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Geology and Development of the Paloma Field, Kern County, California

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STRATIGRAPHY, structure and closure of the Paloma field are discussed, with some details regarding the present state of development. The Paloma anticline, a large dome modified by faults, is the largest single closed dome in the southern San Joaquin Valley without surface outcrop or topographic expression. It owes its discovery to geophysics. Of nine wells drilled to the Stevens sand, seven are productive. The ultimate productive area may approximate 3000 acres when the limits of the field are determined.

INTRODUCTION

THE Paloma field derives its name from the Paloma school, ½ mile north of what is now the center of the field.

The field is 17 miles southwest of Bakersfield, in the south central part of the San Joaquin Valley (Fig. 1). The present developed area and its expected extensions are in townships 31 and 32S., R.26E. It is the most southerly of several fields that produce from the Stevens sand zone.

The first well to produce condensate was a joint test drilled by the Western Gulf Oil Co. and The Texas Co. near the center of sec. 3, T.32S., R.26E., well No. 54-3. This well was completed on Aug. 31, 1939, at a depth of 10,178 ft. The initial production was 2280 bbl. a day of condensate and 14,750,000 cu. ft. of gas (½-hr. gauge) through a ⅜-in. bean.

Prior to the drilling of this well, the Ohio Oil Co. discovered and developed a small gas field, which embraces a part of three townships about their common corner but lies chiefly in secs. 31 and 32, T.31S., R.26E. The first well was completed on July 1, 1934, at a plugged depth of 5239 ft. after having been drilled to 7957 ft. Production was found in a 59-ft. zone 110 ft. below the Fourth Mya bed, within the San Joaquin clays. Until recently this field was known as the Buena Vista gas field. It is now carried by the Division of Oil and Gas as the Paloma gas field. Production within the Paloma gas field is derived from six wells, producing from several different zones in the interval from 4177 to 5548 feet.

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GEOLOGY

Stratigraphy

The sediments penetrated by wells in the Paloma field range in age from Recent to Upper Miocene. The entire section, which exceeds 10,000 ft. in thickness, conforms generally to the standard section of the south central San Joaquin Valley. The producing zone, sometimes called the Paloma sand, is the approximate equivalent of the Stevens sand zone of the Ten Section, Canal, Coles Levee and other fields. The stratigraphic section is shown in Table 1.

*Paloma Producing Zone** (*Stevens Sand Zone, Upper Miocene*).—The Paloma producing zone (Fig. 2), frequently referred to as the Paloma sand, is encountered at depths ranging from 9950 to 10,300 ft. In general, it is a massive, firm to hard, not too well sorted, fine to medium fine sand. It is interbedded with thin, hard, calcareous sand shells of similar texture and cherty

* Commences with first sand below base of chert zone (100 ft. ± below the *N* point) and continues to top of *Pulvinulinella gyroidinaformis* zone.

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TABLE 1.—*Stratigraphic Section, Paloma Field*

Age	Formation	Thickness, Ft.	Description
Quaternary	Alluvium	1000 ±	Incoherent sands and shales.
Pleistocene	Upper Tulare	850–1200	Friable sands medium to fine-grained with beds of gray-green or brownish mottled sandy clay having infrequent thin beds of fresh-water fossils. Water near base changes from fresh or mildly brackish to salty, as shown by electric logs.
Pleistocene	Lower Tulare	1850–2200	Sand beds less numerous than in the section above, due to thickening of intervening gray-green or brown mottled shales. Carbonaceous material more abundant, with occasional thin seams of lignite or lignitic clays, one of the latter attaining a recorded thickness of 6 feet.
Upper Pliocene	San Joaquin Clays	1450–1500	Predominantly clays, with interbedded fine-medium-grained sands, intervening between the top of the First Mya bed and the top of the Upper Mulinia bed. Fresh-water and marine fossil zones alternate throughout the section. The five Mya zones as well as the Upper and Lower Scalez and the "Stinking Brown Shale" have all been recognized.
Middle Pliocene	Upper Etchegoin	2570–3300	Essentially a sandy zone with intervening shales. Sands vary from silty and fine grained to coarse with excellent porosity and permeability. Difficult to correlate from well to well, owing to lenticularity. Sands increase in abundance and coarseness to east, and shales decrease. Marine fossils scattered throughout but decrease in abundance with depth. Basal sands reach lower and lower into stratigraphic column from west to east.
Lower Pliocene	Lower Etchegoin	250–975	A transition zone of dark gray to greenish gray claystones lying between the above sandy section and the brown shale. Generally regarded as lowermost Pliocene. Contact with underlying brown shale is gradational and is placed where shale body assumes a definite brownish hue.
Upper Miocene	Brown Shale	860–970	A claystone massive and dull grayish brown at top grading within 100 to 200 ft. into dark, greenish brown clay shale. A chert streak appears about 360 ft. above the base, which grades into an almost continuous light brown cherty zone that constitutes the base of this member. Top of continuous chert corresponds to the *N* point of electric logs. This point can be picked in other Stevens-sand fields such as Ten Section, Canal and Coles Levee. In the discovery area the chert zone rests upon the Paloma producing sand. To the east in the Western Gulf B-12-12, this zone is largely replaced by a sand known as the B-12-12 sand.
Upper Miocene	Paloma Producing Zone (Stevens Sand Zone)	300–390	See special description in text
Upper Miocene	Lower Stevens Zone	796 ±	See special description in text

or dark brown siliceous shales. One conspicuous shale bed varying from 10 to 50 ft. in thickness generally occurs within the upper 100 to 150 ft. of sand.

Fresh cores from this zone have been characterized by light tan distillate stains and have a strong gasoline odor. When dry the same cores have an unpleasant smell, described by one observer as a "sour sock" odor. Material resembling Grahamite and giving a dark cut with carbon tetrachloride is frequently found in the sand.

The total effective sand thickness of the productive zone at Paloma is estimated to be from 200 to 250 ft. in the wells now completed. Core analysis indicates an average porosity of about 20 per cent and an average permeability somewhat less than 100 millidarcys. Streaks of sand having permeabilities of 100 to 500 millidarcys are found throughout the section, but doubtless these are of limited extent, as they do not correlate from well to well.

The base of this sand rests with fairly sharp contact upon the underlying Lower Stevens zone.

Lower Stevens Zone (Upper Miocene).—The Lower Stevens Zone is composed chiefly of dark brown semisiliceous and cherty shales, often finely laminated. These shales are infrequently interbedded with sands, which, while similar in texture to those in the producing zone, are in general hard and calcareous. This zone had a thickness of

780 ft. in Ohio K.C.L. A-8 and 796 ft. in Western Gulf K.C.L. A-74. Both wells were bottomed above the *Pulvinulinella gyroid-inaformis* zone, which is considered to be the base of the Stevens zone. Neither well was productive in the Lower Stevens zone.

The potentialities of the formations below the sections penetrated by these wells are unknown.

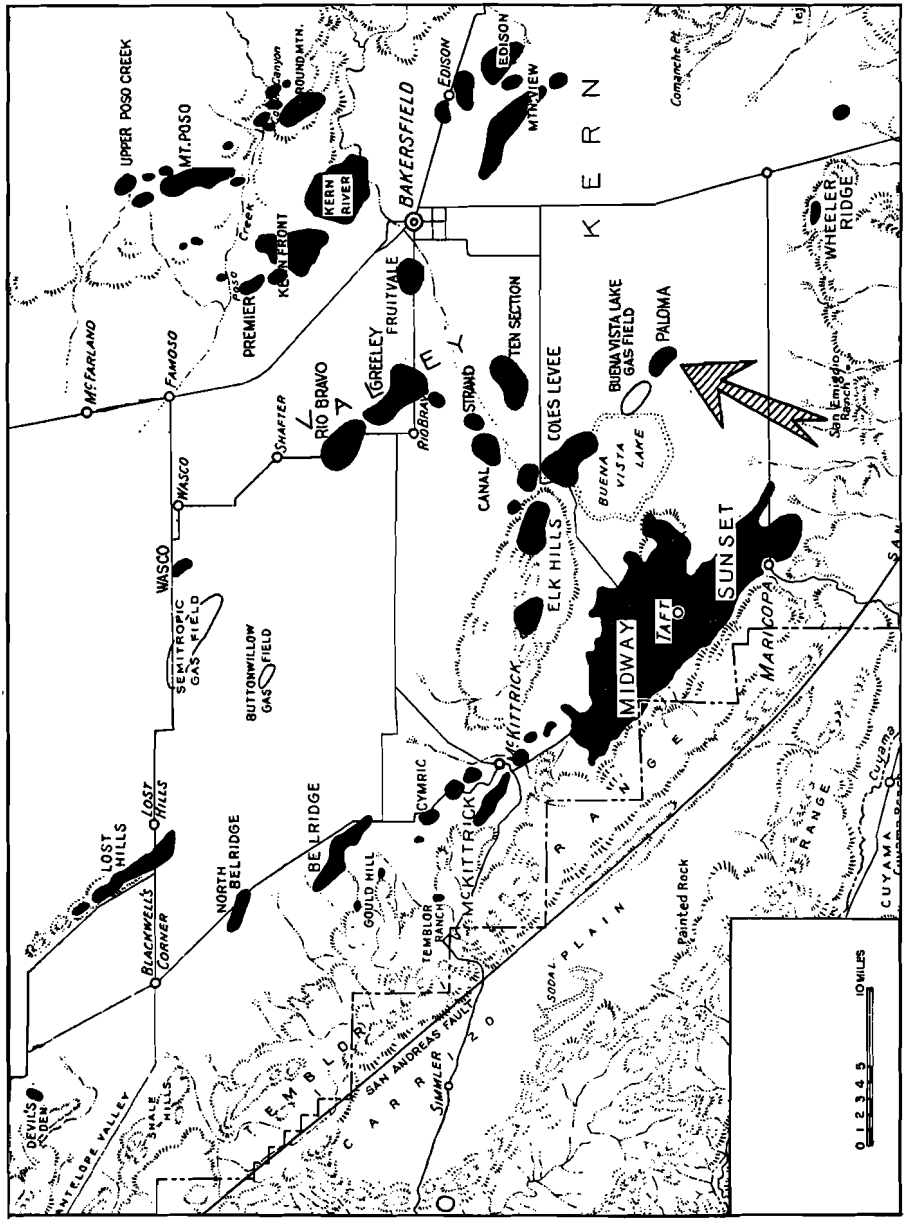

FIG. 1.—PALOMA FIELD AND ADJACENT FIELDS, KERN COUNTY, CALIFORNIA, SEPTEMBER 29, 1941.

Thickness and Distribution of Paloma Producing Zone.—Development is still too limited to define the thickness, distribution

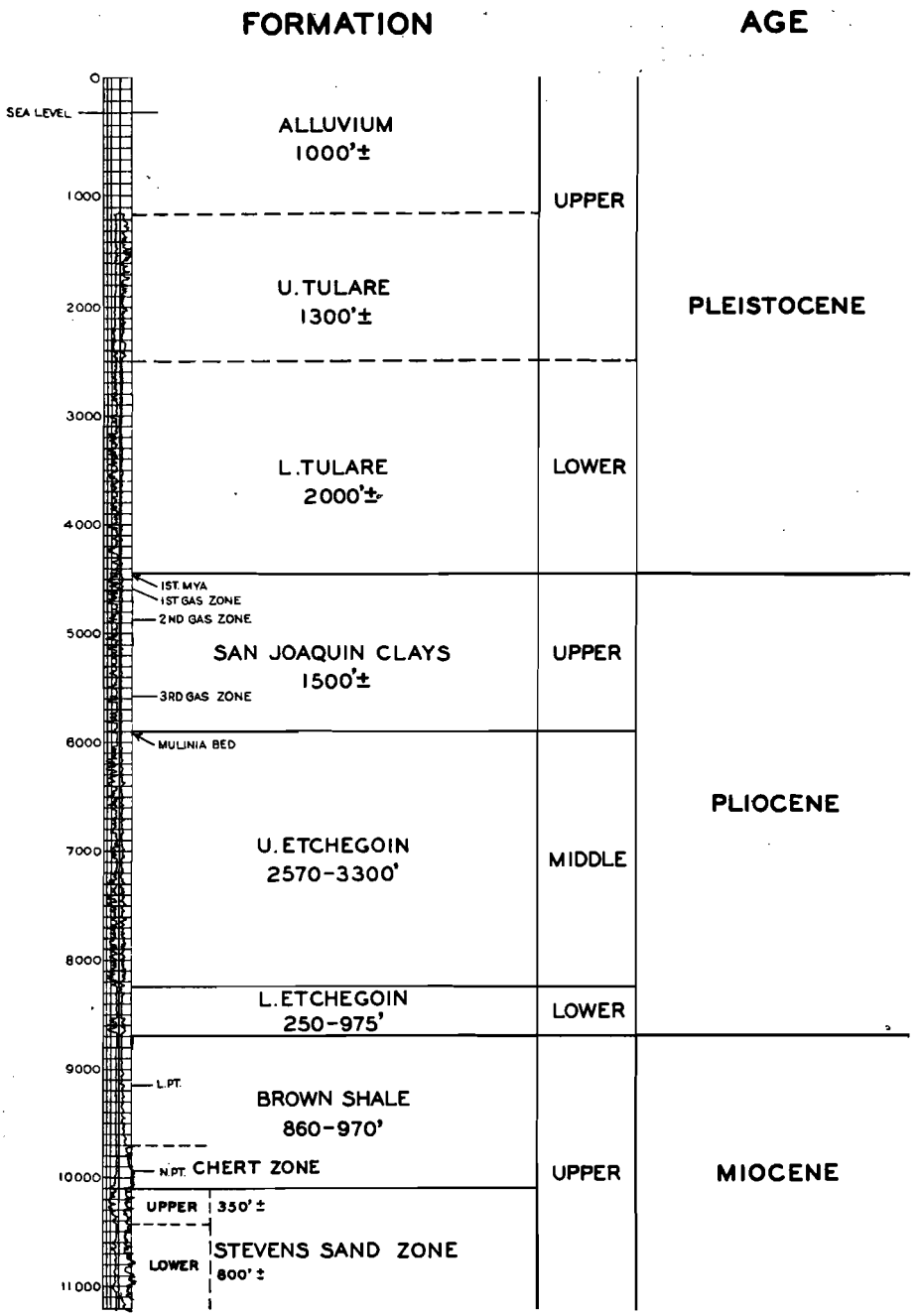

FIG. 2.—STRATIGRAPHIC SECTION, PALOMA PRODUCING ZONE.

and reservoir characteristics of the producing zone throughout the Paloma field. With but one or two exceptions, the wells drilled to date have been located along lines of nearly equal sand thickness. Western Gulf B-12-12 is approximately ¾ mile south of an east-west line passing through the present producing wells. If the upper 90 to 125 ft. of sand in this well is conceded to be a new member, the Stevens sand as known elsewhere in the field has decreased in thickness. Union Oil Company's Morgan No. 81-14, sec. 14, T.32S., R.26E., was abandoned at a depth of 11,456 ft. This well penetrated approximately 285 ft. of sand between 10,640 and bottom. Approximately 213 ft. of sand between 10,640 and 10,853 is considered the equivalent of the B-12-12 sand. The remainder of the sand, approximately 72 ft., occurs between 11,010 and bottom. These sands may be the equivalent of the Paloma producing zone.

Although there are some indications of both thinning and decreasing permeability in the Paloma producing zone southwest of the axis of the structure, more development is necessary before either the southwest or northeast flank can be evaluated.

B-12-12 Sand.—The B-12-12 sand, discovered by Western Gulf B-12-12 early during the current year, is at present confined to the easternmost producing well within the Paloma field. This well's productive zone includes 496 ft. of formation, of which an estimated 260 ft. is sand. The upper 90 to 125 ft. of this sand occurs as a replacement of the chert zone and a small portion of the immediately overlying brown shale.

So little is known at present of the distribution of this sand that it does not merit a great deal of mention other than to say its featheredge lies somewhere between Western Gulf B-12-12 and the next producer to the northwest, Western Gulf A-34. From theoretical considerations and an application of regional geology, it is believed that the featheredge of this new sand will maintain an approximate north-south trend. This means that the B-12-12 sand will be draped about the eastern plunge of the Paloma anticline, and it is anticipated that as it goes down the plunge eastward this sand will expand in thickness and increase in permeability and porosity. Western Gulf Symons 12-7, now drilling exactly one mile east of B-12-12, will test this theory.

Most Reliable Markers for Correlation.—For correlation, the most reliable markers are, from top down, the electrical markers, *L* point, *MM* point, and *N* point, all being within the Miocene brown shale. Intervals between them are approximately 460 and 375 ft. As stated previously, the interval from the *N* point to the top of the Paloma producing zone proper is about 100 feet.

Structure

The Paloma anticline is believed to be a single large dome modified somewhat by faults, the exact position and details of which are still unknown. The Paloma field is lower structurally than any of the San Joaquin Valley fields that produce from the Stevens sand zone, it being the only one in which drilling below 10,000 ft. is necessary to reach this sand (Fig. 3).

South of the Paloma anticline lies the large, structurally deep Buena Vista-Kern Lake synclinal basin into which, it appears from regional studies, were discharged the Stevens sands and other sediments representing their time equivalents along the southwestern edge of the San Joaquin Valley. It is to be expected that these sands grade into richly organic shales toward the center of this basin. This area, to a believer in lateral migration, appears to be the most likely source of much of the oil now accumulated in Stevens sand fields. The low point in this basin is probably at least 3500 ft. lower than equivalent measures on top of the Paloma anticline.

Closure

The Paloma anticline is the largest single closed dome in the southern San Joaquin Valley without surface outcrop or topographic expression. It owes its discovery entirely to geophysics. This fold has a known length of 9 miles, with an indicated geophysical closure of 500 ft. The reversal against the regional dip on its northeastern flank is 1000 ft. opposite the apex of the dome. The vertical relief between the apex and the syncline on the south exceeds 3500 ft. The breadth of the north flank, from anticlinal axis to synclinal axis, is approximately 2 miles.

The productive closure—that is, the vertical relief from the top of a given productive sand at its highest point to the bottom of the lowest dry well within that sand, exceeds 811 ft. by an unknown amount. This figure is obtained by subtracting the subsea-level depth to the top of the Stevens sand (9644 ft.) in Ohio B-3 from the subsea-level depth of Western Gulf B-12-12 (10,455). Subsequent development may prove that stratigraphic closure by lateral

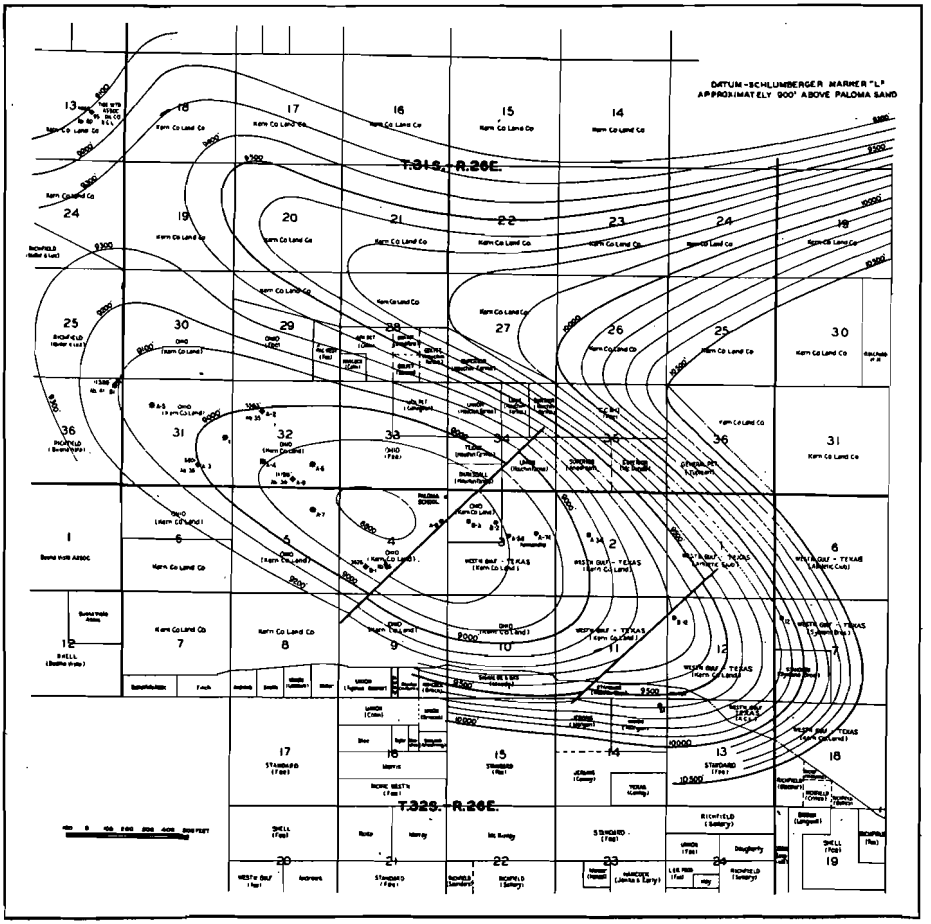

FIG. 3.—STRUCTURAL MAP, PALOMA FIELD, SEPTEMBER 29, 1941.

change of facies is an important factor in accumulation.

Present State of Development

Nine wells have been drilled to the Stevens sand in the Paloma area; all capable of producing except two—Ohio Oil Company's A-8, near the south quarter corner of sec. 32, T.31S., R.26E., and Union Oil Company's Morgan 81-14, sec. 14, T.32S., R.26E. (abandoned 9-30-41). A-8 was the first in the area to penetrate the Stevens zone. Although the prospects for production seemed good, the well failed to produce and since has remained something of a mystery. Union Oil Company's Morgan 81-14 penetrated approximately 200 ft. of sand, believed to be the equivalent of the B-12-12 sand. This sand did not, in the opinion of the operator, warrant a test. Western Gulf Oil Company's Symons Bros. Development Co. No. 12-7 is now drilling at 11,021 ft. This well is in sec. 7, T.32S., R.27E., and is lower structurally than the Union Morgan No. 81-14.

The seven productive wells, three of which were drilled by the Ohio Oil Co. and four by the Western Gulf Oil Co., have an average depth of 10,467 ft. The deepest well drilled in the field is Western Gulf 74-3, which was carried to a depth of 11,422 ft. and later plugged back to 10,700 feet.

The drilling program to date has been to set a 13⅜-in. surface string between 1200 and 1300 ft. A 7-in. water string is then set above the sand at approximately 9500 ft., followed by a 4¾-in. shop-perforated liner on bottom. A majority of the wells are completed with 2-in. tubing.

The ultimate productive area has been estimated to be from 3000 to over 5000 acres. A number of additional wells must be drilled before the field is definitely defined.