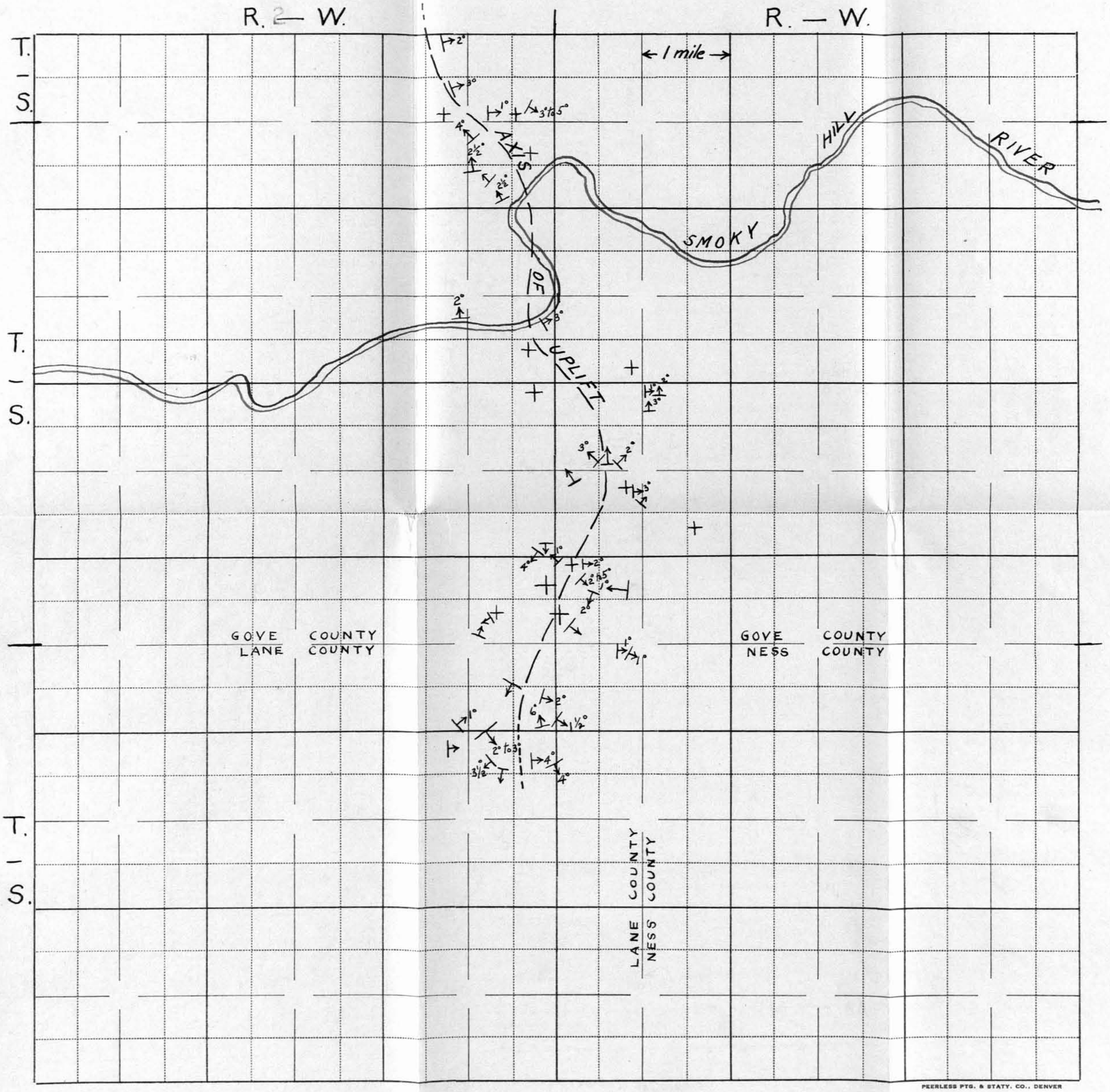
Legend
↳ Approximate dip.
+ Approximately flat.

ALANTHUS STRUCTURE

GOVE & LANE COUNTIES, KANSAS.

Scale:- 1 inch = 1 mile.

J. S. Irwin, Geologist.



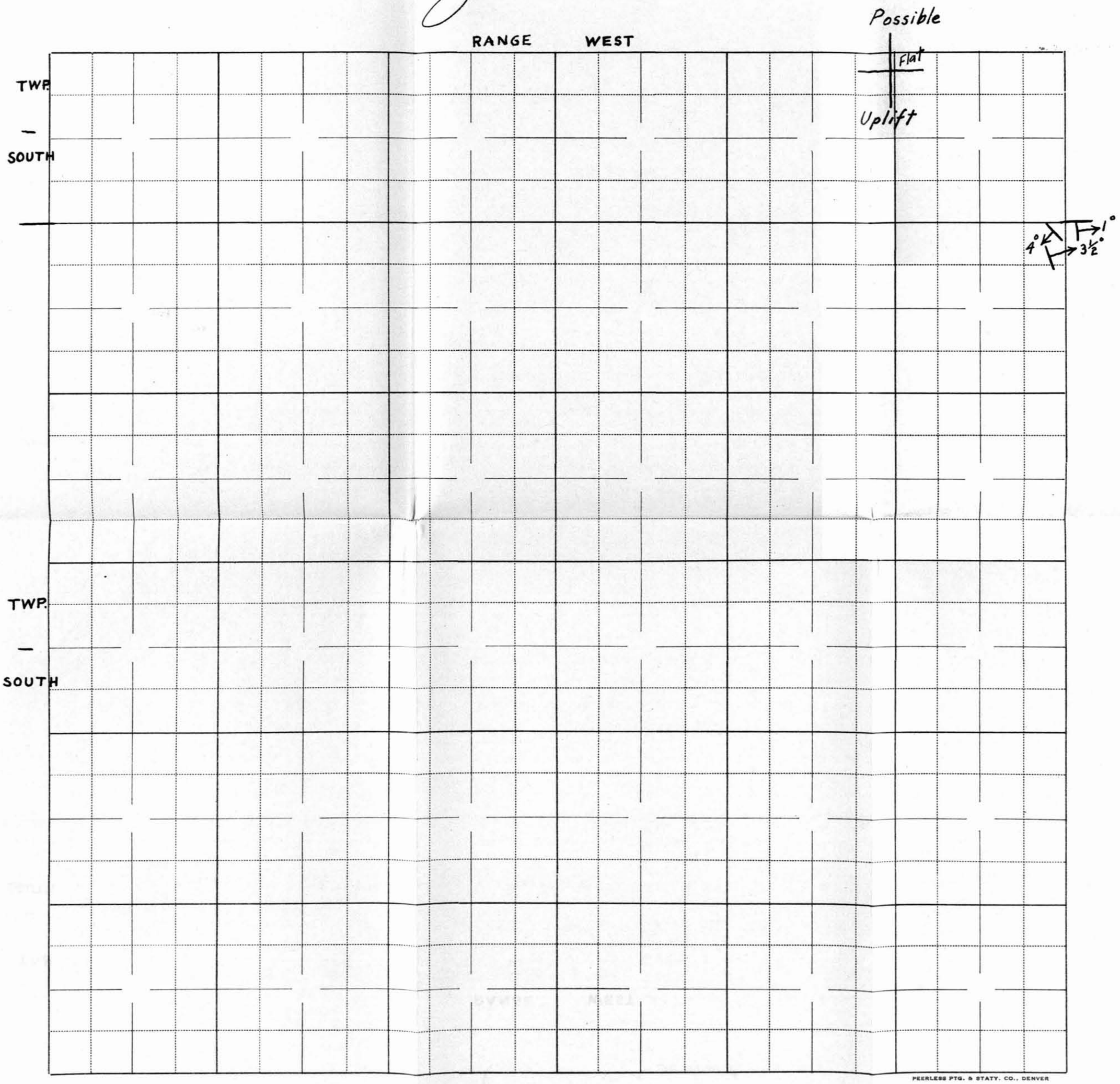
PEERLESS PTG. & STATY. CO., DENVER

BEN ALLEN STRUCTURE

LOGAN COUNTY, KANSAS.

Scale :- 2 inches = 1 mile.

J. S. Irwin Geologist.



PEERLESS PTG. & STATY. CO., DENVER

TWIN BUTTES STRUCTURE

LOGAN COUNTY, KANSAS.

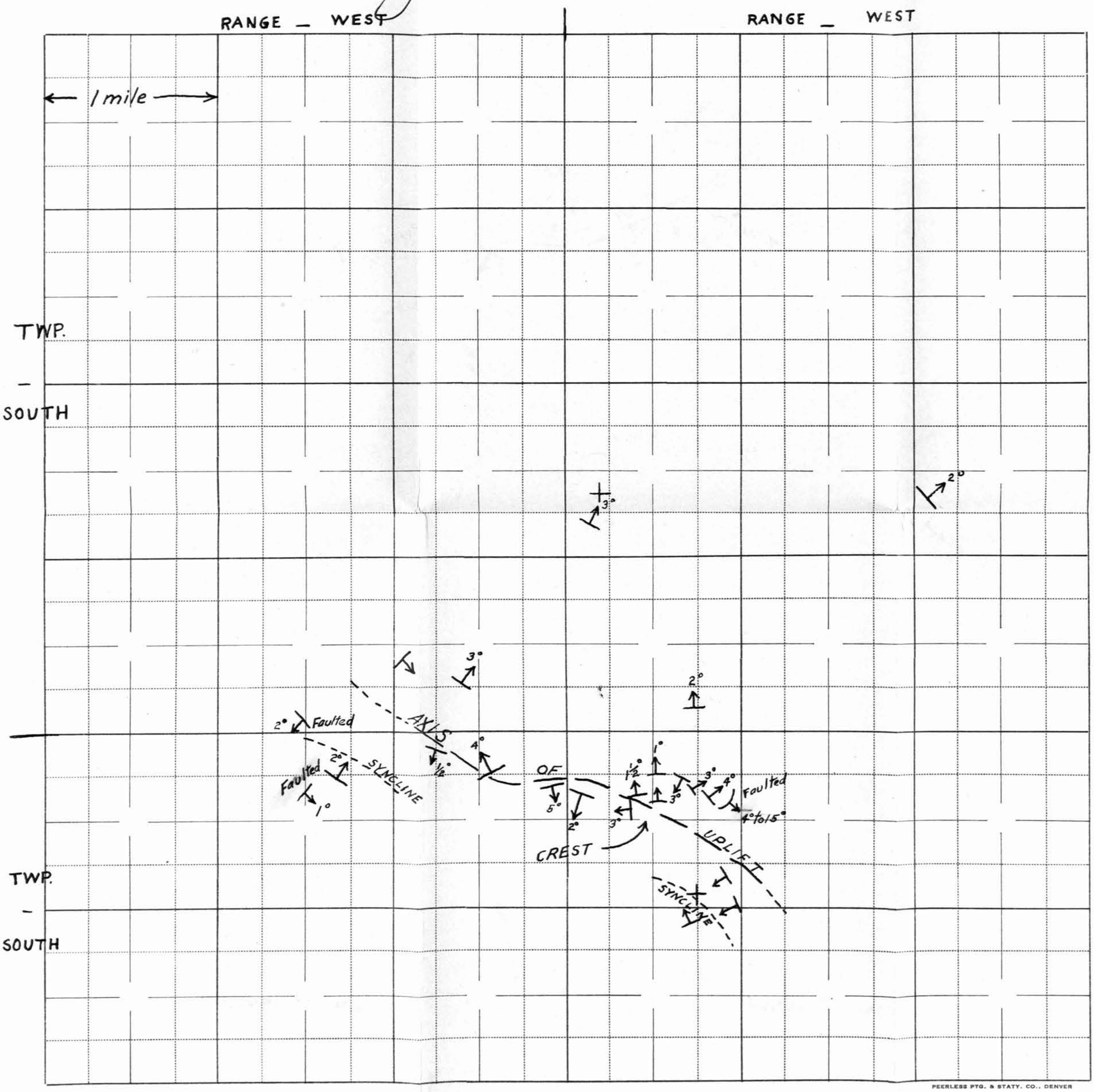
Scale: 2 inches = 1 mile.

J. S. Irwin Geologist

LEGEND

↘ Approximate dip.

+ Approximately flat.



PEERLESS PTG. & STATY. CO., DENVER

SERIES III
No. 10

NORTHEAST TWIN BUTTES STRUCTURE

LOGAN COUNTY, KANSAS

Scale :- 2 inches = 1 mile.

J. S. Irwin Geologist

LEGEND

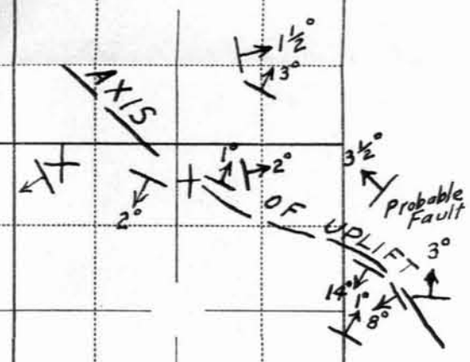
↘ Approximate dip.

\+ Approximately flat.

RANGE _ WEST

← 1 mile →

TWP. – SOUTH



PEERLESS PTG. & STATY. CO., DENVER

STRUCTURE MAP OF BILLY CREEK DOME JOHNSON COUNTY WYOMING

¼ ½ 1 mile

DATUM :- SEA LEVEL

Structure contours on surface between Parkman sandstone and Pierre shale.

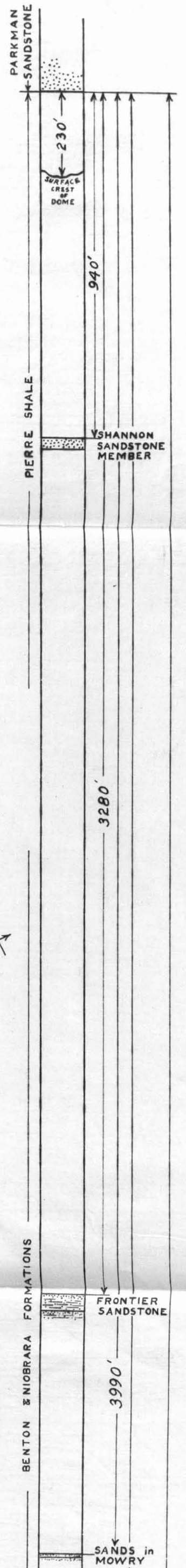
J S Irwin, Geologist.

LEGEND

- Strike and dip.
- 04982 Survey station. Figures show elevation of key horizon above sea level.
- O Proposed location.
- ⊕ Drilling well.
- ⊕ Abandoned well.

SECTION MEASURED ON MUDDY CREEK

VERTICAL SCALE : 1 INCH = 200 FEET.



R. 82 W.

T. 48 N.

31 32 33 34

6 5 4

18 8 9 16

19 20

30

Muddy Creek

Billy Creek

PROBABLE FAULT (Concealed)

SECTION A-A KEY HORIZON

SECTION B-B KEY HORIZON

SECTION C-C KEY HORIZON

El. 5000

El. 4900

D.2260 El. 4982

D.750' El. 5018

Three miles to Big Horn Mountains

R.82 W. R.81 W.

T 43 N

T 42 N

KAYCEE DOME

4 CLEVELAND-WYOMING OIL CO. ①

KAYCEE

3 2 6

9 10 11 12 7

16 15 14 13 18

21 22 23 24 19

28 27 26 25 30

33 34 35 36 31

4 3 2 1 6

9 10 12 7

16 15 14 13 18

21 22 23 24 19

28 27 26 25 30

ANTICLINAL AXIS

Road to Kaycee

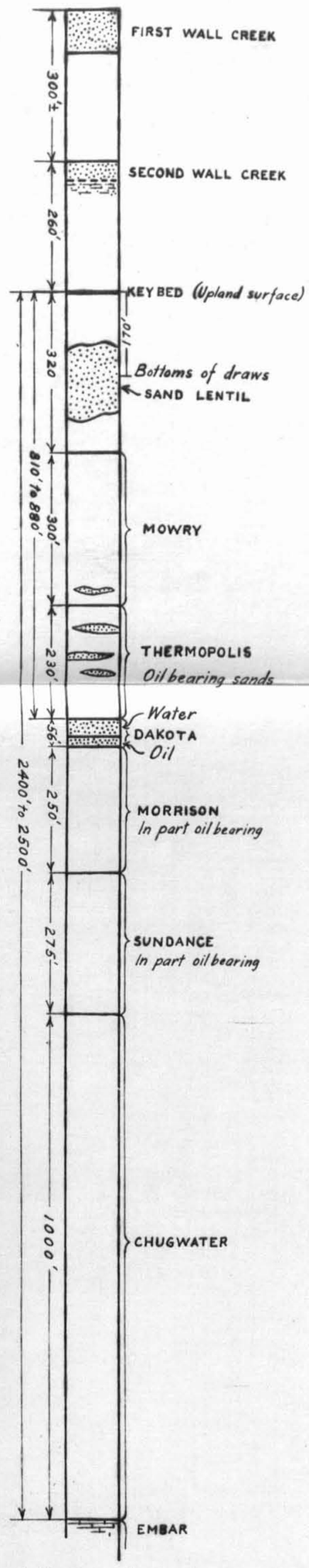
Murphy Creek

4700 4800 4900 5000 4500 4600

2° 4° 6° 2½°

Powder River Dome

COLUMNAR SECTION



Vertical Scale : 1" = 200'

Above Mowry, - section measured in field.
Below Mowry, - section taken from U.S.Geol. Survey Bull. 471.

LEGEND

- Survey station.
- Proposed location.
- Abandoned hole.
- Second Wall Creek escarpment.
- Structure contours.
- Strike and dip.

STRUCTURE MAP OF MURPHY CREEK DOME

JOHNSON COUNTY
WYOMING

¼ ½ 1 2 miles.

DATUM :- SEA LEVEL

J. S. Irwin Geologist