SELECTED PAPERS

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CONTENTS

EDITOR

EDITORIAL STAFF

INTRODUCTION

In keeping with its aim of disseminating geological and related information of interest to geologists, the San Joaquin Geological Society is honored and pleased to publish herewith Volume III of the continuing series of Selected Papers. Our Society is indebted to the authors' tireless efforts and dedication to summarize in print the contents in the following pages, previously presented to members at the regular monthly dinner meetings. Not all of the papers presented to the Society lend themselves to the publication here, but equal gratitude is hereby expressed to the speakers who shared their knowledge and talents.

In the hope of inspiring future presentations and publications, this Volume is dedicated to all those in the geological profession who have yet to stand and speak before their fellow members.

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PREVIOUSLY PUBLISHED PAPERS

SELECTED PAPERS—VOLUME I

Edited by Stanley E. Karp

Late Mesozoic Stratigraphy of the Sacramento Valley . . . By Stewart Chuber

Stratigraphy of the Late Upper Cretaceous in the Sacramento Valley . . . . By William F. Edmondson

Geology of the Kione Formation . . . . By John N. Thompson

Grimes Gas Field . . . . By Frank E. Weagant

Distribution of Upper Miocene Sands and their Relation to Production in the North Midway Area, Midway-Sunset Field . . . . By David C. Callaway

SELECTED PAPERS—VOLUME II

Edited by William F. Edmondson

Distribution of Uppermost Cretaceous Sands in the Sacramento-Northern San Joaquin Basin of California . . By David C. Callaway

Geology and Development of the Lathrop Gas Field, San Joaquin County, California . . . . By Robert A. Teitsworth

Geology of the Northern San Joaquin Valley . . . . . By Robert D. Hoffman

Kettleman Hills Area . . . . By Hy Seiden

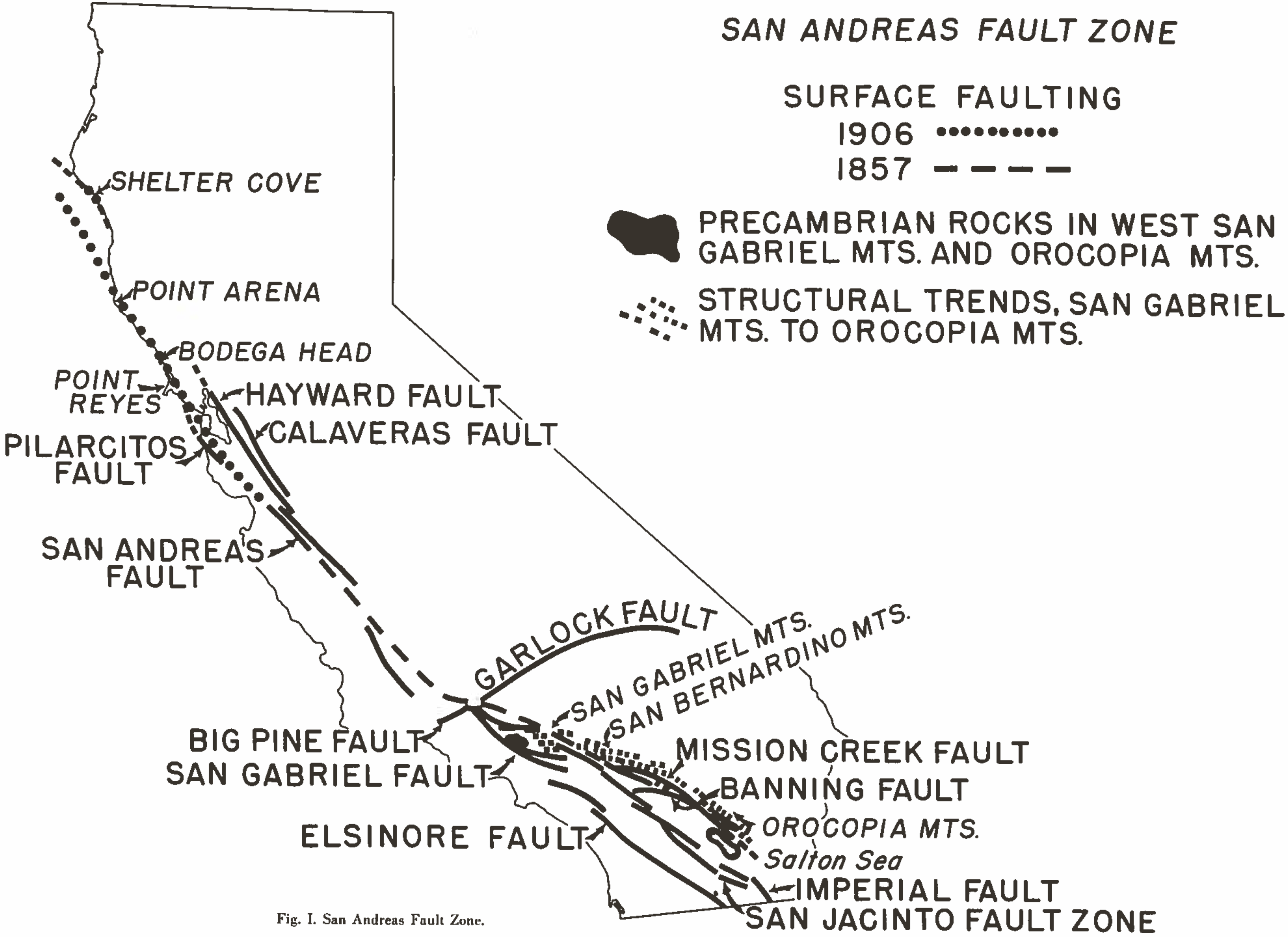

Fig. I. San Andreas Fault Zone.

SAN ANDREAS FAULT: PREDOMINANT LATERAL OR VERTICAL DISPLACEMENT?[1]

GORDON B. OAKESHOTT[2]

ABSTRACT

Critical, objective re-evaluation of geologic mapping and the literature, and years of spot-checking important segments of the fault in the field favor predominantly vertical movement rather than large strike-slip displacement on the San Andreas fault in pre-Quaternary time. Extrapolation of historic behavior of the fault over geologic periods of millions of years is insupportable.

South of Tejon Pass the fault breaks into a system of northwest-trending faults, but the San Andreas fault proper appears to terminate in a knot of faults in San Gorgonio Pass. Neither geologic nor geophysical evidence supports continuation of this fault zone south of the Salton Sea. Probable pre-fault distribution of pre-Cretaceous geologic units in the San Gabriel-Orocopia mountain belt does not require large lateral separation. The San Andreas fault zone, during Cenozoic time, was a locus of deposition of sediments; this has made measurement of lateral offsets of formations uncertain. Character of the sediments, however, offers convincing evidence of large, adjacent vertical uplift.

In central and northern California, matching of stratigraphy, structure, and geologic history across the San Andreas fault, from Late Cretaceous to Pleistocene time, leaves little room for large strike-slip displacement.

For a distance of 350 miles north of the San Emigdio Mountains, the San Andreas fault zone appears to separate Late Mesozoic ensimatic, eugeosynclinal Franciscan rocks from the Late Mesozoic sialic granitic rocks. Distribution of these two great rock units cannot be readily explained by large strike-slip movement, but does appear to require vertical displacements on the order of more than 10 miles.

INTRODUCTION

In 1953, Hill and Dibblee advanced the possibility of cumulative right-lateral displacement of hundreds of miles since Jurassic time on the San Andreas fault. This hypothesis has received very wide acceptance among earth scientists, even to the point of incorporation in a number of leading elementary textbooks as a more-or-less qualified fact for the instruction of young geologists (Garrels, 1951; Moore, 1958; Zumberge, 1958). Even Eardley (1962), who recognizes the conflicting literature, closes his statement by saying: "It is recognized that the major movement on the San Andreas fault has been strike-slip movement."

Perhaps the first to fully appreciate the history of the San Andreas fault during Quaternary time was Noble (1926) who studied the rift in the early 1920's from Palmdale to Cajon Pass. He recognized the rift features as the "product of movements that have taken place repeatedly throughout Quaternary time, and that the movements are still in progress." He noted that distribution of certain Tertiary rocks along the fault affords a suggestion that a horizontal shift of many miles—apparently 24 miles since deposition of the "Martinez" (Paleocene) beds—has taken place, but he concludes with the statement: "The evidence just cited, however, is not convincing, and it certainly is not definite enough to amount to proof." Thus, the concept of lateral displacement along the San Andreas fault in terms of many miles was not original with Hill and Dibblee, but their 1953 paper captured the imagination of geologists and inspired new work by geologists, geophysicists, and geodisists. Hill and Dibblee used lithologic, faunal, and facies similarities in attempting correlations across the fault to suggest right-lateral separation of 10 miles since the Pleistocene, 65 miles since upper Miocene, 175 miles since early Miocene, 225 miles since late Eocene, 320 miles since Cretaceous, and 350 miles since the Jurassic period. This was especially impressive since Dibblee had personally mapped about 300 miles along the San Andreas fault zone on the mile-to-the-inch scale. Suggesting the uncertainty of such correlations, Taliaferro (1943), who had previously mapped more of the fault zone than any other geologist save Dibblee, stated unequivocally that horizontal movement on the San Andreas fault north of Parkfield has been less than one mile!

Geologic evidence is so varied that geologists have drawn conflicting interpretations of the geologic history and characteristics of the fault; at one extreme are those who believe that there has been several hundred miles of right-slip since Late Jurassic time, and at the other are those who consider that there has been large vertical displacement on an ancestral San Andreas fault, and relatively small lateral displacement in Late Tertiary and Quaternary time. In spite of the interest of geologists, and the increasing amount of time and attention given by geologists and seismologists to study of the fault, it remains very incompletely known and understood. After a critical review of the evidence, it is clear that there are no satisfactory answers to such fundamental questions as: When did the fault originate? Should the Quaternary and pre-Quaternary San Andreas be regarded as quite different faults, developed by different stresses and with entirely different characteristics and displacements? Have the sense and direction of movement always been the same? If pre-Quaternary displacement was dominantly vertical, has the same block always moved downward (or upward)? If displacement has been dominantly right-slip, has the present displacement or strain been at approximately the same rate (about 2 inches a year) since Late Jurassic time? What are the true relationships between the granitic rocks which form the basement of the western block in the central Coast Ranges and the Franciscan Formation and mafic rocks which form the eastern block? Finally, is the cumulative displacement on the fault a matter of several thousand feet only, or is it on the order of several hundred miles?

I have been concerned about these problems for many years and have made field checks along the San Andreas fault from one end to the other to try to resolve them in the light of the literature and published and unpublished geologic mapping.

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1. Modified from a paper delivered March 28, 1964 before the Seismological Society of America, meeting in conjunction with the Cordilleran Section of the Geological Society of America at University of Washington, Seattle, Washington. Also presented to the San Joaquin Geological Society November 10, 1964.

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DISCUSSION

Seismologic evidence, geodetic measurements, and geomorphic observations point strongly, but not entirely, to historic and Late Quaternary right-lateral displacement. This type of evidence and the remarkable rift-valley features are too well known to justify more than a sketchy review here. Observers who contributed to the monumental report of the State Earthquake Investigation Commission after 1906 (Lawson, et al, 1908) cited the obvious preponderance of right separation along the fault trace, up to a maximum of 21 feet; but they also noted that the western block moved relatively upward a probable maximum of 3 feet. Re-surveys of first-order triangulation nets by the Coast and Geodetic Survey suggest that strain or displacement on the San Andreas fault has averaged about 2 inches a year since 1885, the east block moving south (Whitten, 1955). In a talk presented to the Stanford Journal Club in October, 1963, Robert D. Burford reported on an analysis of C. A. Whitten's vectors across the San Andreas fault system near Hollister. His analysis showed right displacement on the northwest-trending faults, left displacement on two northeast-trending faults, and extension at right angles to the trace of the San Andreas fault. He concluded that displacement closest to the San Andreas fault has been at the rate of 3 centimeters per year, and a few miles to the west and east, at the rate of 2 centimeters per year. Wallace (1949) computed a displacement of 0.2 inches per year since 1857 by adding movements in earthquakes. Tocher (1960) has measured slow creep at the winery south of Hollister, at about one-half inch per year. This occurs in "spasms" of a few days, separated by intervals of weeks or months. Hill and Dibblee (1953) computed average displacement of 0.2 to 0.3 inches per year, based on their postulated movements for various ages as far back as Late Jurassic time.

Recently, the State Department of Water Resources in its crustal strain investigation program (1963) has made geodimeter measurements of 2,600 miles of surveying across the San Andreas and related faults. That Department's statement is ". . . a preliminary evaluation of measurements across the San Andreas fault suggests right-lateral movement between Hollister and Simmler. The few repeat measurements available between Simmler and the intersection of the San Andreas and Garlock faults suggest left-lateral movement. South of the Garlock fault, it has not been possible to establish a consistent pattern of movement. Repetition of measurements will, of course, be continued to confirm or revise these preliminary evaluations, and to establish more definite directions, amounts, and, possibly variations of magnitude in the movements." (See also Gibson, 1961).

In 1941 Gutenberg published a paper discussing the distribution of compressions and dilatations in a large number of earthquakes in southern and central California. He found that "In almost all earthquakes the block on the northeast side of the fault moves southeastward relative to the other block" and that "vertical movements are usually relatively small." An interesting departure from this pattern has been recorded by Tocher (1959) for the San Francisco earthquake of March 1957. In applying Byerly's method for deducing the nature of faulting from seismograms, Tocher concluded that the movement causing that earthquake was not a repetition of the observed right-lateral movement of 1906, but instead was largely vertical displacement on a steeply-dipping reverse fault with the east block moving relatively upward. Thus, it would appear that increments of movement on the San Andreas fault may be of different sense at different times and places.

QUATERNARY DISPLACEMENT

Most of the geomorphic evidence for Quaternary displacement on the San Andreas fault has been based on offset drainage features. Nature of the evidence may be seen from the following examples: Noble (1926) reported 4 deep ravines which were offset 150 feet at a point 3 miles southeast of Cajon Pass: J. E. Allen (1946) noted offsets of drainage amounting to 3,800 feet in the Gabilan Range; Wallace said that drainage features were offset up to 1½ miles on the north side of the San Gabriel Mountains; and Hill and Dibblee saw 3,000 feet of stream offset in the Temblor Range. Higgins (1961) did detailed mapping in the fault zone in a strip north of San Francisco Bay and concluded that there the fault was active before middle Pliocene time, but that the evidence was insufficient to allow determination of either the type or amount of pre-middle Pliocene displacement. Present positions on opposite sides of the fault that appear to have been marine entrances to middle Pliocene basins east of the fault trace suggest that right displacement has not exceeded 15 miles and most possibly has not been over 1 to 1½ miles. During this same geologic time, Higgins found that the eastern block has been relatively elevated by about 500 feet. None of the anomalous stream courses here gives clear evidence of lateral displacement; all can best be attributed to deflection by slides, earthflows, headward erosion along softened rocks in the fault zone, fault slivers that have moved vertically, and other minor structural controls within the fault zone.

Seismograph records date back about 75 years, geodetic measurements began about the same time, historic records of California earthquakes cover only the last 200 years, and the geomorphic rift-valley features in the San Andreas fault zone are certainly Quaternary and therefore less than one million years old. Of course, the latter are often etched in much older rocks.

Seismologic evidence, geodetic measurements, and geomorphic observations generally strongly suggest right slip in very late Quaternary time, but also indicate that the sense of movement in increments of slip has not always been the same. *Extrapolation of this very short experience back over geologic periods of many millions of years is unscientific and insupportable.*

PRE-QUATERNARY DISPLACEMENT

Unraveling of pre-Quaternary history of the San Andreas fault is much more difficult than its later history and uncertainties multiply as we attempt to trace the fault displacements back into early Tertiary time and to document a possible pre-Tertiary history. We shall now examine a small part of that evidence, referring to the accompanying figures which show some of the geology of critical areas along the fault zone.

Figure I shows the San Andreas fault much as it was mapped by Lawson, et al, in 1906. The dotted segment of the fault, from San Juan Bautista to the ocean north of Pt. Arena, denotes surface faulting which caused the 1906 San Francisco earthquake. Surface faulting (east block raised) took place at the same time along an *en echelon* fault at Shelter Cove in southern Humboldt County. On the San Francisco Peninsula the major fault which separates distinctive geologic units is the Pilarcitos, not the San Andreas as named by Lawson (1908). Here the Late Quaternary San Andreas fault departs from the old major fault zone. Surface faulting which took place at the time of the 1857 Fort Tejon earthquake, from Priest Valley to San Bernardino, is shown by the dashed-line segment. A few related faults have been added.

Near its juncture with the Garlock-Big Pine fault, the San Andreas fault changes direction sharply and splits into a system of related faults as much as 50 miles across, chief of which are the San Gabriel, Elsinore, San Jacinto, and Banning-Mission Creek fault zone. Of these, the San Andreas, Elsinore, and San Jacinto have been historically active, while the San Gabriel, and segments of the Mission Creek and Banning, were certainly inactive by the close of Pleistocene time. Crowell (1952), after large-scale Mapping of the Lebec quadrangle near the San Andreas-Garlock junction, stated that "No conclusive evidence on the direction and amount of movement on the San Andreas fault, or on its age, has come to light as the result of this study." However, he believes that the mapping shows that the fault is one "of large displacement and great structural significance." In an important paper which resulted from geologic mapping in the San Gorgonio Pass area, Allen (1957) discussed structural relationships in this area. The San Andreas fault proper appears to butt against the westerly-trending Banning fault in that vicinity. There is no geologic evidence to support its continuation farther south, a conclusion Fairbanks reached in his mapping for the Earthquake Commission in 1906 (Lawson, et al, 1908). In turn, the Mission Creek-Banning fault zone can be traced southward only as far as the Salton Sea where it apparently dies out. In a Ph.D. thesis by Kovach in 1962, and in a later paper in the same year, Kovach, Allen, and Press reach the conclusion that gravity and seismic data do not support continuity of the Mission Creek-Banning fault southward into the Colorado Delta region, although they do find that the Elsinore, San Jacinto, and an unnamed fault beneath the Sand Hills are well-delineated by such data. It is extremely difficult to reconcile the complex pattern of faulting in the San Gorgonio Pass and the evidence for dying out of San Andreas and Mission Creek-Banning faults with large lateral displacement!

The strongest support and best documentation for large strike-slip on the San Andreas fault in southern California is found in a recent paper by Crowell (1962) and a companion paper by Crowell and Walker (1962). Crowell's conclusion that "evidence in hand suggests that 160-175 miles of right slip on the San Andreas and closely associated faults since early Miocene is probable" is based on correlation of a Precambrian suite of gneisses and anorthosite overlain by Eocene marine and Oligocene non-marine rocks in the Orocopia Mountains, with a similar association in the western San Gabriel Mountains. Two questions are pertinent here: (1), Are these two Precambrian suites so uniquely similar as to require a contiguous situation in pre-fault time?; and (2), What was the pre-fault outline of the Ecene-Oligocene basin of deposition? From my own mapping (Oakeshott, 1958) in the San Gabriel Mountains, I would say to the first question that the San Gabriel and Orocopia Precambrian rocks bear only that similarity to each other that might be expected of Precambrian anorthosites and associated rocks whether adjacent or not. Further, the west-to-east structural trend in the San Gabriel Mountains continuously and gradually, without apparent discontinuity, swings to more southerly trends through the San Bernardino and Little San Bernardino Mountains to the northwest-trending structures in the Orocopia Mountains. Concerning the second question, pre-fault outlines of the Eocene-Oligocene basin are not known because post-Oligocene uplift, faulting, and erosion have largely removed these sedimentary units. It is not only possible, but quite probable, that the basins of deposition of the Tertiary sediments were at least partly controlled by the rift zone.

As Crowell points out, all rocks earlier than earliest Miocene appear to be displaced by the same amount. Thus, if we were to accpet his postulate, the original 350-mile-displacement figure of Hill and Dibblee would be cut in half.

Figure II shows the 40-mile stretch of the San Andreas fault zone, after Noble (1954), along the north side of the San Gabriel Mountains from Little Rock to Cajon Pass. Distribution of the folded beds of upper Miocene non-marine conglomerate and sandstone of the Punch Bowl Formation is shown with the symbol, Tp. These beds were obviously deposited in the trough of the fault zone and were derived from Cretaceous and Jurassic granitic rocks, pre-Cretaceous Pelona schist, and Tertiary formations. Noble believes that the combination of distribution of features shown here—that is, Punch Bowl Formation, lower Miocene marine Vaqueros Formation (Tv), Paleocene marine Martinez Formation (not shown), Punch Bowl fault, and Cajon Valley fault—suggests right-lateral offset of at least 30 miles. However, it appears most likely that deposition of the Paleocene and lower Miocene formations, as well as the upper Miocene Punch Bowl Formation, was controlled by the trough of the fault zone. In that case, there is nothing anomalous about the present distribution of erosional remnants of these formations. Noble's suggestion that the Cajon Valley fault is the offset correlative of the Punch Bowl fault is not convincing in this complex zone of faulting.

There is even greater difficulty in attempting to postulate offsets of the Cretaceous and Jurassic (?) granitic rocks and the pre-Cretaceous Pelona schist. Granitic rocks of many varieties occur on both sides of the fault zone and in it. The Pelona schist is widely distributed in and broadly adjacent to the San Andreas and Garlock fault zones; little or nothing is certainly known of its pre-faulting distribution. It is interesting to note that Wallace (1949) found that occurrence of "blocks of Pelona schist on opposite sides of the rift suggests displacement of 9 miles in the opposite direction to that indicated by recent faulting," although he believed this to be "only apparent and possibly the result of differential vertical uplift of two separate Pelona schist blocks." Woodford (1960) also had difficulties in reconciling bedrock patterns and strike-slip faulting. Quoting him: "Greater displacements (than 30 miles) may have occurred in the bedrock but they have not been demonstrated. Some apparent net separations are puzzling, to say the least . . . the arrangement of the four principal masses of Pelona and similar schists seems to show left-lateral separations of 40 miles along the San Andreas fault."

In comment on this latter paragraph of my manuscript, Crowell recently wrote me (April 1964):

> "This is certainly a problem! But note how widespread the schist is: from Abel Mt. to the south end of the Chocolate Mountains, from Randsburg to well southwest of the San Andreas Zone, and perhaps even related to the Catalina schist. When we work out the original distribution of these

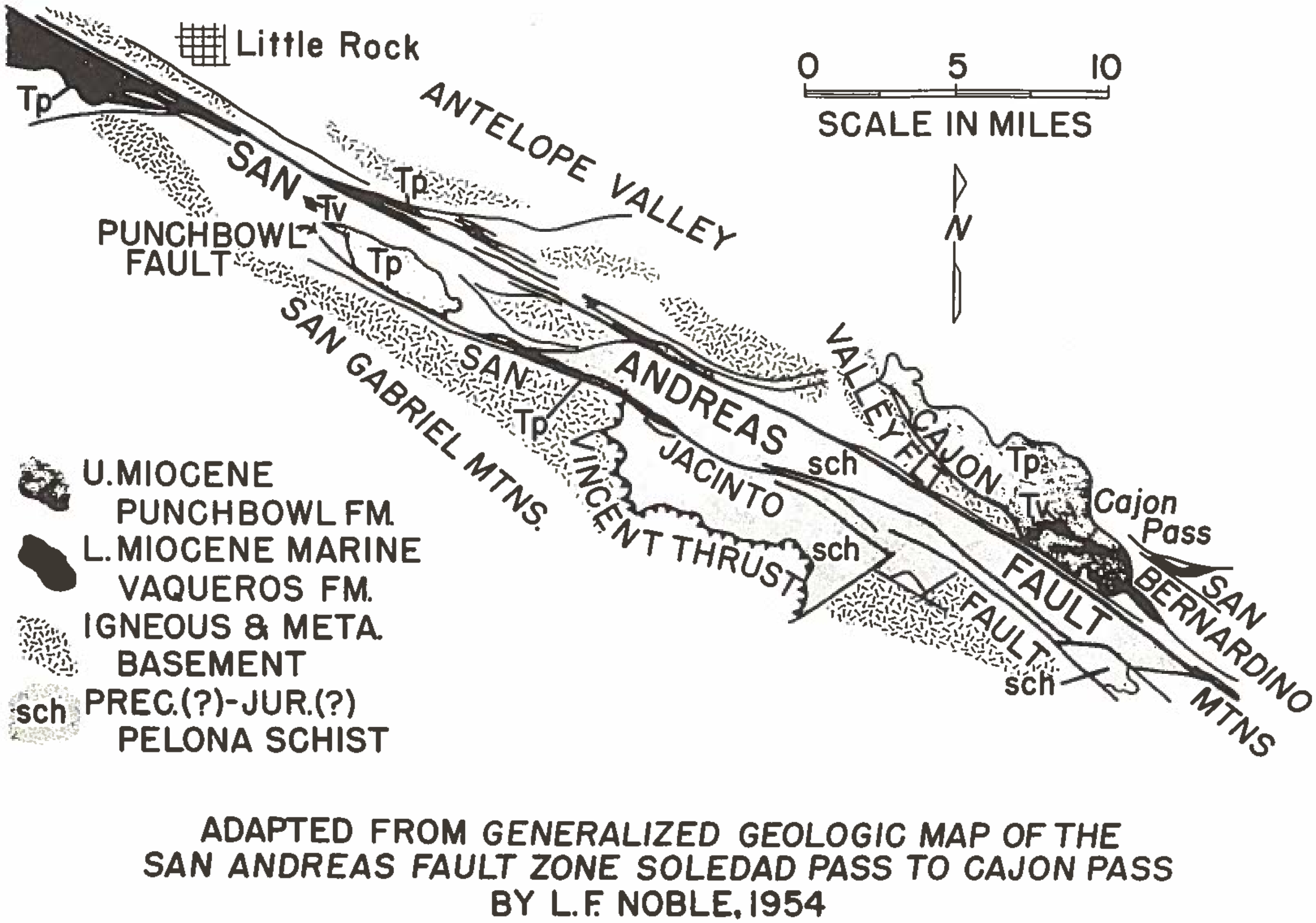

Fig. II. San Andreas Fault Zone, Little Rock to Cajon Pass.

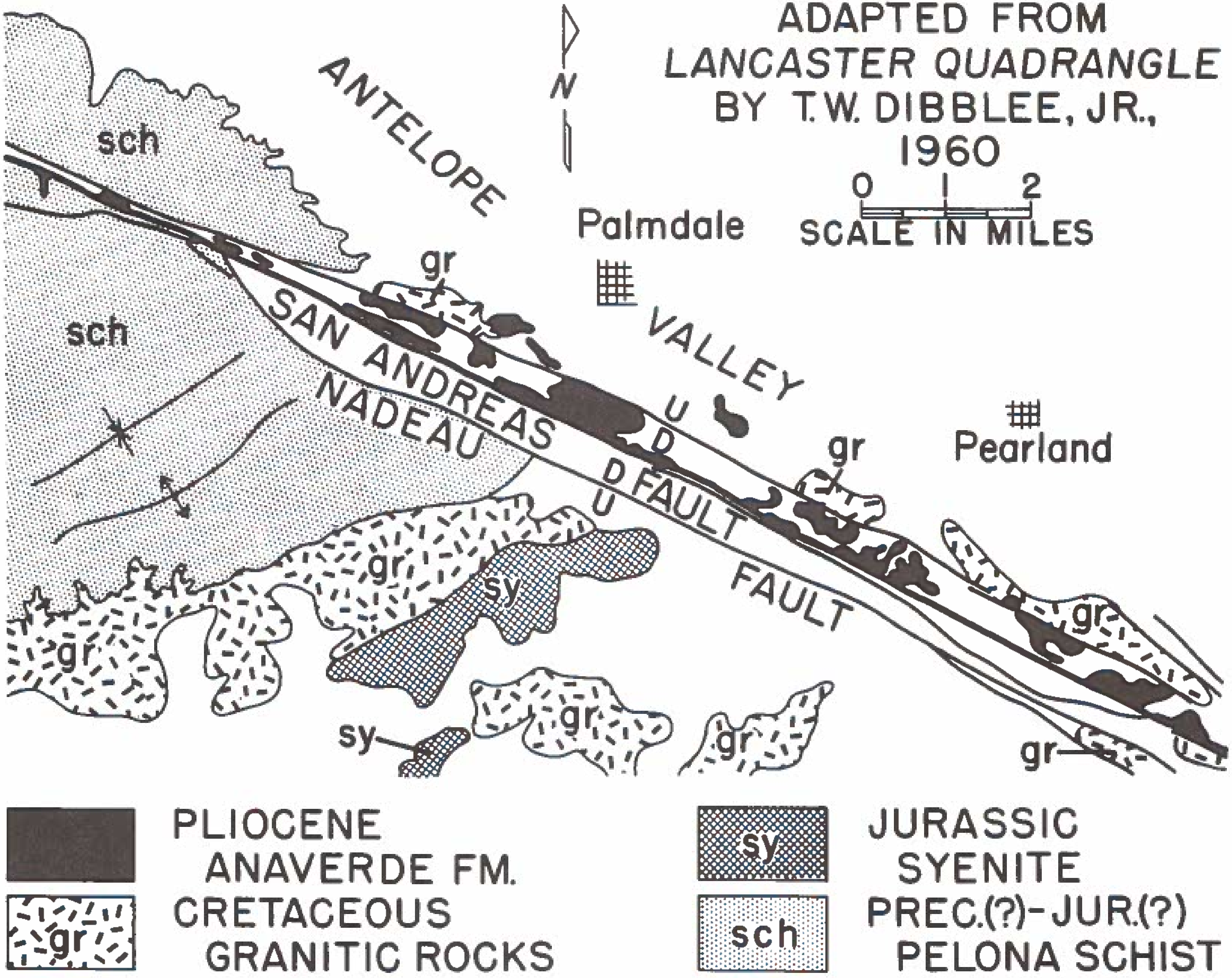

Fig. III. San Andreas Fault Zone across the Lancaster quadrangle.

schists, we will have made great strides in understanding California tectonics."

Figure III shows the San Andreas fault zone across the Lancaster 15-minute quadrangle as mapped by Dibblee (1960). The Pliocene Anaverde Formation, whose distribution is shown in small dark patches in the fault graben, consists of terrestrial sedimentary rocks, and, like the upper Miocene Punch Bowl Formation, was deposited in the fault trough during active faulting. The Anaverde is largely arkosic sandstone and was obviously derived from granitic rocks. A problem is the seeming lack of clasts of Pelona schist and gneiss of the San Gabriel Mountains. Noble (1954) believes the Anaverde lies wholly north of the San Andreas fault and was derived from erosion of the Liebre Quartz Monzonite which crops out 35 miles northwest of Palmdale on the south side of the fault. The nearby granitic rocks in the Lancaster quadrangle include abundant quartz monzonite, grandodiorite, and syenite, as described by Dibblee. It therefore appears most reasonable that sands of the Anaverde Formation were derived mainly from exposures of granitic rocks in the immediately adjacent, high-standing San Gabriel Mountains on the south and were deposited in rift valleys along this portion of the San Andreas fault zone. A considerable amount of vertical movement is suggested, but lateral displacement is not necessary to explain the geological relationships.

No satisfaction can be gained from distribution of the Pelona schists, Cretaceous granitic rocks, and Jurassic syenite along the fault zone in the Lancaster quadrangle. No outcrops of the syenite have been found north of the San Andreas fault, but granitic rocks and schist crop out in both blocks.

Figure IV shows a segment of the San Andreas fault, as mapped by Noble (1953), on the north side of the San Gabriel Mountains. The Harold Formation, whose distribution is shown in the solid dark shade, is a coarse-grained, loosely-consolidated, land-laid deposit which consists largely of detritus derived from Cretaceous granitic rocks and Pelona schist of unknown pre-Cretaceous age. Noble states that the Harold Formation south of the fault is composed of granitic material, while north of the fault it consists of Pelona schist detritus. He concludes that the Harold Formation "may have been displaced as much as 5 miles" in a right-lateral sense. The San Andreas fault zone is roughly 6 miles wide here and the Harold Formation was obviously deposited within that fault zone. From the distribution of remnants of the Harold Formation and their apparent offsetting by minor faults within the San Andreas zone, the only conclusions that seem valid here are that deposition of the Harold sediments was controlled by the rift zone and that faulting went on during deposition.

Figure VI is a diagrammatic section (my field interpretation from Allen, 1946) representing rock formations which are exposed in the Pajaro River Gap and vicinity across the southern end of the Santa Cruz Mountains. Figure V shows the pattern of faulting in this area, according to Allen (1946). Here the San Andreas fault is unusually well exposed. Basement rocks in the west block consist of the Sur Series gneisses and schists of pre-Cretaceous age which have been intruded by Late Jurassic and Cretaceous granitic rocks. On the east are the complex rocks of the Late Jurassic to Late Cretaceous Franciscan Formation. More follows shortly about the relationships of these two very different formations. Three Tertiary formations, which are exposed above the basement rocks on both sides of the fault, appear lithologically, structurally, and stratigraphically identical. Oligocene marine shale crops out on both sides of the fault and grades upward into the distinctive, thin-bedded sandstone and silicious shale of the Miocene Monterey Formation. Unconformably lying on the Monterey Formation on both sides of the fault are the much coarser sandstones and conglomerates of the Pliocene Purisima Formation. The Purisima overlaps the older Tertiary units to lie unconformably on the Franciscan in the east block and on the granitic rocks and Sur Series on the west. At one nearby locality basal beds of the Purisima which lie on granitic rocks contain an abundance of extremely coarse clasts of Franciscan rocks which must have come across the fault zone. There is thus no evidence for, and no necessity for, large Tertiary or post-Tertiary displacement on the San Andreas fault in this region.

In Figure VI, the west side of the section is the southern end of the Santa Cruz Basin, the east side is the north end of the Hollister Trough. If there has been large lateral displacement on the San Andreas fault, these two Tertiary basins are not continuous but would be matched by sedimentary-rock sections many miles apart across the fault. After years of work in this region, Gribi (1963) recently had this to say:

> "'Slippers' would match the Hollister Trough sediments with rocks in some basin far to the northwest on the west side of the San Andreas fault. However, the rocks from Eocene into middle Miocene of the southeast end of the Santa Cruz Basin are similar to their counterparts immediately across the fault in the northwest end of the Hollister Trough in lithology, thickness, and faunal content. Upper Miocene and Pliocene rocks show some differing characteristics, but these differences are no greater than have been demonstrated by simple facies and thickness changes in similar rocks in areas not affected by lateral faulting. Therefore, as a working hypothesis here it is assumed that the Hollister Trough is the depositional and structural continuation of the Half Moon Bay-Santa Cruz Basin. With its definite connection to the San Benito Trough, Vallecitos Snycline, Priest Valley-Warthan Canyon Syncline, the San Joaquin Valley, and probably the Bitterwater Basin and the Salinas Basin, the Hollister Trough becomes an integral part of California Tertiary sedimentary history and particularly of a great linear zone of weakness, a portion of which coincides with the present-day San Andreas Fault."

At San Juan Bautista, about 6 miles southeast of Pajaro Gap, the west block of the fault, in which Sur Series gneisses and granitic rocks are exposed, is at least 10,000 feet structurally higher than the Hollister Trough immediately across the fault to the east.

Farther north in the Santa Cruz Mountains, Brabb (1960) and associates (Cummings, Touring, and Brabb, 1962) did large-scale, detailed geologic mapping west of the San Andreas fault and compared the Late Cretaceous-to-Pliocene geologic columns and histories across the San Andreas-Pilarcitos fault zone as shown on Figure VII. Lithology, stratigraphy, fossil zones, and geologic history correlate so strikingly across the faults here from Late Campanian to Pliocene time as to apparently preclude any cumulative offset measurable in miles since the late Cretaceous.

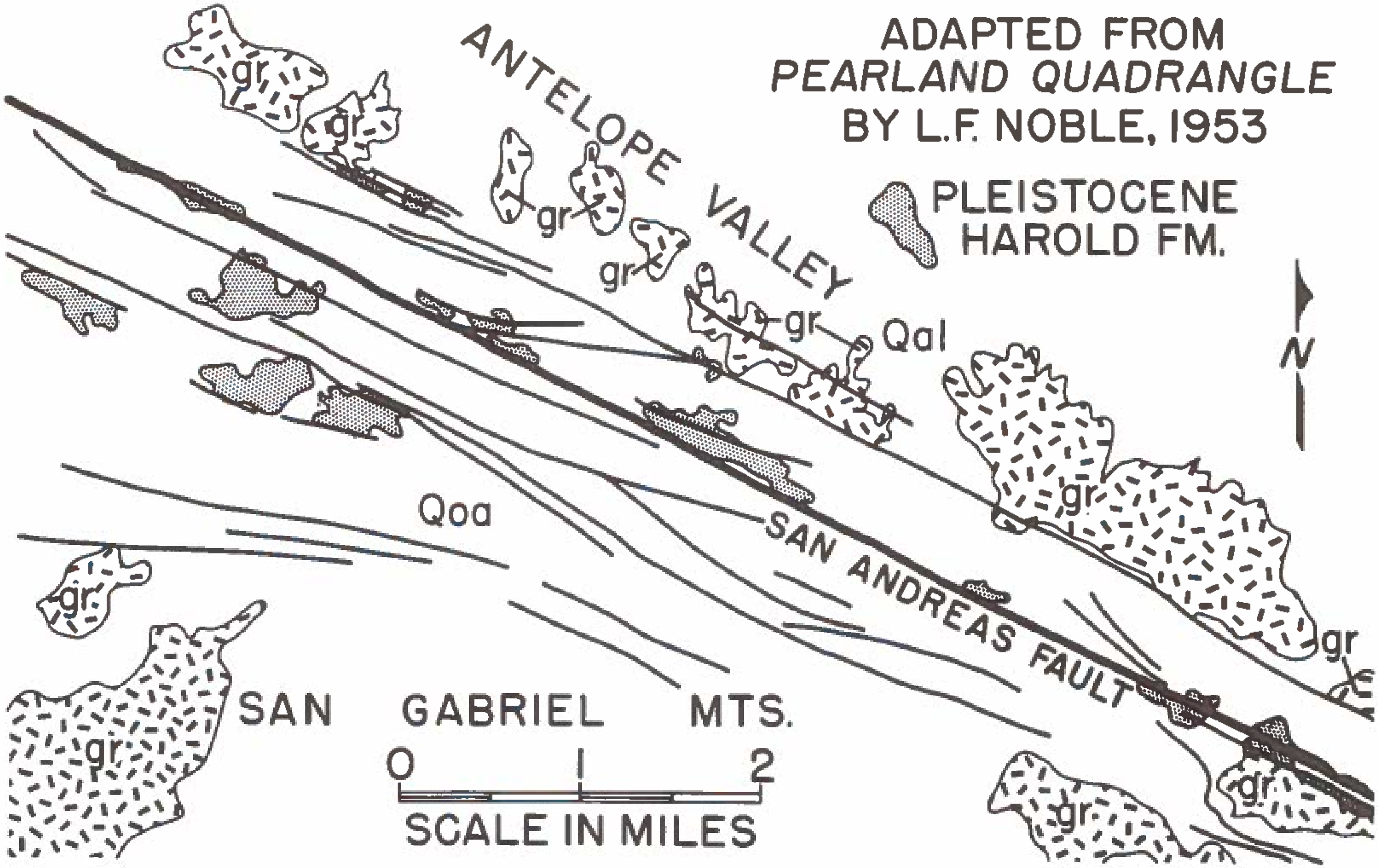

Fig. IV. San Andreas Fault Zone in the Pearland quadrangle showing distribution of the Harold Formation.

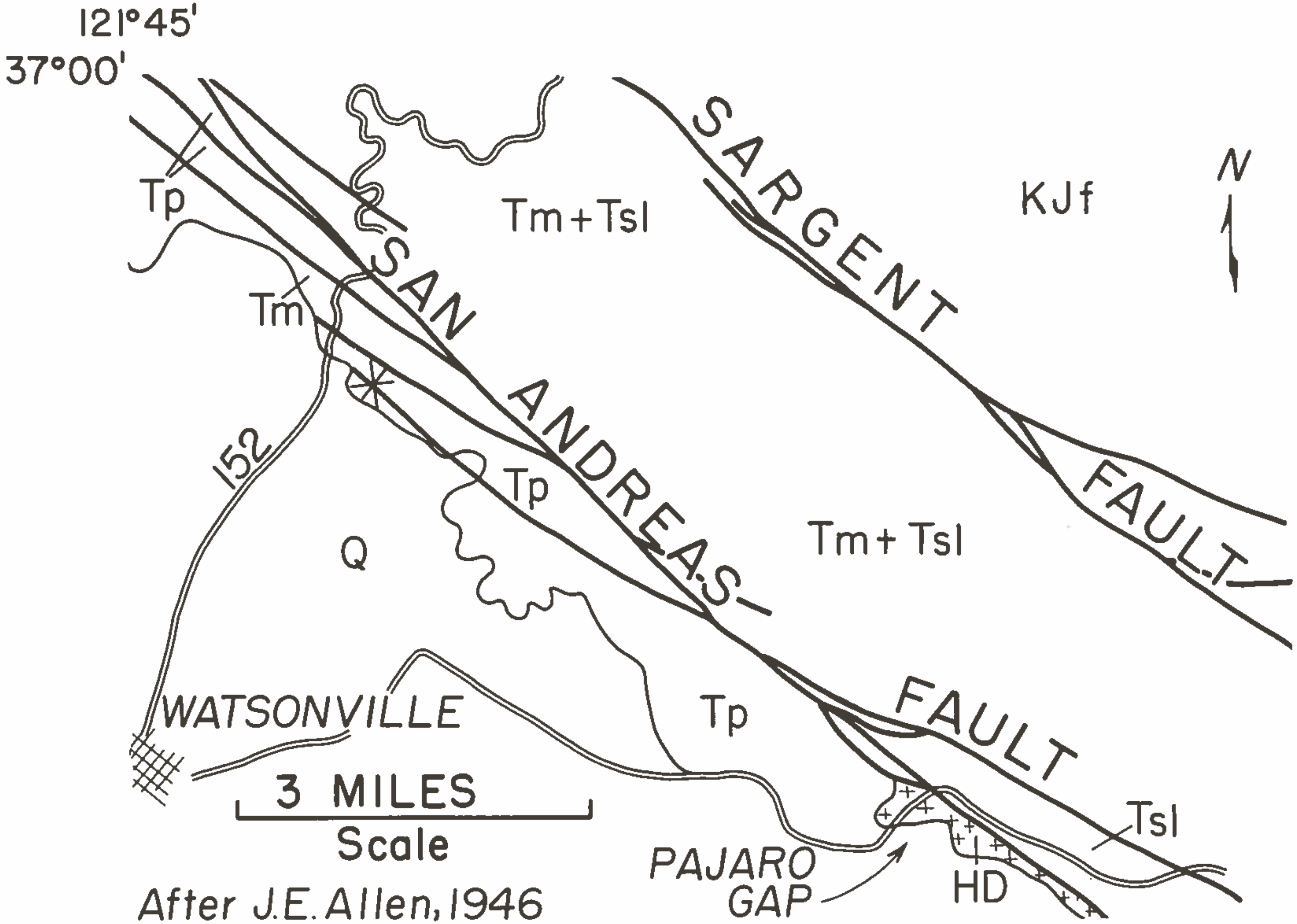

Fig. V. Pattern of faulting in the Pajaro Gap area.

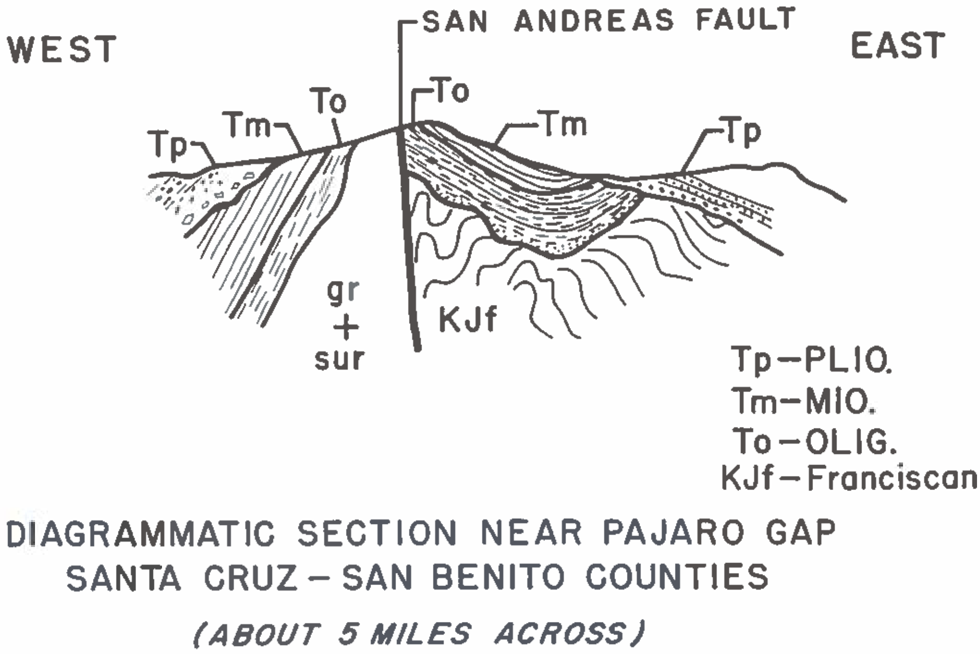

Fig. VI. Diagrammatic section near Pajaro Gap, Santa Cruz-San Benito Counties.

Evidence from the given examples of matching geology across the fault suggests that there are no compelling geological reasons for large lateral displacement since Late Cretaceous (Santonian?) time.

Figure VIII is an attempt to remove all post-Franciscan and all post-granitic rock formations and thus expose present contacts between the Franciscan Formation and the granitic rocks. In recent years considerable strides have been made in radiometric dating of these granitic rocks and also in our understanding of the age, origin, and history of the Franciscan. The granitic rocks have yielded dates which are mostly in the Late Cretaceous time span, but some in the foothills of the Sierra Nevada, the Klamath Mountains, and the Coast Ranges are Late Jurassic. Fossil evidence of the age of the Franciscan suggests that rocks of Franciscan type are of Late Jurassic to early Late Cretaceous age. Thus, the age ranges of the Franciscan and the granitic rocks cover approximately the same time span.

The Franciscan Formation is the principal "basement rock" of the Coast Ranges. It is exposed from southwestern Oregon to offshore southern California and similar rocks extend far south into Mexican waters off the west coast of Baja California. It is a tremendously-thick, folded and faulted, eugeosynclinal assemblage of sedimentary and volcanic rocks consisting of 80 to 90 percent graywacke and dark shale, with lesser amounts of chert, limestone, metabasalt, and other volcanic rocks, diabase and gabbro, glaucophane schist, and eclogite, all intruded by peridotite and serpentine. No base for the Franciscan has been found and all contacts observed in the field between Franciscan rocks and granite are faults.

Bailey and others (Bailey, 1961; Bailey, Irwin, and Jones, in press, 1964; Coleman and Lee, 1963), have lately contributed significantly to our understanding of the Franciscan and its relationship to other formations of similar age. Along the west side of the Great Valley, miogeosynclinal (shelf-facies) sedimentary rock formations, also of Late Jurassic to Late Cretaceous age, occur in fault contact with the Franciscan eugeosynclinal rocks which lie to the west. Evidence is accumulating that Franciscan sediments and volcanics were deposited rapidly on a simatic floor to great depth in a sharp and narrow geosynclinal trough at the base of the continental slope. Bailey (1961) says that "The metamorphic facies of the Franciscan Formation suggest it is 50,000 feet thick and was deposited, warped downward, and elevated in a period no longer than a few tens of millions of years." Metamorphic petrologists and geochemists have determined that the eclogites and some of the glaucophane-schist minerals were developed under conditions of relatively-high pressure but low temperature. Coleman and Lee (1963) state that exotic blocks of glaucophane schist and eclogite which are so characteristically found in the field have been transported upward tectonically 50,000 feet or more.

The San Andreas is but one of three first-order faults which separate Franciscan from granitic rocks. The "West Valley" fault (named in an unpublished map by Corey, 1964) is buried under Valley alluvium and Late Cretaceous-to-Quaternary sedimentary rocks, but it strikes northward into the major South Fork Mountain fault zone which forms the contact between granitic and older crystalline rocks of the Klamath Mountains and the Franciscan of the Coast Ranges. Thus, the West Valley-South Fork Mountain fault forms the boundary between the Sierra Nevada-Klamath Mountains province and the Coast Range province. The Nacimiento fault zone forms the far-western boundary of granitic rock, as does also the Newport-Inglewood fault zone in southern and Baja California. The West Valley, San Andreas, and Nacimiento faults merge southward into the knot of major faults at the junction of the Coast Range,

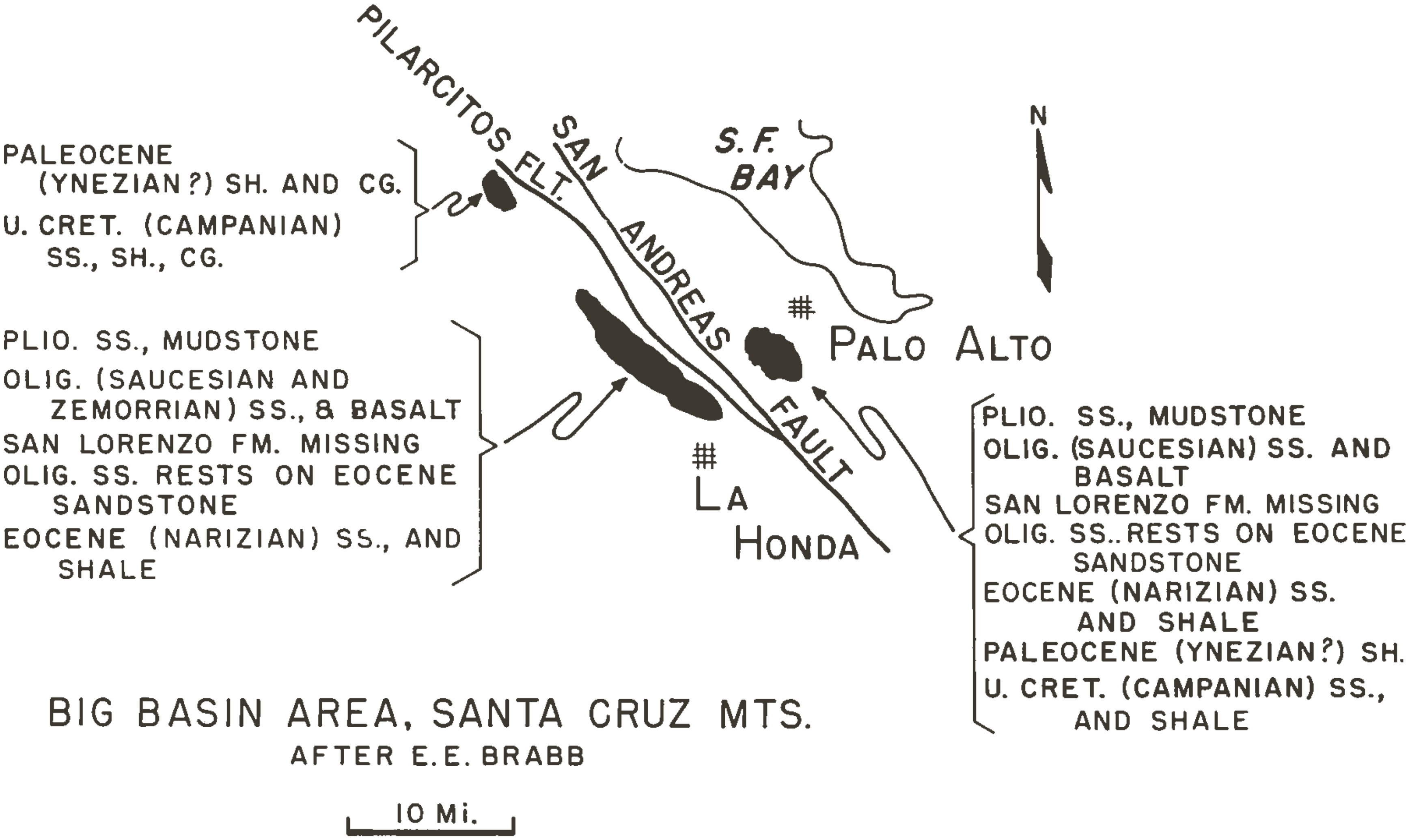

Fig. VII. San Andreas Fault Zone in Big Basin area, Santa Cruz Mountains.

Sierra Nevada, and Transverse Ranges provinces. It is most intriguing that these three great northwest-trending fault zones are completely interrupted by the east-west structures of the Transverse Ranges. *Location and relationships of these first-order faults, interruption by the structures of the Transverse Ranges, and present distribution of the Franciscan Formation as shown are not readily reconcilable with hundreds of miles of right slip on the San Andreas fault.*

In a paper presented to the Cordilleran Section last spring, Edgar Bailey (1963) proprosed westward crustal drifting, and rifting to form "sphenochasms" between blocks of continental crust, thus providing sites for deposition of the Franciscan Formation directly on sima. In any case, the geologic relationships seem to require absolute vertical elevation of the Franciscan on the order of 10 miles, and elevation relative to granitic segments of the crust an unestimated amount. Initiation of this great faulting at the juncture of the ocean basin and continental platform was probably in closing Jurassic time; additional first-order faulting took place in Late Cretaceous time. Slivers and pods of ultramafic rocks were caught up and intruded into the lower part of the Franciscan from the upper mantle at the time the eugeosynclinal trough reached its maximum depression. Figure IX, after Dietz (1963A, 1963B), suggests how this might happen.

Figure IX shows three stages in alpine orogeny after Dietz' concept of geosynclines and mountain building which appears compatible with the great fault features of western California which we have so briefly outlined. I have modified his diagrams somewhat and have added hyothetical faults in stage III.

I. Franciscan sediments and volcanics are rapidly deposited in a eugeosynclinal wedge at the base of the continental slope, generally seaward from nearly-contemporaneous deposition of shelf, or miogeosynclinal, deposits.

II. Sea-floor spreading (under a force supplied by thermal convection cells in the mantle) provides the initial thrust which causes the sima to slip under the sial of the continent. Bottom of the prism of deepsea turbidites is forced even deeper and is intruded by, and picks up, fragments of the simatic basement.

III. The mantle tends to shear beneath the continental platform, granitic intrusion begins early in the thrusting, and the prism is intensely folded, faulted, and elevated to form coastal mountains. I have added generalized, diagrammatic faults to Dietz' picture to emphasize the prominent role that steep, dip-slip, reverse faults probably play in this history.

Benioff (1954) studied the elastic strain-rebound characteristics and related spatial distributions of foci of hundreds of seismic sequences to demonstrate the characteristics of oceanic and marginal orogenic faults. Figure X is his diagram showing a continental crustal section with orogenic fault type. I am not sure to what extent Benioff would now support this precise model, with fault dip angles of 32° to 300 km. and 60° to 700 km., but it is significant that seismology, quite independently, develops a diagram showing deep major faulting extending under the continental margin and dipping toward the continent.

CONCLUSIONS

In the present state of knowledge, origin, nature, and history of movement on the San Andreas and related faults are not clear. Late Quaternary evidence strongly, but not exclusively, favors predominant right slip displacement. Late Cretaceous and Tertiary stratigraphy, structure, and geologic history which can be matched across the fault in central and northern California leave little room for strike-slip displacement of more than a mile or two. Distribution of Late Mesozoic Franciscan rocks and granitic rocks of near-equivalent age cannot be explained by large strike-slip movement, but does appear to require vertical displacements on the order of more than 10 miles.

For the present, geologists, seismologists, and geophysicists should retain multiple working hypotheses concerning displacement on the San Andreas and related major faults.

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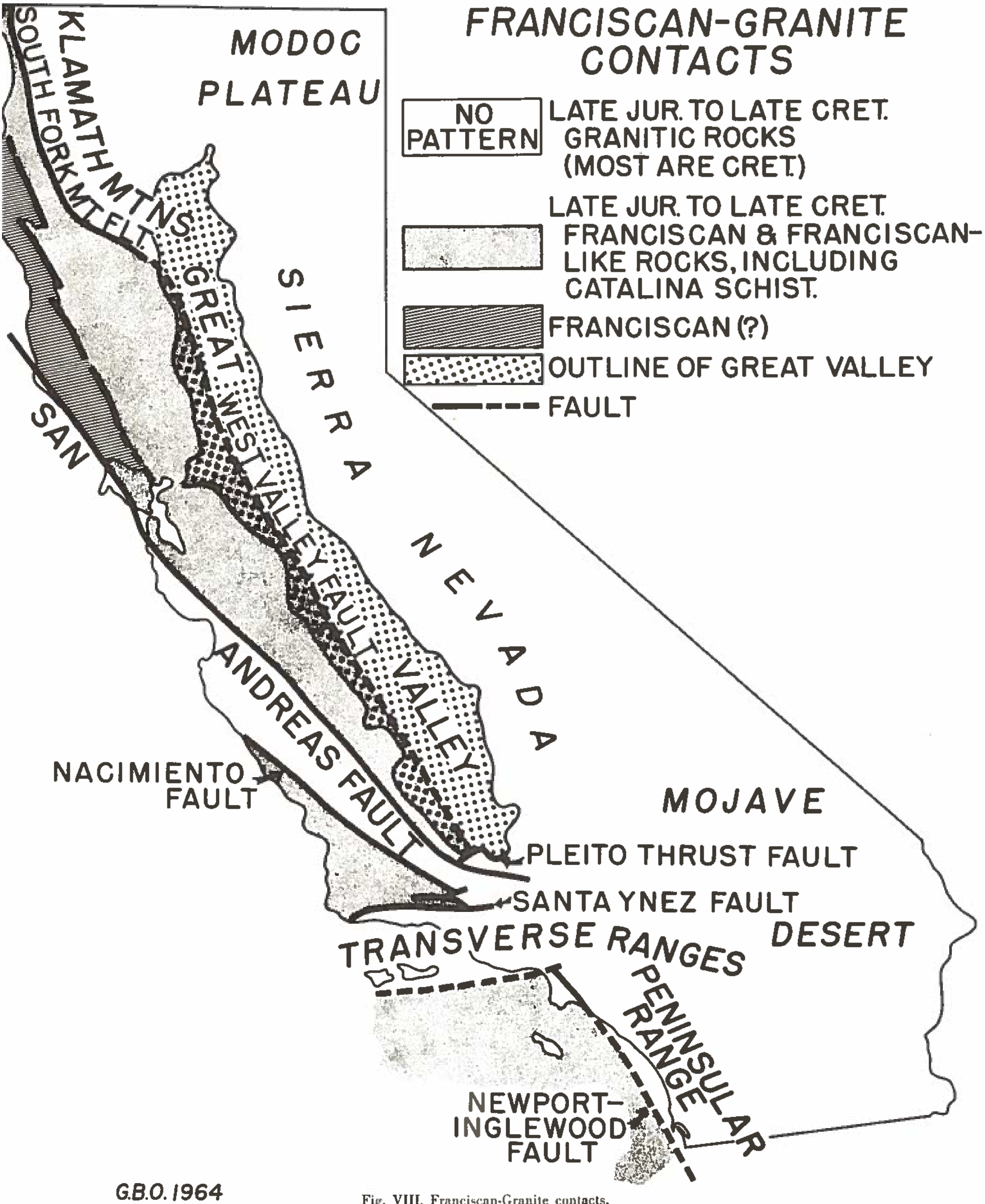
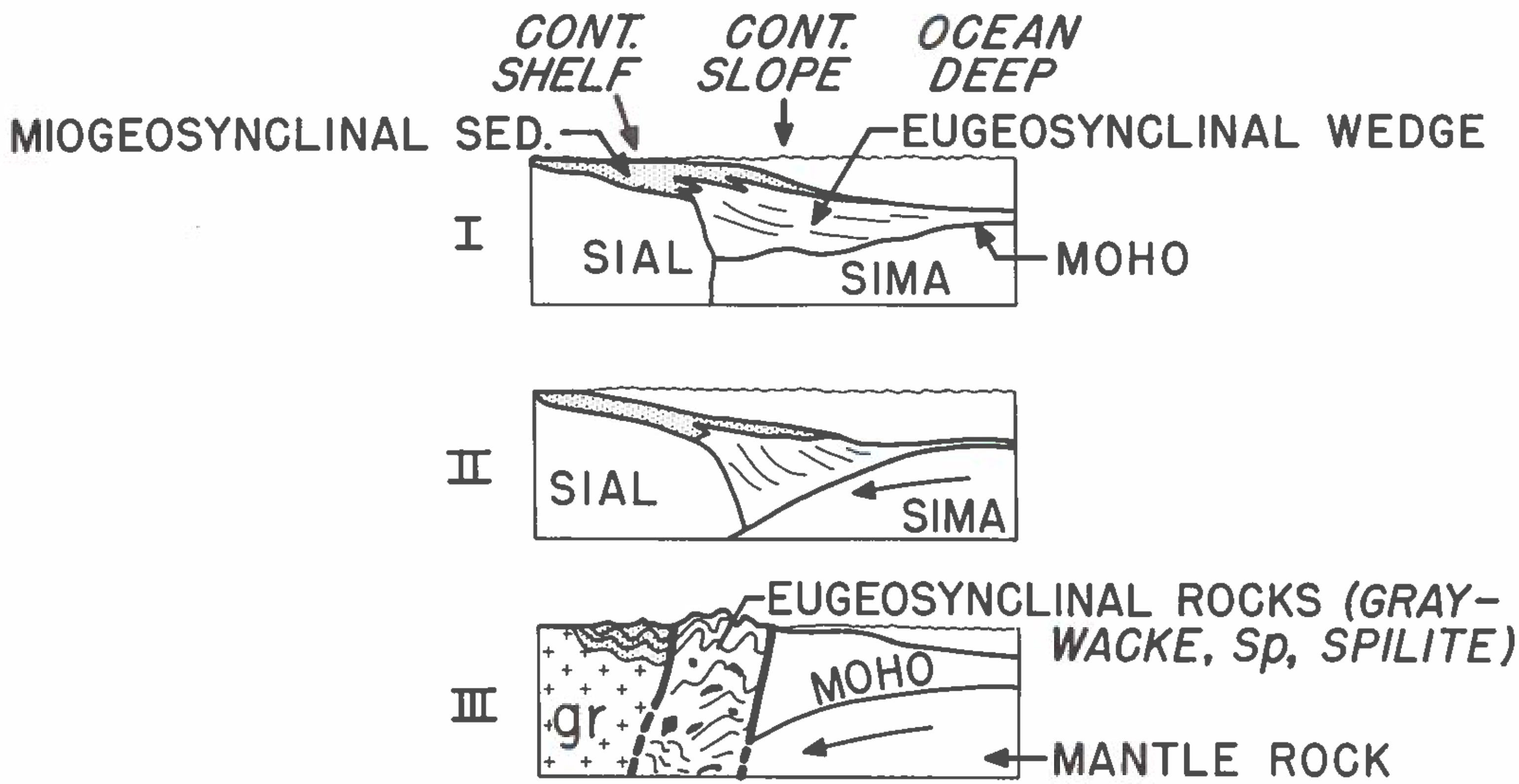


Fig. VIII. Franciscan-Granite contacts.



STAGES IN ALPINE OROGENY

(AFTER DIETZ 1963; HYPOTHETICAL FAULTS ADDED)

Fig. IX. Stages in Alpine Orogeny compatible with great faults of California.

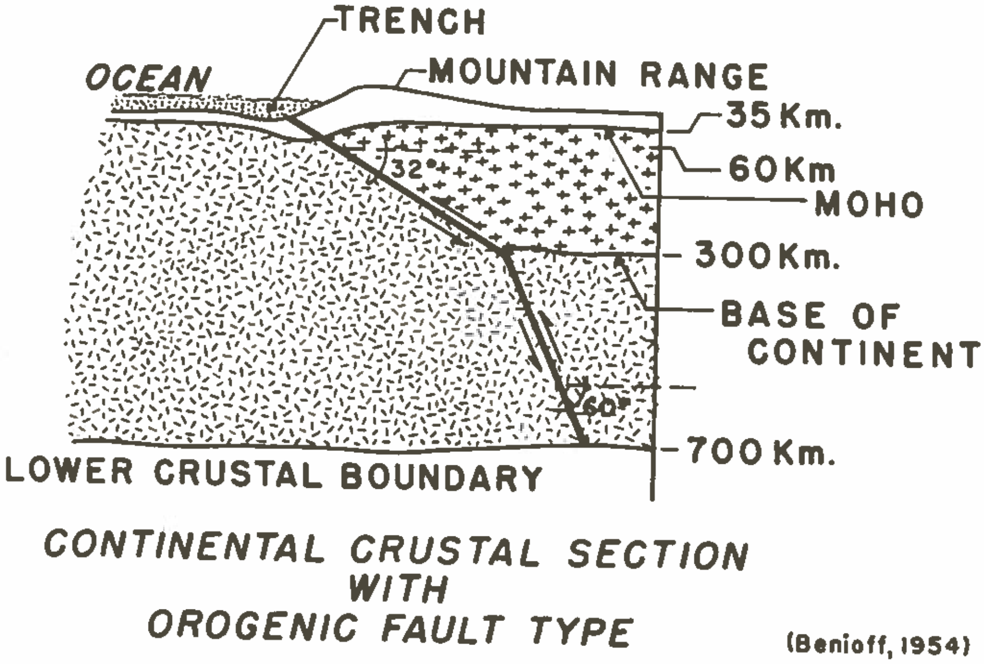


Fig. X. Continental Crustal Section with orogenic fault type.

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THE 29D MONARCH AND 10-10 POOL
A "SLEEPER" IN THE OLD MIDWAY-SUNSET OIL FIELD, KERN COUNTY, CALIFORNIA[1]

By DARRELL C. GALLEAR[2]
and JAMES O. KISTLER[3]

ABSTRACT

The 29D Monarch and 10-10 pool is located 2½ miles southeast of Taft, California, in the "29D" area of the Midway-Sunset oil field. Although surrounded by wells in an old producing area, the pool remained undiscovered until December, 1962.

Closure is not present in the uppermost Upper Miocene horizons on the 29D portion of the Spellacy Anticline, but westward thickening of deeper sediments provides localized structural reversal and closure in the Monarch and 10-10 sands. Isopachous maps and established structure maps were employed to demonstrate this closure prior to testing the structure.

As a result of the pool discovery, seven significant phenomena were noted: (1) Long interval tests recovered only strong gas blows in intermingled gas, oil and water zones; (2) One thousand feet of productive interval were found in a gross sand body having less than 200 feet of structural closure; (3) Ten feet or less of shale was sufficient to form vertical barriers; (4) A natural bounudary within the gross sand body separates the Monarch and 10-10 intervals; (5) Tilted oil/water interfaces were found in all reservoirs; (6) A 1 ohm-meter increase in resistivity over that of a wet sand may indicate clean oil sand; (7) Comparison of sonic logs before and after testing may show intervals of gas entry in an oil and gas sequence when only gas is recovered.

Cumulative production through June, 1965, exceeded 4 million barrels of 32° API oil and oil equivalent gas. At its peak the pool produced nearly 9,000 barrels per day of oil and oil equivalent gas from 32 flowing wells having an average total depth of 4,700 feet.

INTRODUCTION

The 29D Monarch and 10-10 pool of the Midway-Sunset field is located on the west side of the San Joaquin Valley in Kern County, California, approximately 2½ miles southeast of the city of Taft in the so-called "29D" area of the field. State Highway 33 passes directly over the pool at a point nearly midway between Taft and the small oil town of Maricopa (Fig. 1). The productive area consists of 225 acres of proved land, all contained within Standard Oil Company of California fee sections 29D and 30D, T. 32 S., R. 24 E., M.D.B. & M. Geologically, the pool is found on the plunge of the Spellacy or 29D-25C Anticline between two other major producing areas, the Buena Vista Hills structure to the north and the "35" Anticline to the south.

HISTORICAL DEVELOPMENT

Historically, drilling in the "29D" area dates from the early part of the century. At first, it was directed toward the well known productive zones of the Pliocene, namely, the Top Oil, Kinsey, and Wilhelm-Gusher sands. The famous Lakeview gusher, which blew in on March 14, 1910, is located only 2 miles to the southeast. This event heralded some exploration into the upper part of the Miocene, but the shallower Pliocene zones received the major emphasis until exploitation of the Plio-Miocene Lakeview sand to the southeast in the middle Thirties, and lower Pliocene Calitroleum sands to the north in the early Forties. Although a few wells tested the Miocene Sub-Lakeview sands, located between "N" and "Pa" electric log points (Fig. 2), it wasn't until 1952 that the deeper Miocene horizons in the "29D' area received attention. As a result, the Exeter and 29D pools, lying between electric log markers "Y" point and "O/1" point, were discovered in 1954 and actively developed through 1956. Stratigraphic entrapment was found in the Above-Exeter, Exeter and 29D sands which occur just below the Monarch and 10-10 sand body. It was believed that these sands pinched out updip on the Spellacy nose near the present eastern limit of the new Monarch and 10-10 pool. Only minor stepout drilling was undertaken to the west, as the updip edge wells went to gas, and there was little indication in the more shallow horizons that any structural entrapment could occur. The wells that were drilled, however, practically outlined the present productive limits of the new Monarch and 10-10 pool.

Subsequently, a detailed review of the area was undertaken in 1962. This study indicated the probability that closure did occur in the deeper Miocene beds and a test of the feature was recommended. Accordingly, the Monarch and 10-10 pool was discovered by Standard Oil Company of California well 324-29D in December, 1962. The well was completed on January 14, 1963, as well 524-29D and development drilling continued through February, 1964.

A sizeable accumulation was outlined which, though covering about 225 acres in maximum areal extent, spans over 1000 feet of vertical interval. During the first 2½ years of development a cumulative of over 4 million barrels of 32° gravity oil and oil equivalent gas have been recovered. At peak capacity daily production yielded almost 9,000 barrels of oil equivalents from 32 flowing wells having an average total depth of 4,700 feet.

STRUCTURE

Structurally, the "29D" area is dominated by the Spellacy Anticline, one of the major surface and subsurface features of the Midway-Sunset field (Figs. 1 and 3). This anticline is a broad, easterly plunging feature, flanked by a sharp syncline to the south and a broader, more regional

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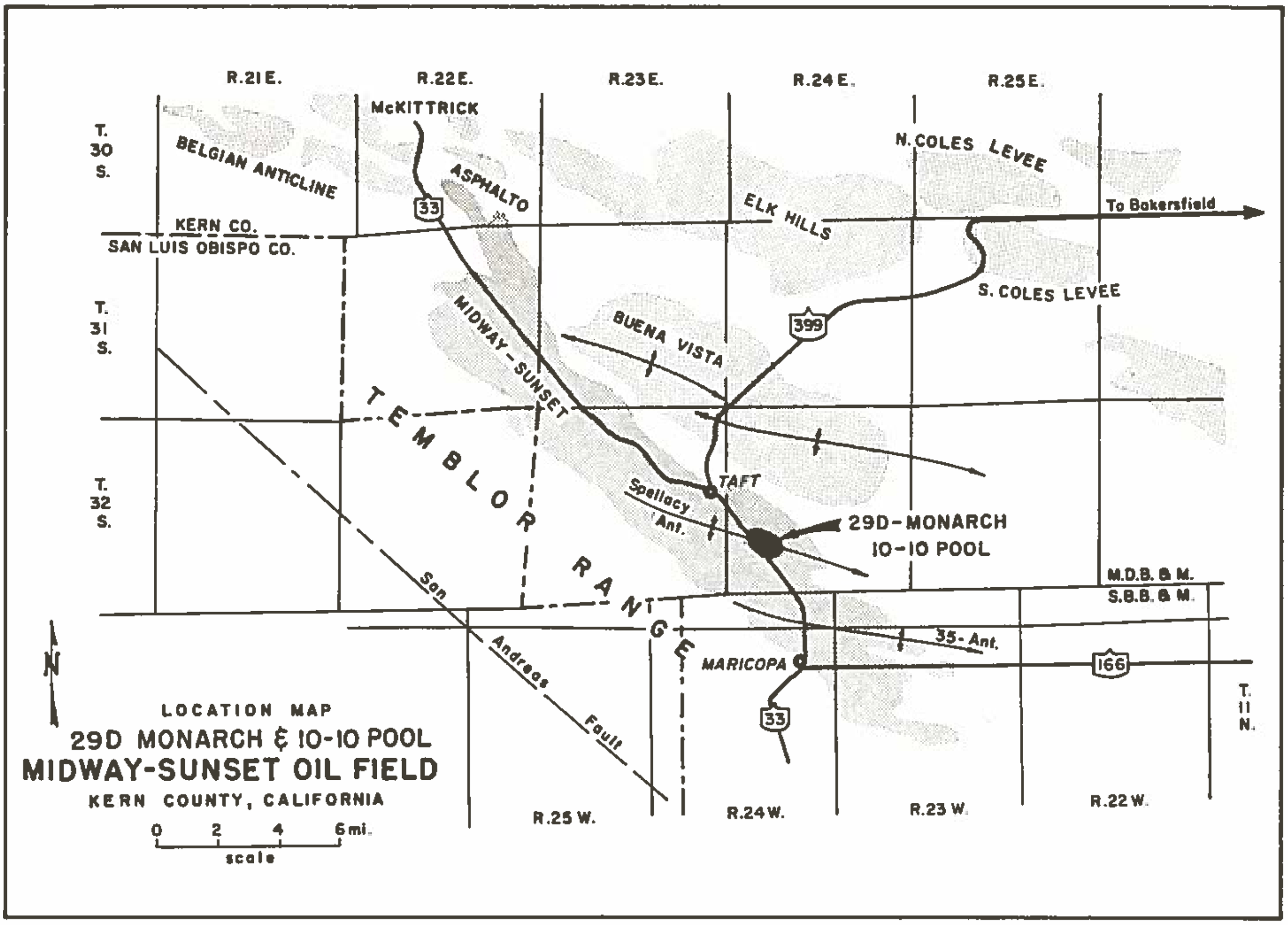


Fig. 1

syncline to the north. In the Pliocene and very uppermost Upper Miocene, it is a continuous plunging structural nose; whereas, at greater depth a minor reversal and doming is expressed in the "29D" and "30D" area. Until recently this reversal was not generally recognized at the Monarch and 10-10 horizons. It is certainly not apparent at the "N" point horizon near the top of the Miocene where control is quite extensive. Structure mapping at "N" point shows the gentle easterly plunge of the Spellacy Anticline and the absence of any westerly reversal in the "30D" area (Fig. 3). Since "N" point is the best controlled Miocene horizon, it is not too surprising that deeper structure was patterened after "N" point structure, and therefore, closure was not generally recognized at the Monarch and 10-10 horizons.

Slight anticlinal closure, however, can be demonstrated at the deeper "O/1" point (Fig. 4) which is the next most widely correlative Miocene horizon in the stratigraphic section. Structure at this "O/1" point is notably different from that seen at "N" point in the "29D" and "30D" area. Here a minor, but unmistakable, doming is now confirmed by development drilling. Otherwise, the general structural configuration of the Spellacy Anticline and related synclines is essentially unchanged.

The "N" point and "O/1" point structural relationships can readily be seen on an east-west section through the Monarch and 10-10 pool (Fig. 5). Gradual, continuous easterly plunge of the Spellacy Anticline is found at "N" point wereas westerly dip and attendant closure is seen at the deeper "O/1" horizon. It is apparent that the entry of Sub-Lakeview sands from the west, together with the thickening of Monarch and 10-10 sands to the west, are the mechanisms responsible for this creation of closure below "N" point. Such closure first occurs near the "Pa" electric log marker, progressively increases with depth until it reaches a maximum in the 10-10 sand interval, and thereafter decreases slightly toward "O/1" point.

Faulting in the area is generally minor and of recent

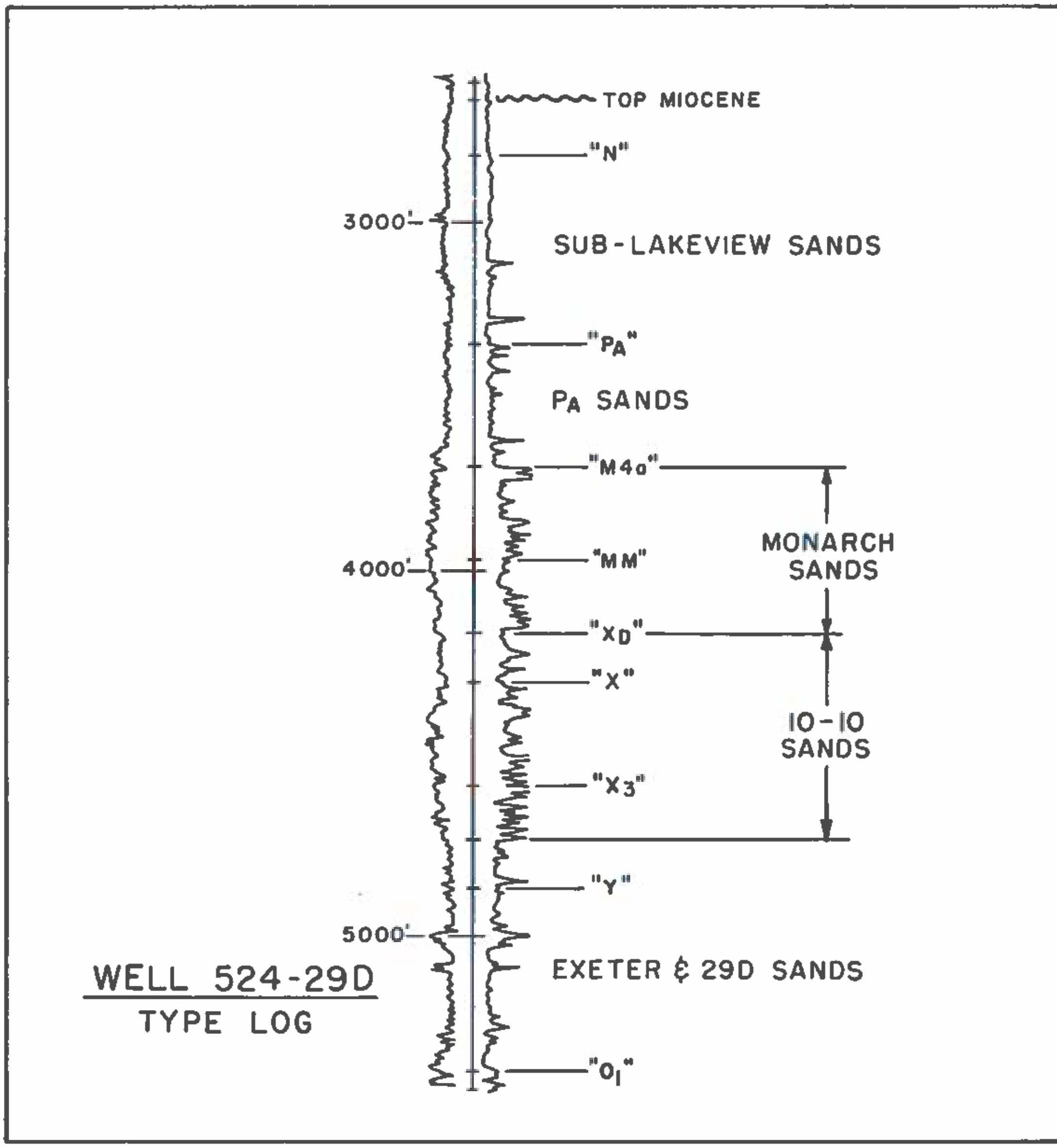


Fig. 2

age. Two such faults, shown in Figures 3 and 4, border the Monarch 10-10 pool, have only slight displacement, and apparently are of such recent age, or are so recently recurrent, as to be readily seen on aerial photographs. However, the most easterly of these faults, may modify the accumulations somewhat, and form an updip barrier for several lower 10-10 sands.

STRATIGRAPHY

This paper is concerned with stratigraphic intervals of the Upper Miocene. These units are depicted in Figure 2, a typical well log from the pool area. Sands found in the interval just below "N" point have been termed Sub-Lakeview sands. They are usually very thinly-bedded and discontinuous. Sub-Lakeview sands are productive where they pinch out updip along the flanks of the Spellacy structure. The "Pa" sands occur in the shale interval between "Pa" point and the top of the Monarch, as shown on the log. They are similar to the Sub-Lakeview sands, and like this group, are thinly-bedded and somewhat discontinuous. On first inspection, in fact, the poorly defined electrical character below "N" point would seem to preclude reliable correlations over any distance. However, many shale beds are widespread and minor electrical deflections provide continuous and precise correlations. Though many such

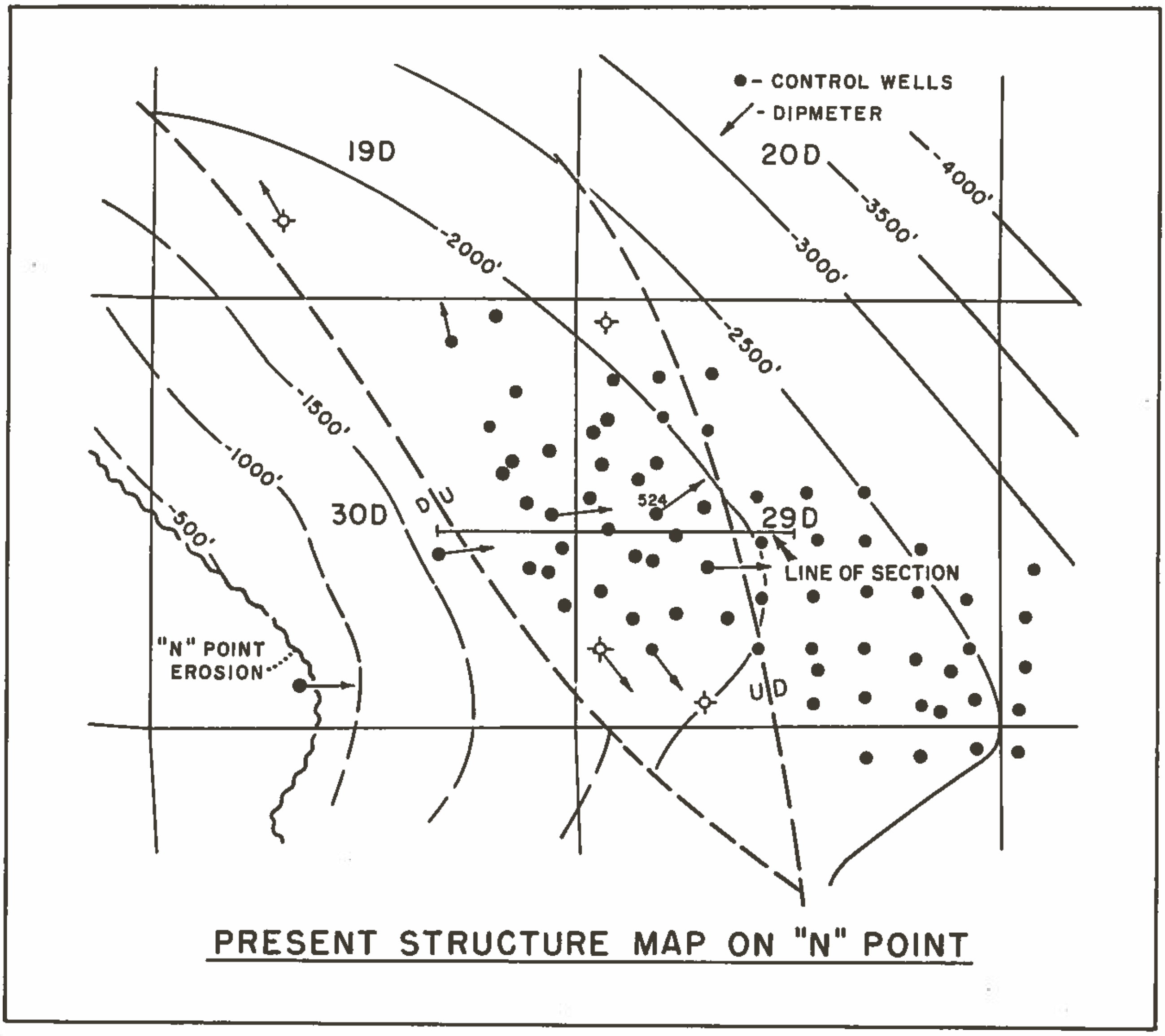


Fig. 3

thin sands "come and go" in the "N" point to Monarch intervals, this interval is essentially shale or silt in most of the "29D" area.

The first major sand group found in the Miocene in this area is the Monarch and 10-10 sequence (Fig. 2). It is composed of over 1000 feet of thinly-bedded sand stringers. Though it appears somewhat massive, the interval is broken by numerous thin shale and silt stringers throughout. Individual sands are generally quite silty, clayey, and vary in grain size from coarse to fine. Core analyses indicate the erratic character of the sands, with porosities averaging about 25 per cent and permeabilities ranging from almost nothing to nearly 3 darcies. Hard sandstone stringers are fairly common in the lowermost part of the section. The more massive, clean, and best reservoir sands are found midway through the 10-10 interval just below "X" point. These "X" point sands are best developed on the west side of the pool. The Monarch and 10-10 intervals, incidentally, were not differentiated at first for there was no obvious separation based on electrical character, and precise correlations could not readily be carried within this sand body from the "10-10" area to the southeast. Later development in the pool area, however, provided a basis for such differentiation.

The hard shale interval immediately below the sand body contains the Above-Exeter, Exeter and 29D sands found productive in those "29D" area pools located just downdip. These sands are channel-like stringers which range in thickness to 100 feet.

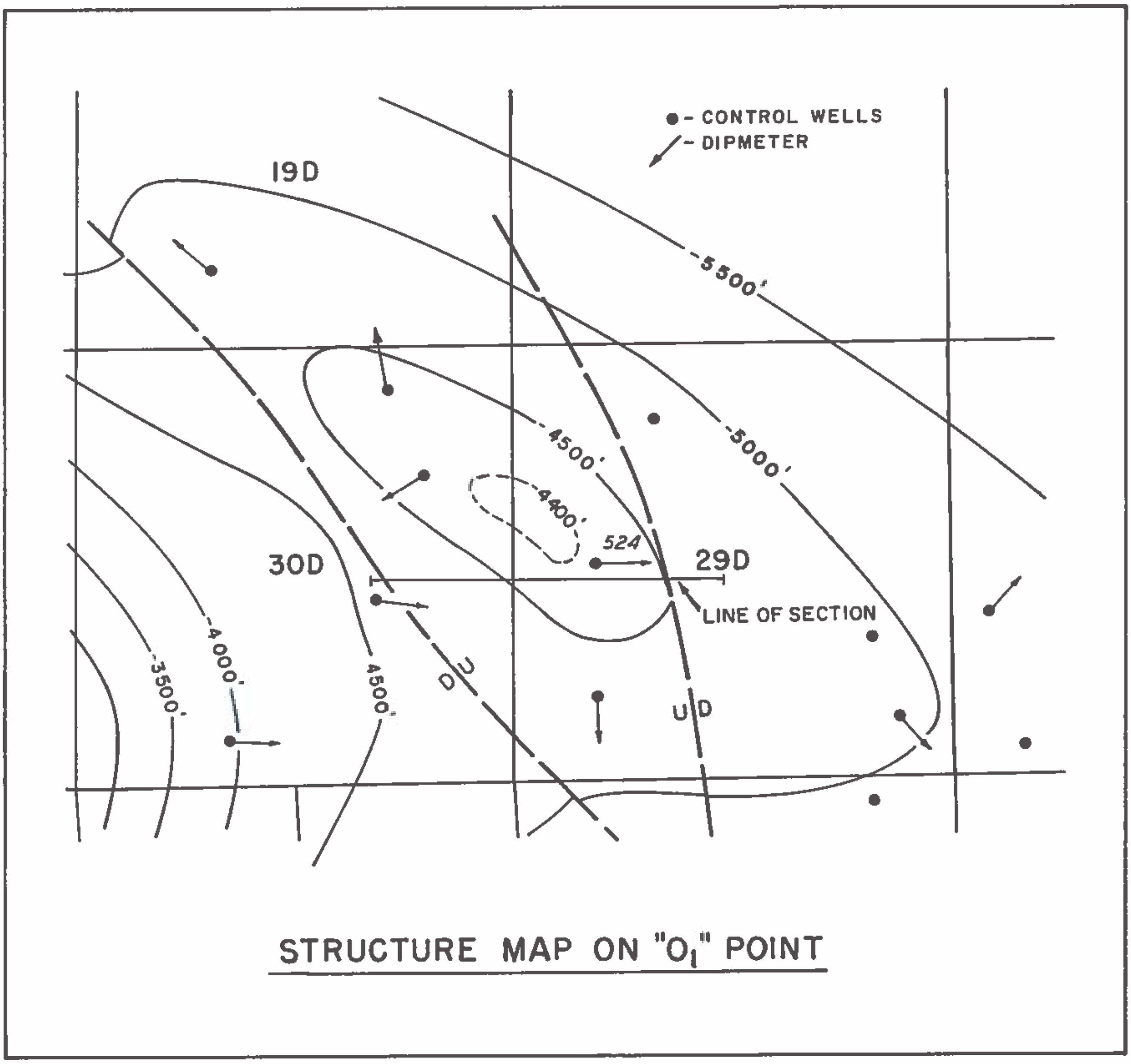


Fig. 4

EXPLORATORY FACTS AND TECHNIQUES

During the detailed review of the "29D" area, prior to the discovery of the Monarch and 10-10 pool, it was recognized that minor closure probably did exist at the "O/1" horizon. Such possible closure had been previously noted, but due to limited control could not be established. As closure was definitely lacking at "N" point, it was not easy to envision significant amounts in the 2,500 foot interval between "N" and "O/1" points. However, this interval was studied in detail and several good correlative points were recognized, particularly in the shale sequence overlying the Monarch. Gross interval isochore and isopach maps were constructed for several intervals below "N" point. "N" to "Pa," "Pa" to Top Monarch, "N" to "O/1," and combinations of these were drawn. They all showed pronounced thickening to the west and south, especially below "Pa" point.

The pre-discovery "N" point to top of Monarch isopachous map, which is shown in Figure 6, illustrates the influx of Sub-Lakeview sands from the northwest with the resultant thickening in that direction. It is important to recognize that these sands are additive to the section—not due to facies change—and thus require interval expansion. It is also of interest to note on this map how completely the pool was encircled by wells prior to discovery. The "M4a-O/1" pre-discovery isopach map (Fig. 7) represents the interval between the top of the Monarch and "O/1" point and shows the thickening of the Monarch and 10-10 sands to the southwest. Westward thickening of both intervals is well shown in the east-west section through the pool (Fig. 5). Employing this isopach data in conjunction

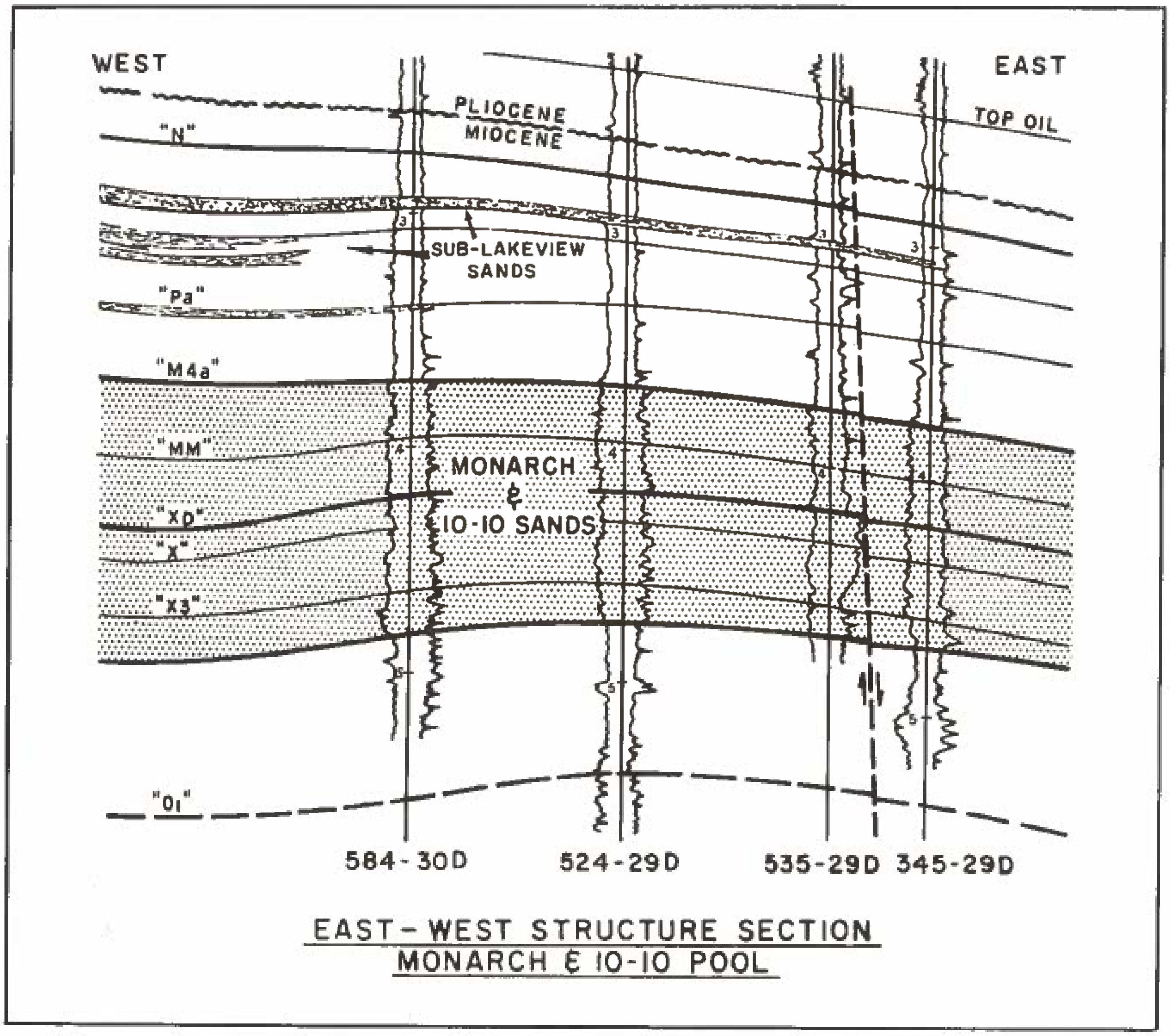


Fig. 5

with the well-controlled "N" point structure map (Fig. 8) enabling the construction of additional structural horizons at several intermediate points between "N" and "O/1."

The flattened area adjacent to the 29D-30D section line on the pre-discovery "N" point map (Fig. 8) might have been interpreted as suggesting closure at deeper horizons. This was only suggestive, though, and hardly basis for any new drilling. The new structure maps, however, did demonstrate such closure at all horizons below "Pa" point, and showed that it did in effect increase with depth to an apparent maximum in the 10-10 interval. Almost 100 feet of closure was now indicated at "Pa," 125 feet at top Monarch and nearly 200 feet toward the base of the sand body.

Once satisfied that closure could exist, the question arose as to how much closure is required to form an economic accumulation where the areal extent is small, that is, less than 200 acres. Although numerous oil shows in the deeper Exeter-29D zone wells in the surrounding area were encouraging, there was also the fear that this was residual oil, and that the remainder had migrated updip 2 miles to the west where these Monarch and 10-10 sands have produced for more than 40 years. However, the isopach work did indicate that at least 100 feet of closure could be present at this location on the Spellacy Anticline, and several objectives could be visualized. These factors prevailed, and thus a Monarch test of the highest structural position was recommended even though it was recognized that closure and areal extent were probably minor and that this feature was surrounded by wells having wet tests in the objective sands.

It is noteworthy, in retrospect, that the presence of these

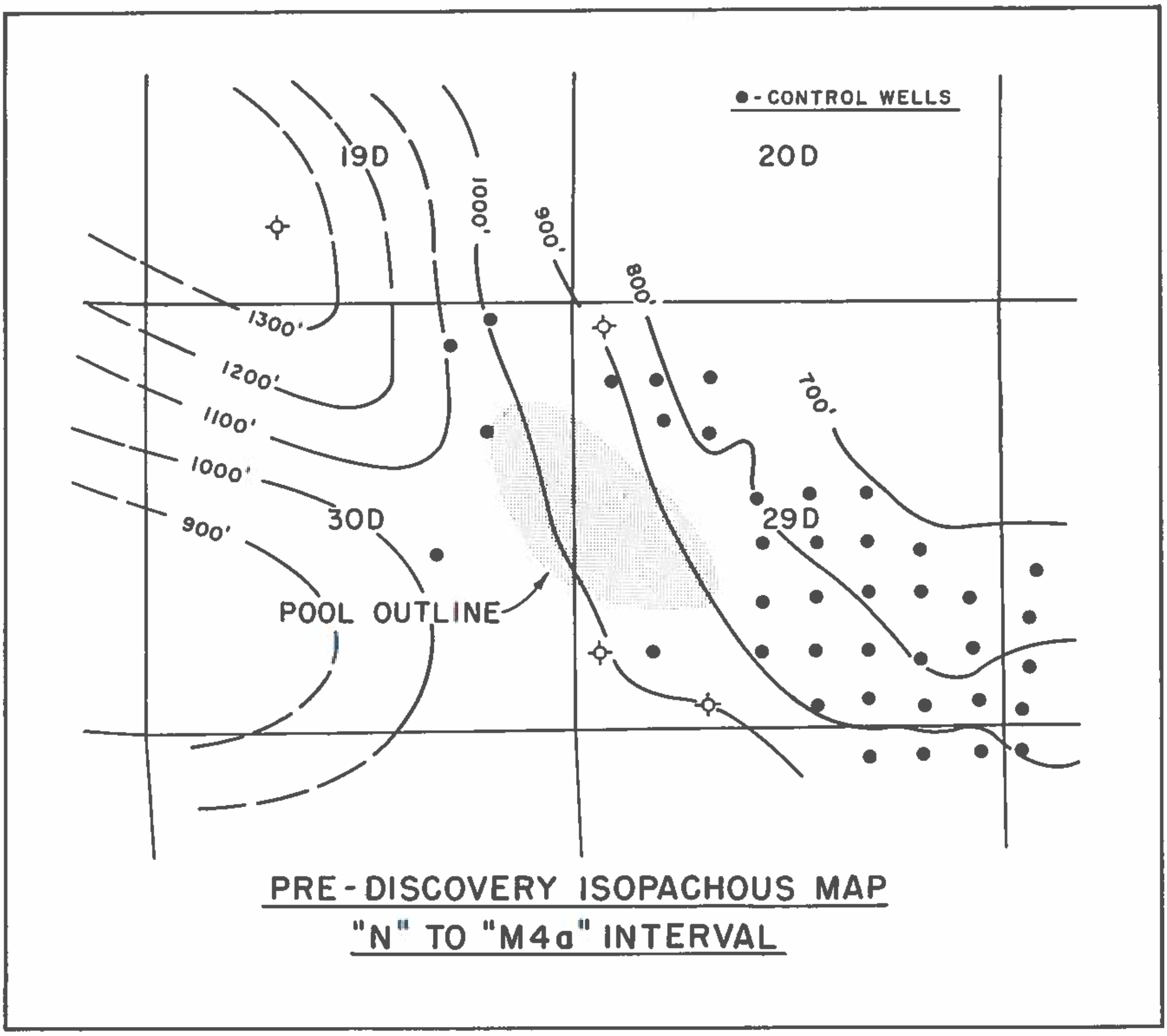


Fig. 6

wet tests had heretofore been a basis for condemnation of the area. However, such tests were made over long intervals (200 to 300 feet) of interbedded thin sands and shales, and though minor oil was recovered, the predominance of salt water was considered definitive in the formation evaluation. Later developments proved that such long interval tests in this type of section could be quite deceiving.

ANOMALIES OBSERVED AND RESULTING CONCLUSIONS

Subsequent to this work, well 524-29D was drilled, the closure was established and the Monarch and 10-10 pool discovered. As a result of the drilling, and that which followed, seven important observations and conclusions were made. In the following discussion of these observations reference will be made to several figures depicting interspersed oil, gas and water reservoirs. It should be recognized that these intervals of oil, gas and water have been greatly simplified for ease of presentation, but a far greater amount of stratification actually occurs.

1. Gas Tests of Mixed Reservoirs Not Definitive

The first conclusion reached was that gas recovered in long interval drill-stem tests might not be defining the actual fluid content of all the sands in the test interval.

Testing of the discovery well 524-29D indicated that the 1,000 foot Monarch and 10-10 sand body contained all gas, even though most of the sidewall samples were oil-stained (Fig. 9). Four consecutive 250 to 300 foot drill-stem tests, shown on the log, blew only gas with little or no liquid recovery. Gas was obtained on each test at rates in excess of 4,000 to 5,000 MCF per day through a ½-inch choke, the capacity of the bean at these pressures. Although this amount of gas is not unusual in the Sacramento Valley area, it is somewhat anomalous in the old Midway-Sunset

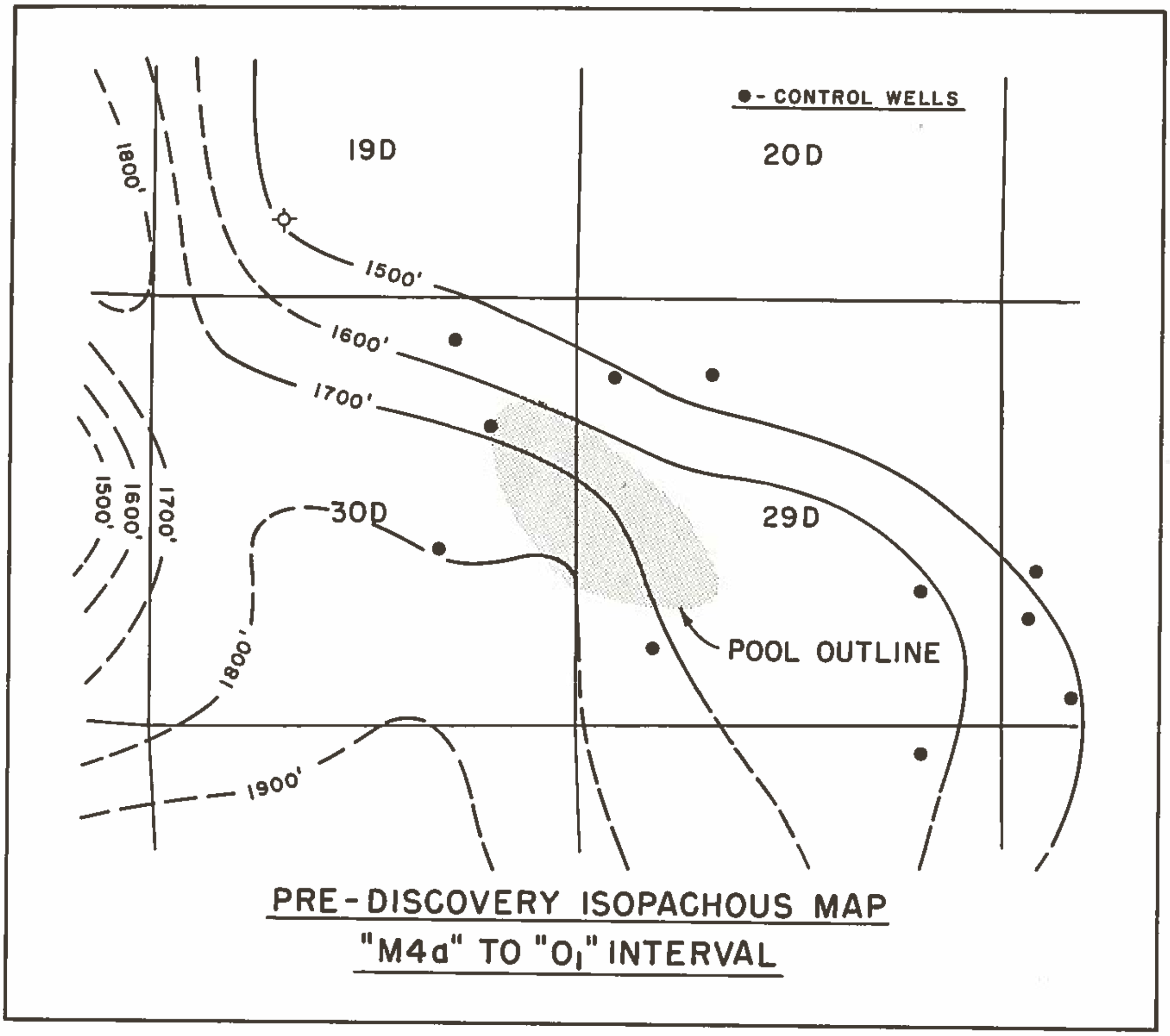


Fig. 7

field on the west side of the San Joaquin Valley. In fact, there was some concern that this gas may have escaped from the propane injection project in the deeper Exeter-29D pools immediately to the east. However, a small amount of oil found in the bottom test was sufficient reason to retest a shorter portion of this interval. It recovered a 4,340-foot rise of oil, mud and water cutting 60 per cent. Critical evaluation of the induction and sonic logs permitted isolation of the oil interval, and the well was completed in January 1963 from a 50 foot sand section, between 4,569 and 4,619 feet, flowing 144 barrels per day of 32.6° API gravity oil, zero water and 468 MCF per day gas.

With this information, a re-examination of the intervals which tested gas previously suggested that this gas recovery was also probably not indicative of all fluids contained in the tested intervals. Due to the far greater transmissibility of gas as compared to oil at the reservoir conditions, it was believed that the gas entry precluded oil production. The 100-pound drawdown on the reservoir was probably not sufficient to allow oil entry into the well bore. Retesting smaller portions of long interval tests later proved this thesis to be correct.

2. Productive Interval Greatly Exceeds Closure

Over 1,000 feet of productive interval were found in what appeared to be a gross sand body, yet less than 200 feet of structural closure could be established (Fig. 10). Obviously, the Monarch and 10-10 pool is not one continuous vertical reservoir, but is composed of numerous separate accumulations. At least 50 such individual reservoirs are believed to exist. The very slight doming and

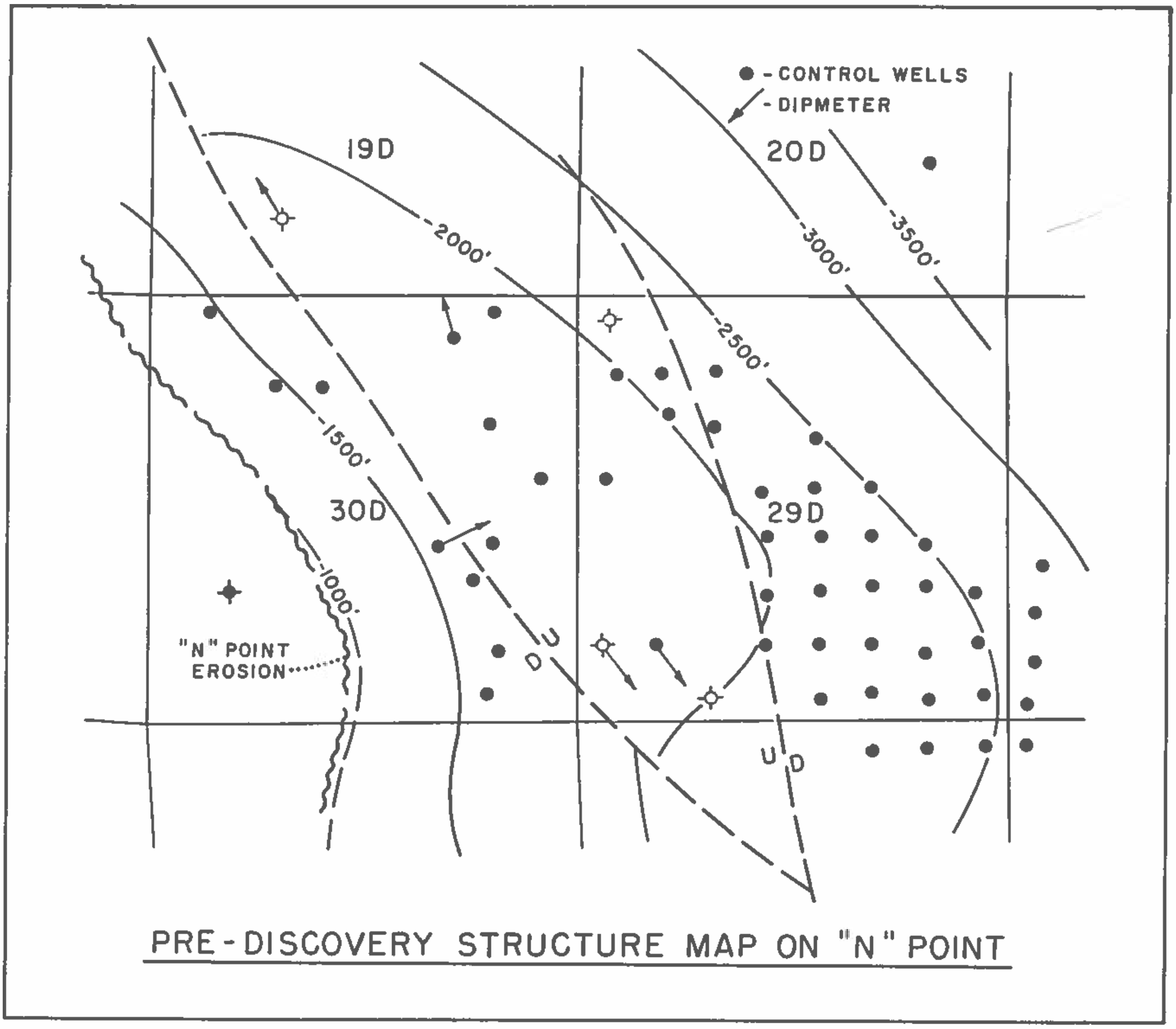


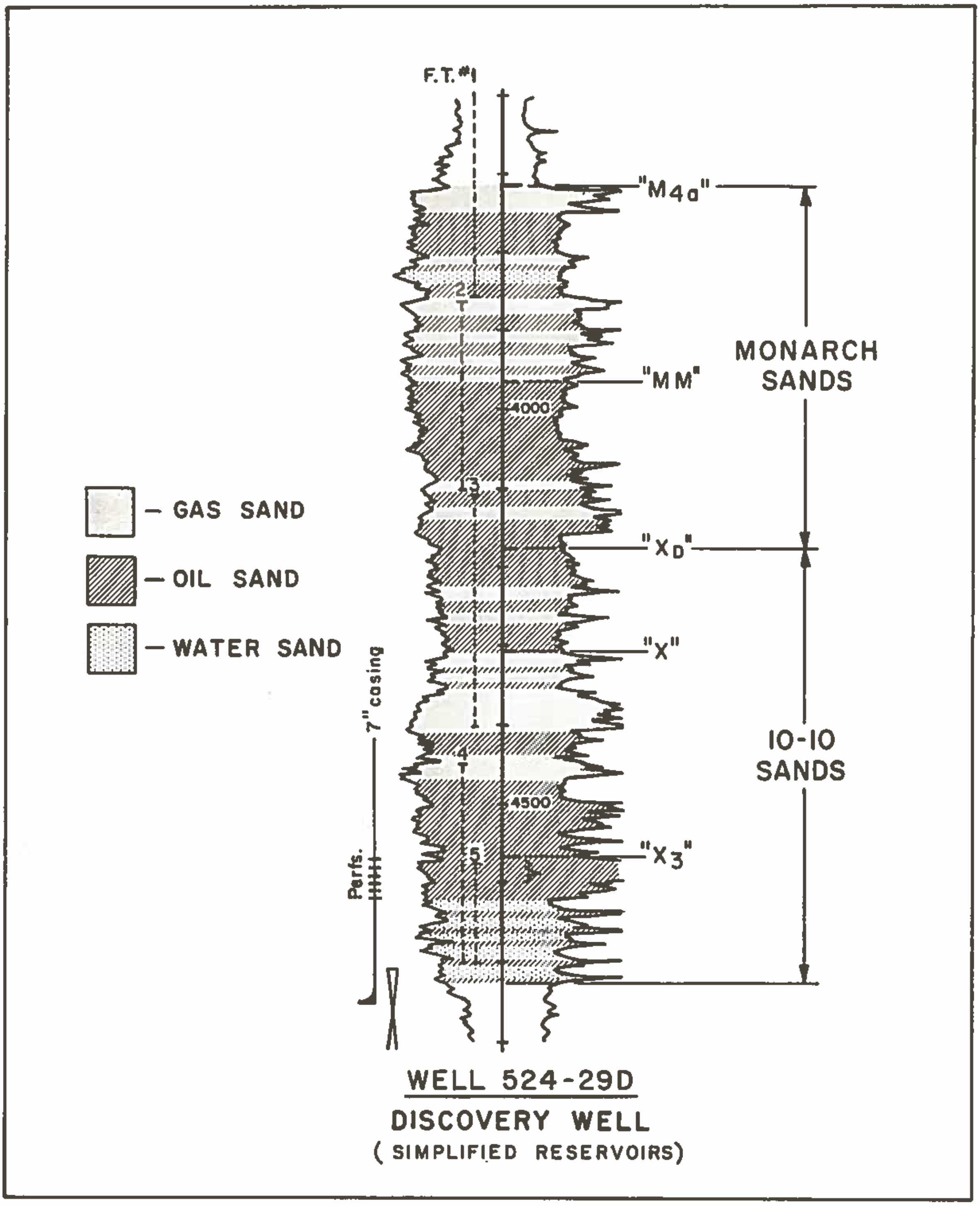
Fig. 8

simplified depiction of the intermingling reservoirs is shown in Figure 10. It is noteworthy that the productive extent is much greater below "X/D" point as shown by the two easternmost wells (S.O. Co. 535-29D and 345-29D). These wells encountered 500 feet of water sand above the productive horizons. The large wet sand bodies are presented in gross aspect only and do not depict the numerous thin interspersed shale beds which also exist.

In order to completely define the closure and productive area within this extensive sand body, it was necessary to construct structure maps at several, regularly spaced intervals. Though correlations within the massive sand were difficult, many of the thin shale breaks proved to be continuous, and with additional development, a good structural picture was established at several intermediate horizons:

a. *Upper Monarch Interval*: The first map was drawn on the top of the sand body at "M4a" point and shows closure of about 100 feet (Fig. 11). The interval lying between this point and the "MM" point has been arbitrarily designated upper Monarch. The individual reservoirs have been lumped together in order to facilitate presentation of a single productive limit. This combined interval encompasses approximately 115 productive acres. There is a tilted oil/water interface of 20 feet, directed toward the southeast. Ten wells were originally completed in this upper Monarch interval.

In the discussion of the remaining maps note that the crest of the structure migrates slightly southeastward and that the pool closure gets larger with increasing depth. Also, a few 50 foot contours are shown as dashed lines on this and subsequent structure maps in order to better



F.T.#1
"M4a"
"MM"
4000
MONARCH
SANDS
— GAS SAND
— OIL SAND
— WATER SAND
"XD"
"X"
7" casing
10-10
SANDS
4500
"X3"
Perfs.
WELL 524-29D
DISCOVERY WELL
(SIMPLIFIED RESERVOIRS)

Fig. 9

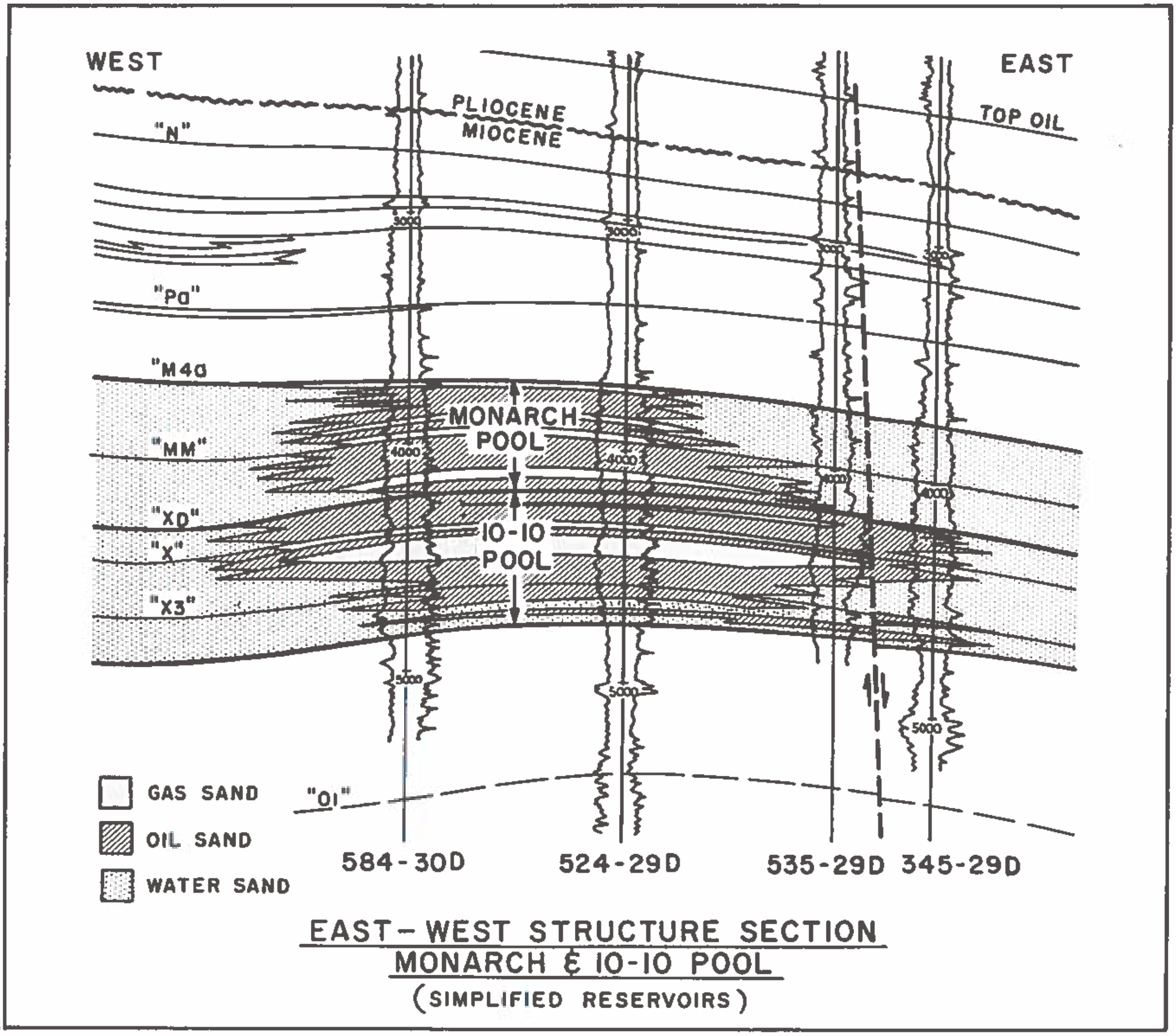


Fig. 10

depict the significant features. The closure is thus more gentle than it may appear on first inspection.

b. *Lower Monarch Interval*: The next map is constructed on the "MM" horizon half way through the Monarch sands (Fig. 12). Pool limits represent the reservoirs in the "MM to X/D" interval. Vertical closure has increased to approximately 125 feet, but the average areal extent has not changed significantly. It now comprises 125 acres of proved land. The tilt of the oil/water interface is quite pronounced to the southeast and has increased to 40 feet. There were 10 producing wells in this lower Monarch zone.

c. *Upper 10-10 Intervals*: Structure at the "X/D" horizon, which denotes the top of the 10-10 sands is shown in Figure 13. The "X/D to X," or upper 10-10 interval, has been combined as before. There is a dramatic increase in areal extent from 125 acres to 220 acres at this midway point in the gross sand body. Closure has also increased markedly to 160 feet. The shape of the pool has become more rounded and the hydrodynamic tilt has increased to 55 feet. Direction of tilt has changed somewhat in the 10-10 sands and trends more southerly. Eighteen wells originally included this interval.

d. *Middle 10-10 Interval*: Figure 14 shows the structure at the "X" horizon with the attendant productive limit for the "X to X/3" interval. This zone encompasses the largest areal extent, 225 acres, and has maximum structural closure, 175 feet. The best developed sands and most prolific production is found in the "X to X/3" interval. Twenty-seven producing wells were completed within the zone. Again the oil/water tilt has increased, this time to a

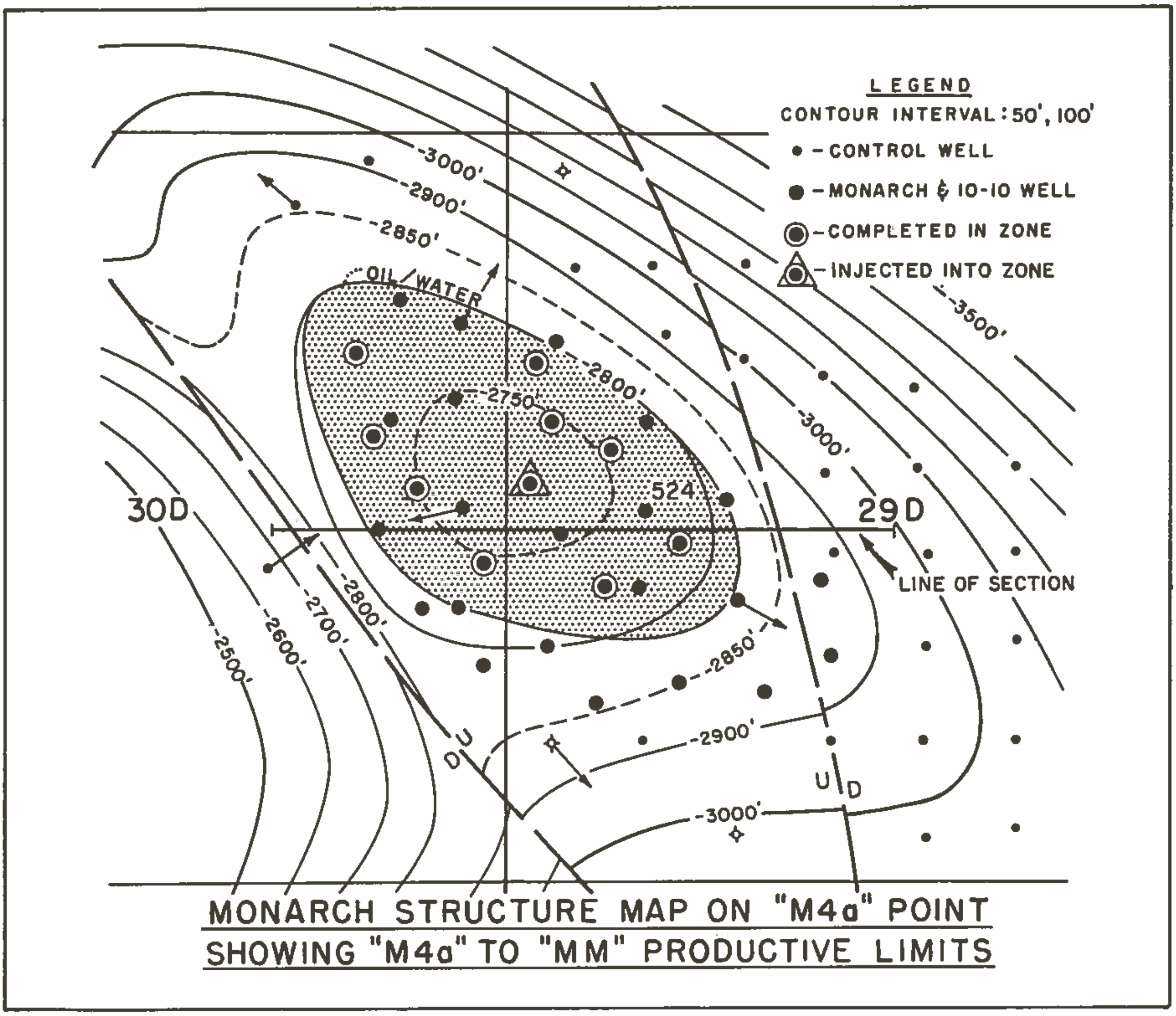


Fig. 11

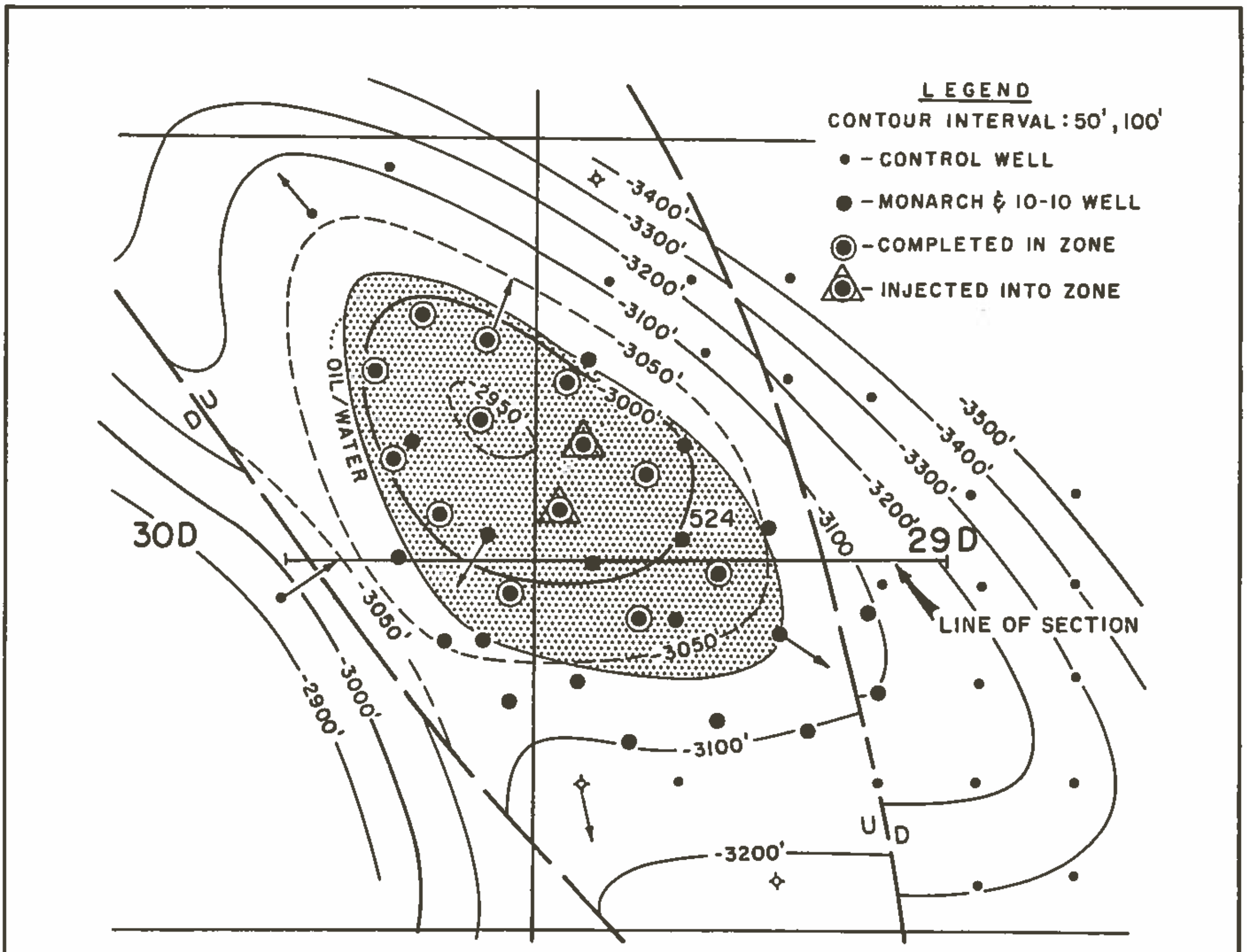
maximum of 75 feet, and the direction is more southerly than the uppermost 10-10 interval.

e. *Basal 10-10 Interval*: The map on the "X/3" horizon near the base of the gross sand body incorporates the production from the sands in the interval below "X/3" point (Fig. 15). This zone now includes only 125 productive acres, a decrease of almost 100 acres from the interval above, even though the closure has not changed. The oil/water tilt has also decreased from 75 feet to 40 feet here in the bottom of the sand. The direction of tilt has swung back more toward the southeast as in the Monarch sands. There were 12 completions in this zone.

In addition to the structural entrapment, faulting may control accumulation in a few thin stringers in the basal portion of the 10-10 sands. The effect of the fault cutting the east side of the pool in the 10-10 horizons has not been too well established. The vertical throw on the fault is probably not more than 50 feet. Such small throw would most likely preclude any entrapment in the thicker beds, but is believed to have some control in a few thinner stringers below the "X/3" point. Although not definitely established, the downstructure production shown to the east appears dependent upon such a fault barrier.

3. Most Cap Rocks Less Than 10 Feet Thick

It is now apparent that the Monarch and 10-10 accumulation is comprised of numerous individual, thinly-bedded reservoirs which must be separated vertically by thin but effective shale barriers, most of which are less than 10 feet in thickness (Fig. 9). In fact, it can be shown in at least one instance that an inter-reservoir cap rock is no greater than 4 feet thick. Although the intervals were



MONARCH STRUCTURE MAP ON "MM" POINT SHOWING "MM" TO "XD" PRODUCTIVE LIMITS

Fig. 12

lumped, the reservoirs are independent, each having its own gas/oil and oil/water interface. Nearly all gas caps are believed secondary though a few primary caps may exist.

4. Vertical Barrier Within Massive Sand Body

The second well, which was drilled 65 feet down-structure from the first, penetrated 500 feet into a massive appearing Monarch sand that was entirely wet. Yet, as drilling continued, the well encountered 300 feet of productive 10-10 interval directly beneath the water sand, but with no definite vertical separation seen on the electric log. Since then, 11 other wells have been drilled which are wet throughout the overlying Monarch but productive in the 10-10 sands. This anomalous condition was seen previously on the east-west structure section through the pool (Fig. 10). It clearly showed that the pool size increases markedly below the "X/D" horizon. Further, the oil/water tilt not only increased but altered direction slightly below this point. Though no obvious geologic change can be readily noted, sands above "X/D" are more discontinuous and difficult to correlate and even appear to have a slightly different depositional trend than those below. Clearly, this "X/D" horizon must mark a real structural and lithologic change not easily seen from the electric log character. Therefore, the Monarch sands and 10-10 sands have been separated at this natural boundary.

5. Hydrodynamic Tilt in All Sands

The hydrodynamic tilt indicated at each horizon is generally directed towards the southeast as was shown on the various structure maps (Figs. 11-15). The direction,

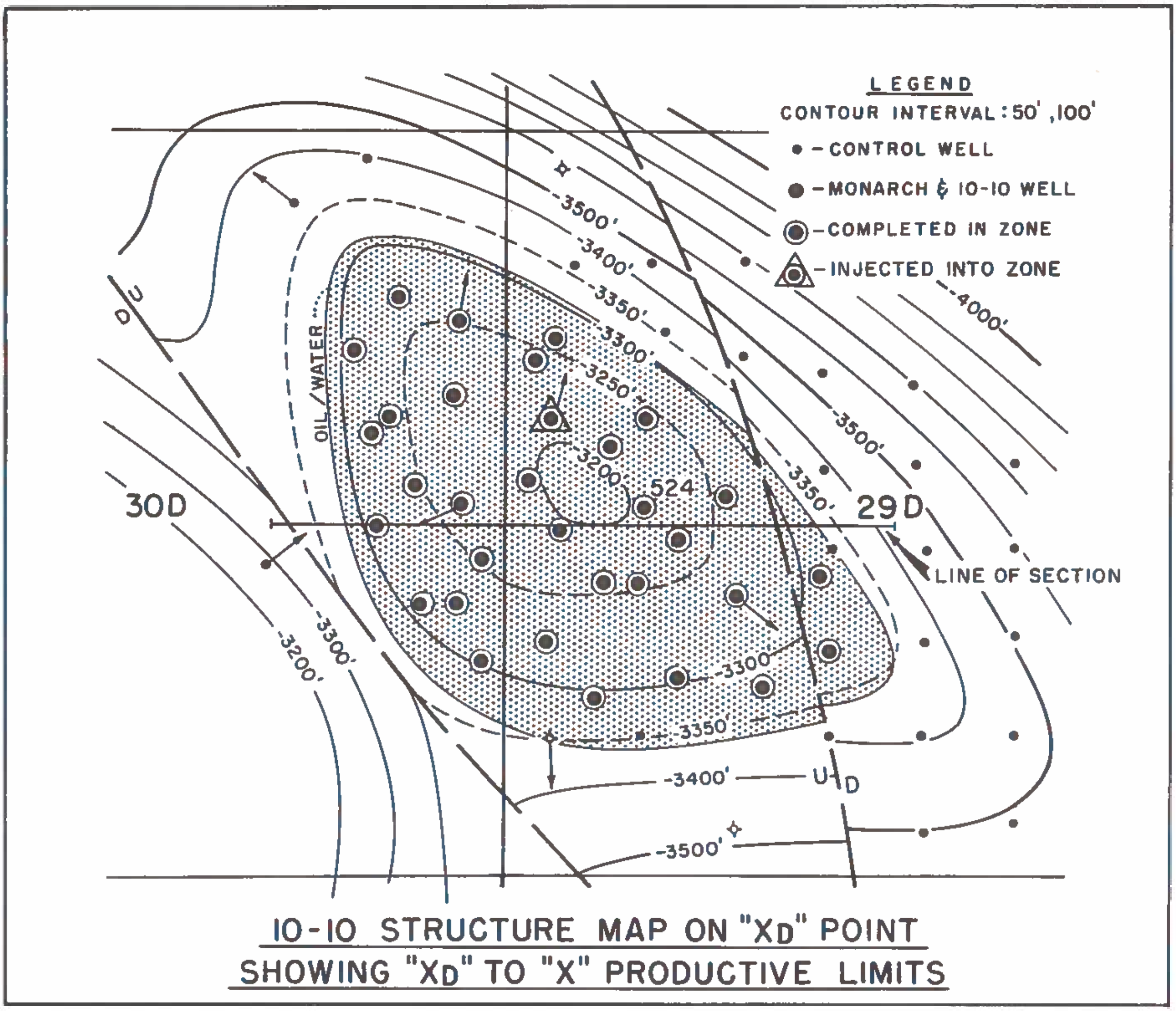


Fig. 13

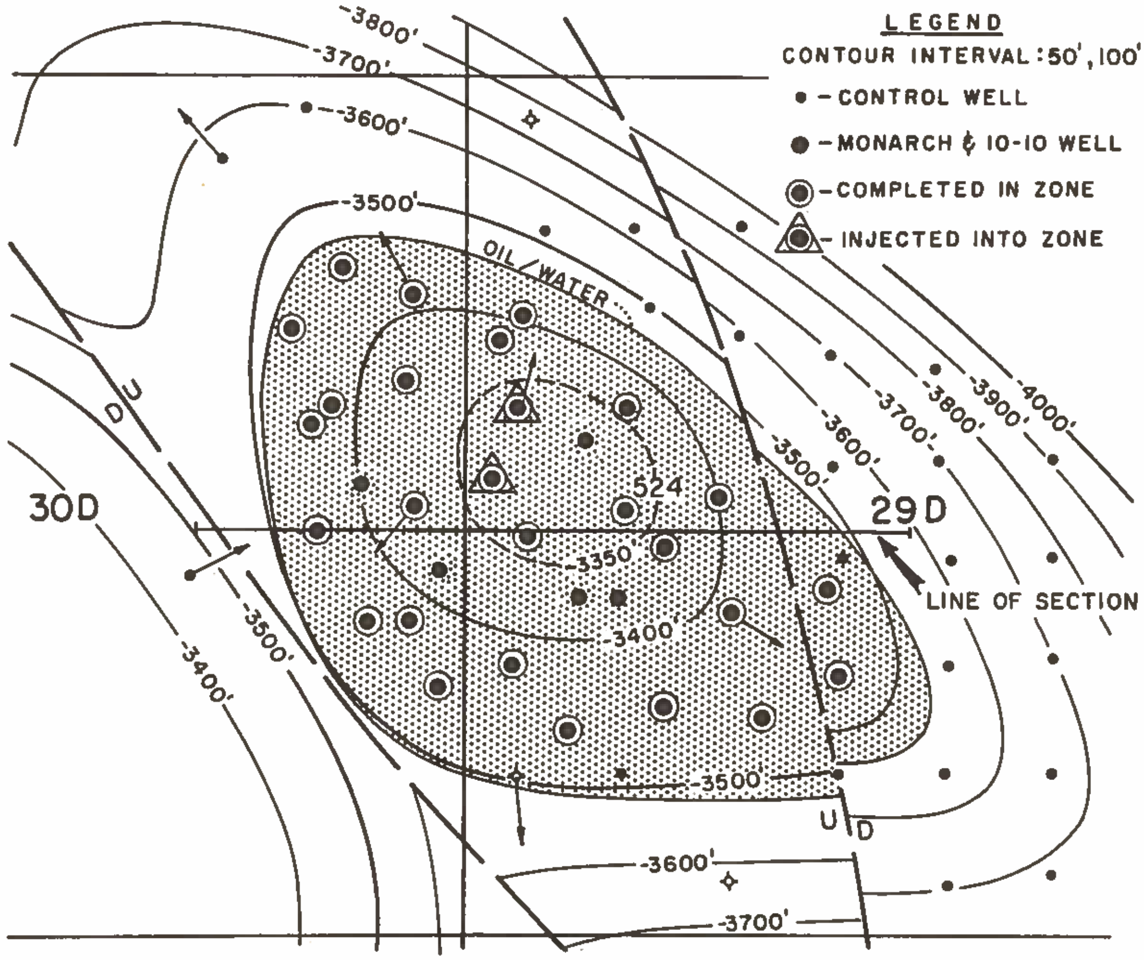
however, is more southerly in the 10-10 sands. This tilt, which is also found in the deeper Exeter-29D accumulations downdip, tends to increase or modify the size of the various pools, but is not believed to be a complete trapping mechanism in itself.

6. Low Differential Resistivity Between Wet and Clean Oil Sands

In logging the sands it was found that an increase of but 1 ohm-meter of resistivity, for example from 2 to 3 ohm-meters, is all that is required to indicate the transition from a wet sand to a clean oil or gas sand. Many sands that might normally be considered wet on the basis of qualitative electric log analysis, were perforated and found to produce clean oil. This anomaly may be due in part to the thin-bed effect inherent in the induction tool, but is most likely due to the silty and clayey nature of many of these reservoir sands.

7. Rerunning Sonic Log After Test May Locate Produced Sands

Relogging the tested interval with the sonic tool very often showed the intervals of gas entry in an oil and gas sequence. Completion of the individual reservoirs and the selective gun perforation of oil sands, while eliminating gas sands, required an exacting evaluation of fluid content in the various stringers. As was pointed out earlier, open hole drill-stem tests of large intervals containing both oil and gas sands recovered only gas; whereas, short interval retests of oil sands would flow oil. It was found that in tests where only gas was recovered the points of gas entry could often be recognized by comparing sonic logs run before



10-10 STRUCTURE MAP ON "X" POINT SHOWING "X" TO "X3" PRODUCTIVE LIMITS

Fig. 14

and after testing. In such cases the post-test sonic log would show dramatic cycle-skipping in the intervals where the gas was produced. The pre-test sonic had not shown such pronounced cycle-skipping, and thus its log character was not sufficient to distinguish the gas from oil. If both gas and oil were recovered in a tested interval, however, this evaluation technique would not be possible. In other words, the method may only be useful in those tests where only gas is recovered. The method is illustrated in Figure 16. Both induction and sonic logs were run, the interval tested, and a second sonic re-run as the first could not distinguish oil and gas. Only gas in excess of 5,000 MCF per day was recovered in the long test interval, drill-stem test #6, shown on the left side of the log, and therefore, the intervals of violent cycle skipping on the post-test sonic were determined to be those contributing the gas. These intervals were then excluded in the final completion. The well was perforated as shown making 300 barrels per day oil, zero water and only 114 MCF per day gas. It should be noted that drill-stem test #7 was made prior to the sonic rerun and recovered water, thereby invalidating this lower portion of the post-test sonic log.

The complete theory behind this evaluation technique has not as yet been established, but this should not preclude using the method for evaluation of such intermixed reservoirs.

DEVELOPMENT AND PRODUCTION

The 29D Monarch and 10-10 pool has been an elusive one. Over the years numerous wells have passed through the interval just downdip from the accumulation, while several others have "bottomed" less than 700 feet above the pool

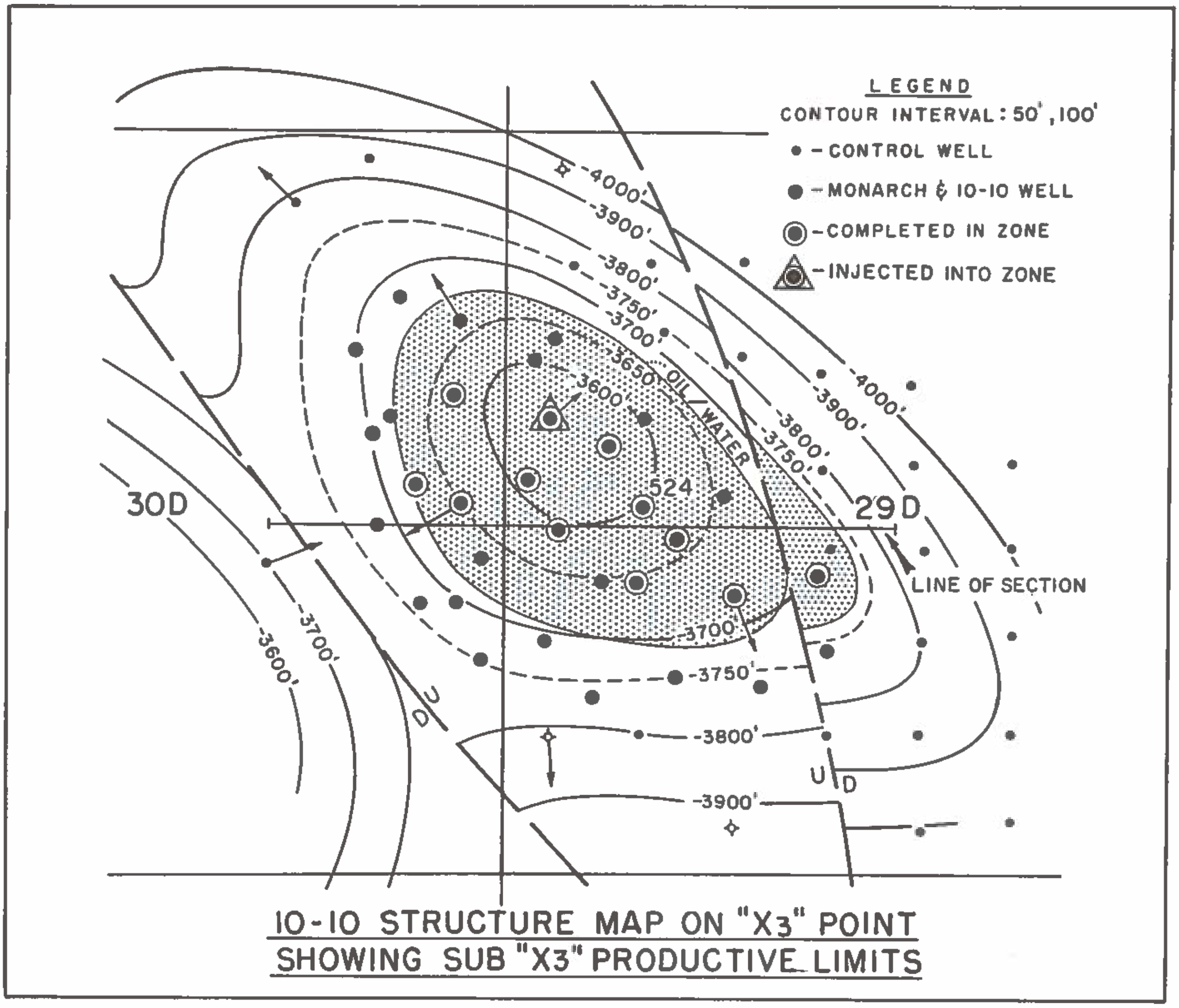


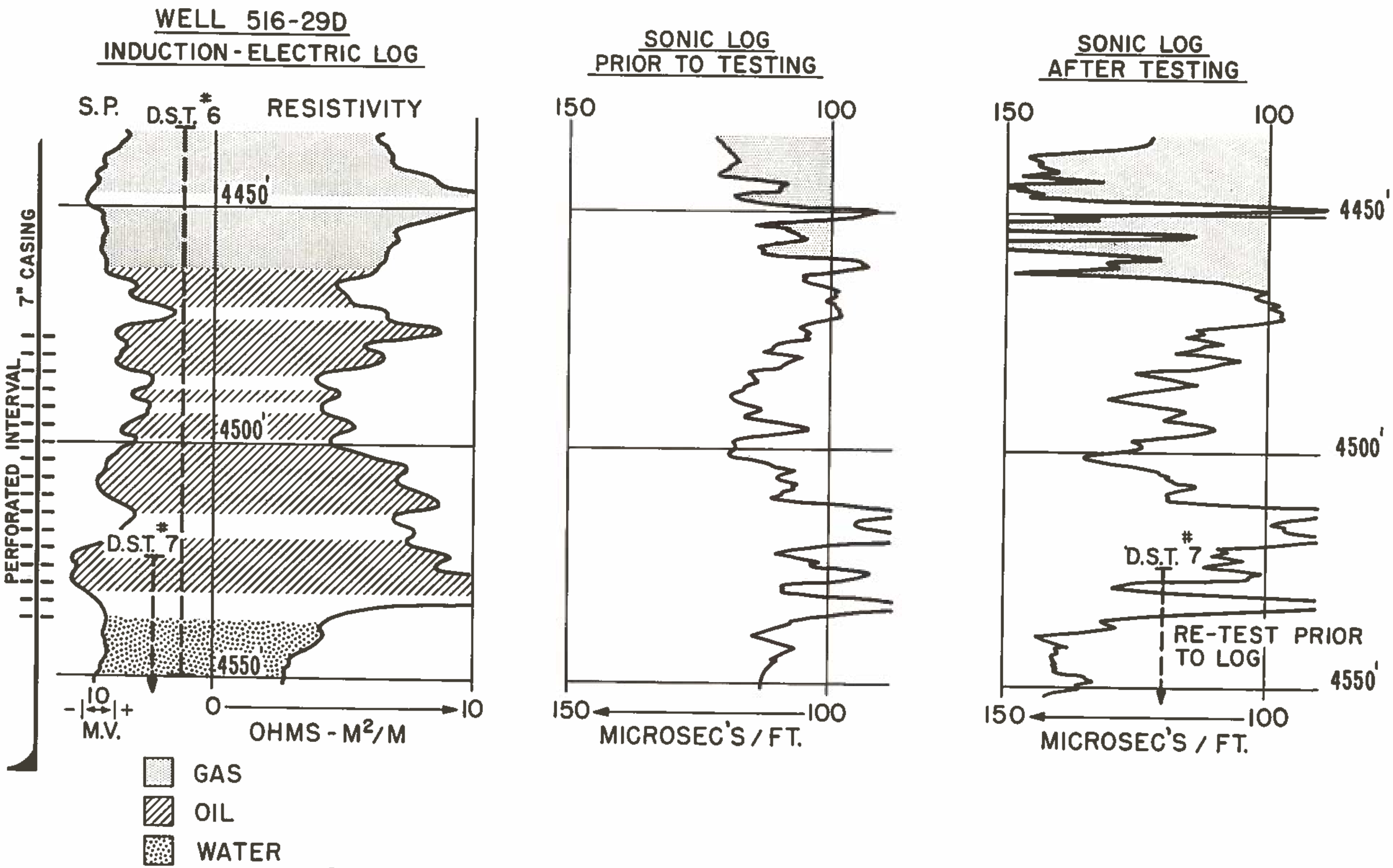
Fig. 15

itself. The "layer-cake" reservoir character has been a most fortuitous occurrence for it has enabled a much larger accumulation than might initially be expected.

Thirty-two wells have been completed in portions of the Monarch and 10-10 pools. Sixty-five strings of tubing were originally run, as 10 wells were triple completions, 13 were duals and 9 singles. All wells were initially completed flowing though a few intervals required gas lift. About one-third of the strings are still flowing after 2½ years of production, while another one-third are now on gas lift and the remaining one-third are either on the pump or temporarily suspended. No dry holes were drilled in the pool development. The initial triple completion, well 584-30D, was reportedly the first ever made on the west side of the San Joaquin Valley.

The pool is currently being operated under a pressure maintenance system. Two of the triple completion wells, 513-29D and 513A-29D, are being used to re-inject formation gas. Presently gas is being injected into most of the producing sands found in the pool. An elaborate injection plant has been built on the site for this purpose.

Cumulative production through June 30, 1965, amounts to over 4 million barrels of 32° API oil and oil equivalent gas. During peak production in late 1963 almost 9,000 barrels per day of oil and oil equivalent gas were recovered from the pool. Wells averaged about 250 barrels per day of oil or nearly 300 barrels per day of oil and gas equivalents. Production comes from thin separate reservoirs in the interval between 3,700 and 4,700 feet. The rate and quantity of production from this recent Monarch and 10-10 pool discovery compares quite favorably with the present average for the rest of the Midway-Sunset field of only 11 barrels per day.



SONIC LOG FLUID DETERMINATION METHOD

Fig. 16

THE MEGANOS GORGE OF THE SOUTHERN SACRAMENTO VALLEY[1]

By William F. Edmondson[2]
Bakersfield, California

ABSTRACT

The Meganos Gorge is a large fossil channel of late Paleocene age present in the subsurface in portions of Contra Costa, San Joaquin and Sacramento Counties, California. The Meganos Gorge Fill crops out on the north flank of Mount Diablo as Division C of the Meganos formation as defined by Clark and Woodford in 1927. Axial length of the Meganos Gorge is 44 miles and it covers an area of approximately 200 square miles. Maximum thickness of the Meganos Gorge Fill is about 2,500 feet and the observed volume is about 25 cubic miles. Average slope of the gorge surface varies from 5 to 16 degrees. The gorge fill is dominantly shale, entirely marine and carries a foraminiferal fauna of Laiming's D Zone.

The sediments beneath the Capay Shale and above the H & T Shale east of the Midland Fault are predominantly Upper Cretaceous and the prior erroneous designation as "Meganos-Martinez undifferentiated" was made before existance of the gorge was known and was based on paleontological determinations from wells which had penetrated the shale of the Meganos Gorge Fill.

The eastern (inland) extremity of the gorge at Walnut Grove has considerable sand present in the gorge fill. This sand is concentrated in the central portion of the gorge with shale on the sides. This gorge fill shale traps gas at Walnut Grove in both the pre-gorge sediments and sand in the gorge fill.

The Paleocene-Cretaceous contact is at the base of the shale which separates the First and Second Massive Sands, at which horizon a major unconformity is observed west of Brentwood.

The Anderson Sand is correlative to both the Wagenet Sand at Kirby Hills and to Divisions A and B of the Meganos formation which immediately underlie the Meganos Gorge Fill at the surface.

At Brentwood and Dutch Slough the Meganos Shale unconformably overlies the Meganos Gorge Fill and is a younger unit than the "Older Meganos" Shale present west of Brentwood which is cut by the Meganos Gorge.

Meganos Gorge Fill shale has very good electrical markers between Brentwood and McDonald Island where deposition was remarkably uniform under relatively quiet and stable conditions. Truncation of the northerly dipping Paleocene and Cretaceous sands at Brentwood by the base of the gorge together with the shale fill accounts for entrapment of oil and gas in these sands.

INTRODUCTION

The Meganos Gorge is a large fossil channel of late Paleocene age which deeply eroded Paleocene and Upper Cretaceous sediments. Immediately after its erosion the gorge was filled by deposition of marine sediments which are herein designated "Meganos Gorge Fill." Meganos Gorge Fill is present in the subsurface in portions of Contra Costa, San Joaquin and Sacramento Counties, California and at the surface on the north flank of Mount Diablo in Contra Costa County.

Bruce L. Clark proposed the name "Meganos" for a group of marine sediments of Lower Tertiary age on the north flank of Mount Diablo (Clark, 1918). The Meganos was later redefined as a formation and subdivided into five divisions (Clark and Woodford, 1927). The 1950 AAPG-SEPM Guidebook to the North Mount Diablo Monocline indicated the following correlation of these divisions to the subsurface in the Sacramento Valley:

Divisions A and B	=	Anderson Sand
Division C	=	Meganos Shale
Division D	=	Margaret Hamilton Sand
Division E	=	Capay Shale

These correlations are valid except that Division C also includes Meganos Gorge Fill as a formation which is separate and distinct from the Meganos Shale. Division C is almost entirely Meganos Gorge Fill but approximately 100 feet at the top is Meganos Shale, a thin shale unit which unconformably overlies the Meganos Gorge Fill west of the Midland Fault and extends beyond the limits of the Meganos Gorge Fill to the north. General recognition of the fact that Division C is for the most part correlative to Meganos Gorge Fill did not occur until development of the Brentwood Field (1962-1964) provided important subsurface data.

First public reference to the Meganos Gorge was made by John Silcox at the 1960 Pacific Section AAPG Annual Meeting in a paper on the West Thornton-Walnut Grove Area. First published reference was also made by Silcox in Bulletin 181 (Silcox, 1962).

AGE OF MEGANOS GORGE FILL

The Meganos Gorge Fill is entirely marine and carries a foraminiferal fauna of Laiming's D Zone which many paleontologists now place at the top of the Paleocene. All available evidence indicates that the filling of the gorge began immediately after its excavation.

Prior to development of the Brentwood field (discovered in 1962) only one well west of the Midland Fault had penetrated the Meganos Gorge Fill. Because of this lack of information west of the Midland Fault the early penetrations and initial recognition of this gorge came in areas east of the Midland Fault where Meganos Gorge Fill is unconformably overlain by Capay Shale of early Eocene age. Here the gorge cuts down into the dominantly sandy section which underlies the Capay Shale (see Fig. 3).

First penetration of Meganos Gorge Fill was made by the Standard "McDonald Island #2," Section 19, T. 2 N., R. 5 E., drilled in 1936. It was then recognized that this well had penetrated an anomalous 130 feet of shale immediately beneath the Capay Shale but this was not recognized as part of a gorge filling unit at that time. This shale

1. Presented to the San Joaquin Geological Society October 13, 1964.
2. Consulting Geologist associated with Reynolds and Carver.

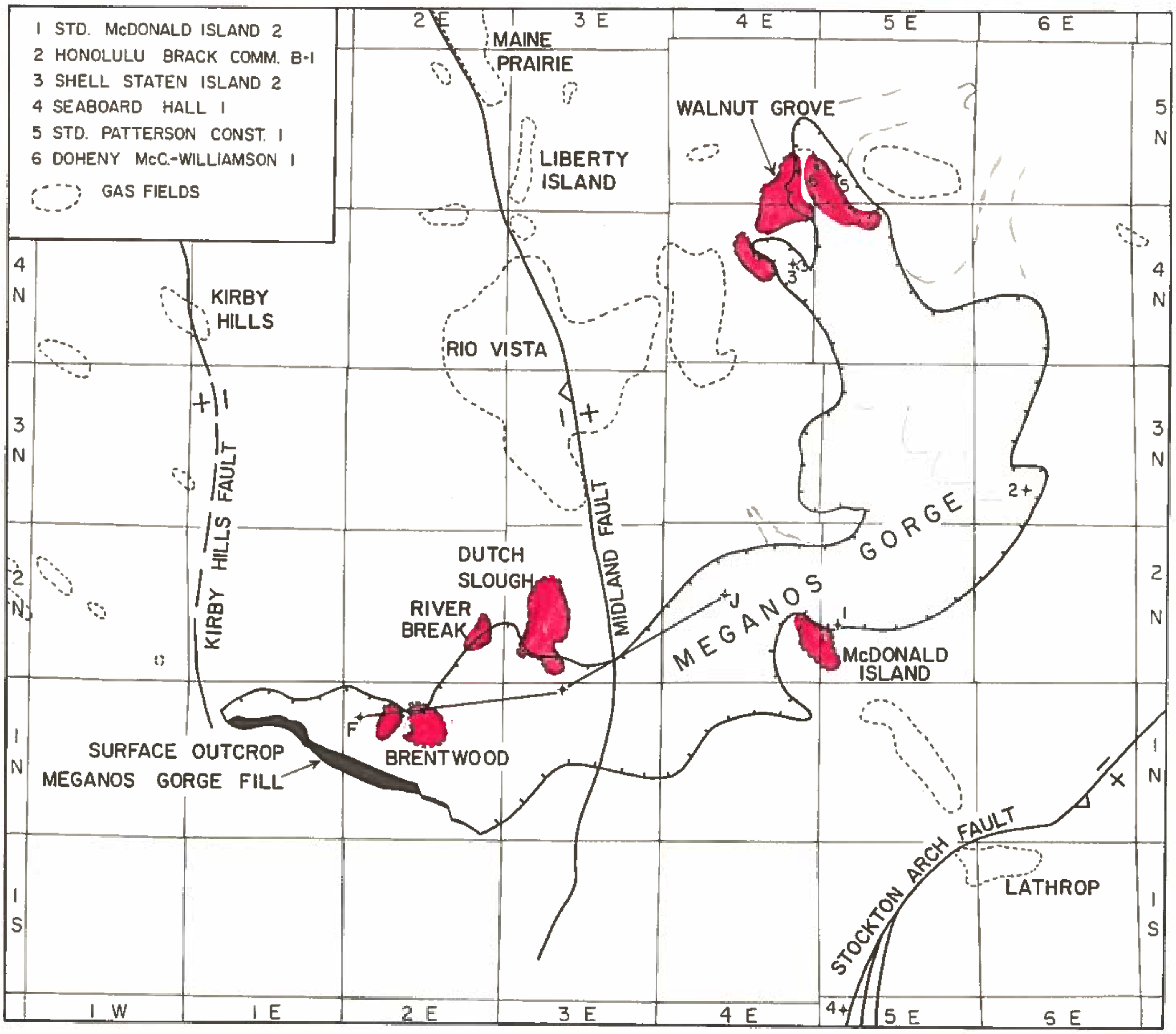


Fig. 1. Location map for the Meganos Gorge.

was designated "Martinez" in an article in Bulletin 118 (Knox, 1943). Among early wells which penetrated Meganos Gorge Fill were the Honolulu (now Tidewater) "Brack Community B-1," Section 29, T. 3 N., R. 6 E. and the Shell "Staten Island #2," Section 13, T. 4 N., R. 4 E., drilled in 1945 and 1946 respectively. Paleontological determinations from the gorge fill shale in these wells showed the presence of a foraminiferal fauna belonging to Laiming's D Zone of Lower Tertiary age and very similar to that found in the Meganos Shale between the Margaret Hamilton Sand and the Anderson Sand at Rio Vista west of the Midland Fault (see Fig. 3). Because the existance of the Meganos Gorge was not then recognized, these and other paleontological determinations from wells which penetrated gorge fill shale became the basis for age identification of the sediments beneath the Capay Shale east of the Midland Fault, a sandy section which carries little or no diagnostic fauna. As a result these sediments were erroneously designated "Meganos-Martinez undifferentiated." This unit is predominantly a near shore or even a non-marine facies of the Uppermost Cretaceous and is correlative to the Second Massive Sand, Hall Shale, and Third Massive Sand in the area north of Brentwood and southwest of Rio Vista (see Fig. 3). At the top of this unit there is a generally massive sand typically 50 to 300 feet thick that is Paleocene in age (see Figs. 3 and 5).

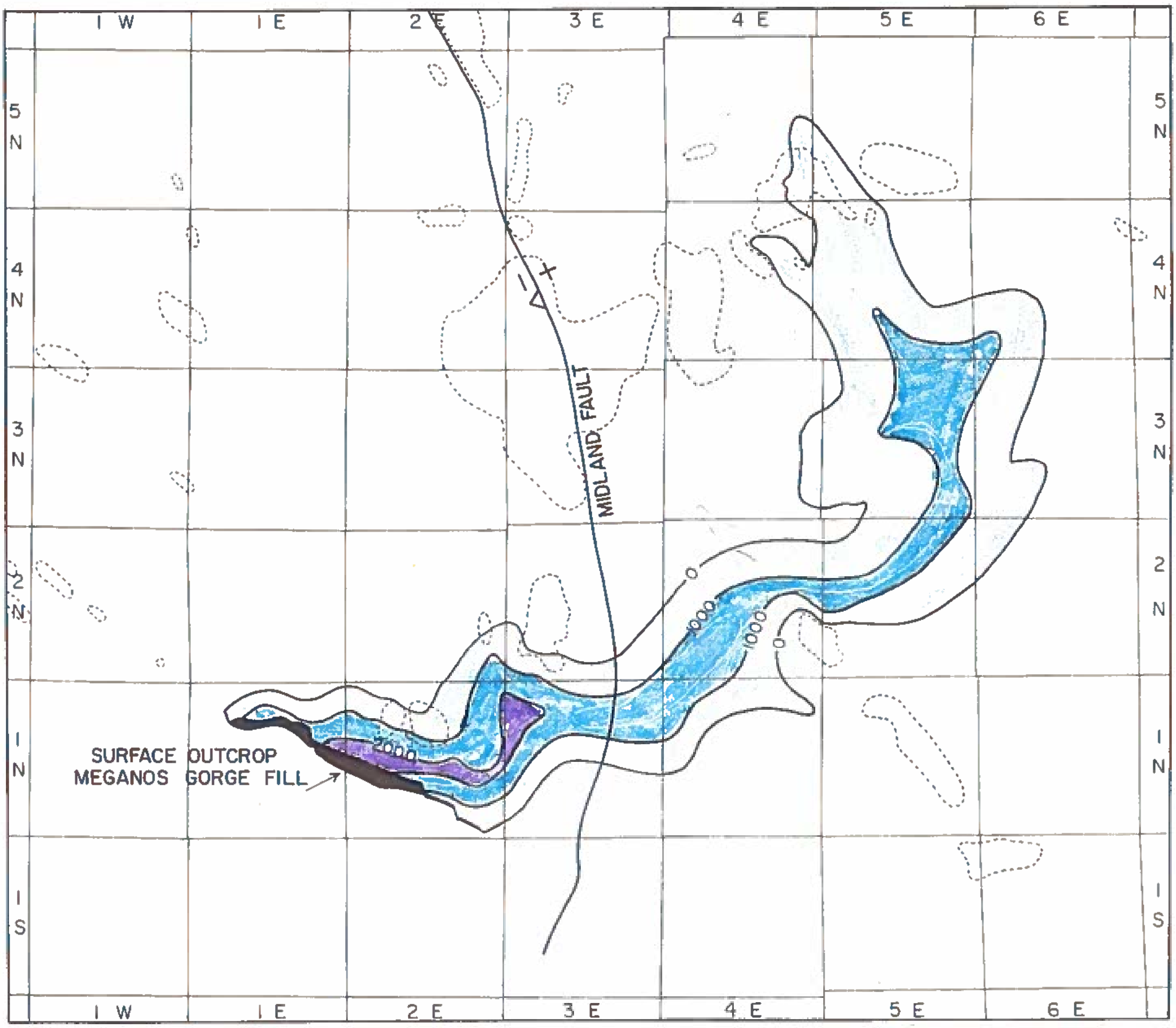


Fig. 2. Isopachs of Meganos Gorge Fill.

PHYSICAL DIMENSIONS OF THE MEGANOS GORGE

The physical dimensions listed below are for the gorge as it is presently preserved in the geologic record. No attempt has been made to compensate for what might have been removed by subsequent erosion or for the effect of differential sedimentary compaction. The original outline of the gorge probably did not extend significantly beyond the limits shown in Figures 1 and 2, excepting its southwestward extension beyond its surface outcropping north of Mount Diablo.

Length: Axial length is 44 miles and straight line length is 32 miles. Original length was certainly greater but there is no basis in existing data for making an estimate.

Area: The area shown in Figures 1 and 2 is about 200 square miles.

Width: Width varies from 3 to 8 miles but is typically 5 to 6 miles.

Volume: Volume is approximately 25 cubic miles.

Depth: Figure 2 shows regional isopachs for the Meganos Gorge Fill. These figures are based on well depth measurements and have not been corrected for dip, which in the Brentwood area may result in errors in thickness of up to 15 per cent. Maximum indicated depth (when corrected for dip) is about 2,500 feet.

Slope: The sides of the gorge slope at angles varying from 5 to 16 degrees; these limits being exceeded only in limited local areas. In general steeper slopes are encountered at the seaward (western) extremity of the gorge.

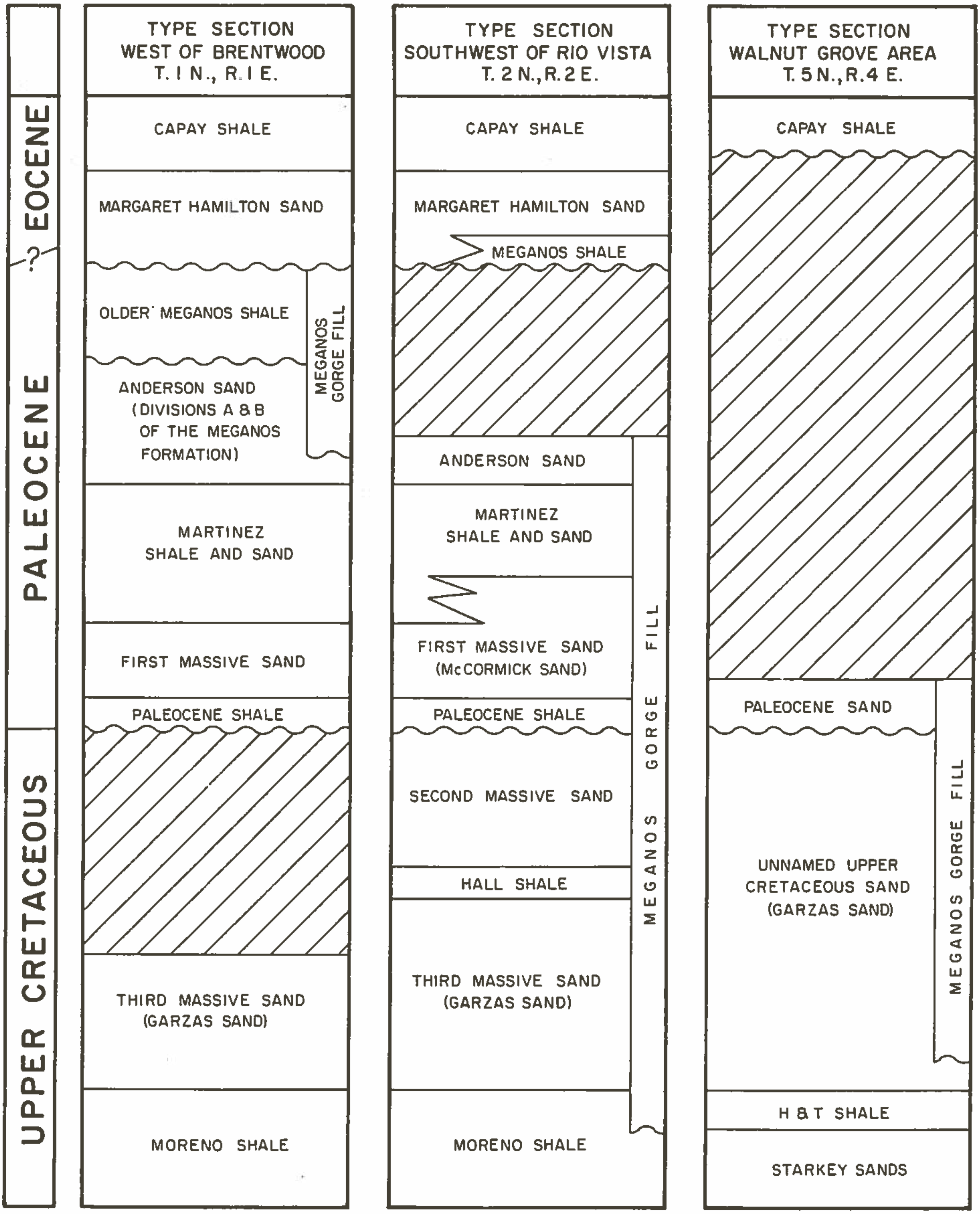


Fig. 3. Type sections for the late Cretaceous and early Tertiary.

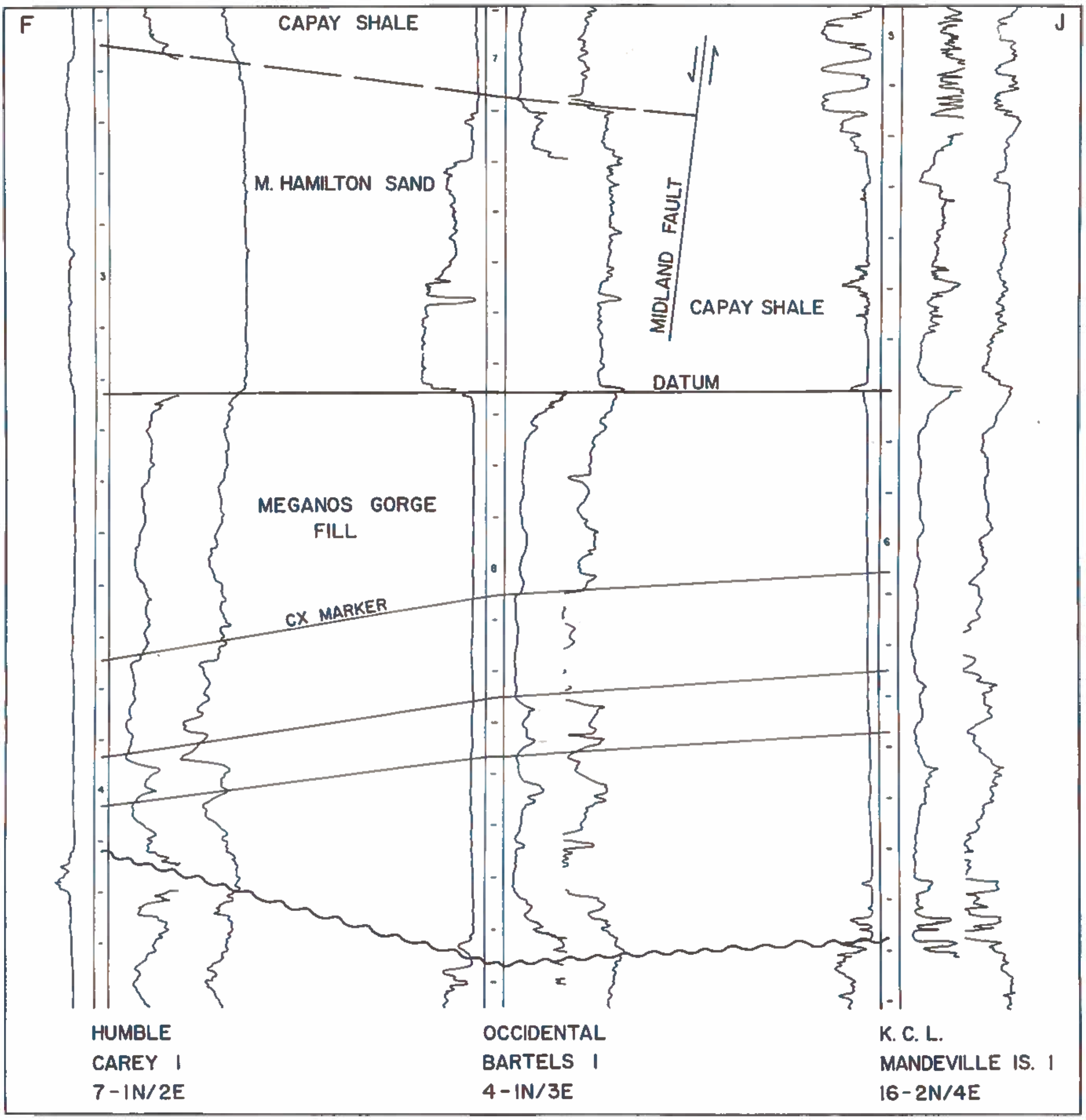


Fig. 4. Correlation section F-J.

EROSION OF THE MEGANOS GORGE

The Midland Fault approximated the eastern limit of deposition for most of the Lower Tertiary formations of the Sacramento Valley. This limitation is particularly applicable to units deposited immediately prior to and after the erosion and fill of the gorge. There is every reason to believe that the Midland Fault approximated the eastern limit of the basin of deposition at the time the gorge was cut.

A great river flowing westward out of the ancestral Sierra Nevada Mountains was the primary force which created the gorge. Initial cutting action was subaerial just east of the Midland Fault. As the cutting of the gorge proceeded, the portion first cut was invaded by the sea becoming an estuary, and further downward cutting was accomplished in a subaqueous environment. This sequence was progressively repeated until the mouth of the river was at Walnut Grove and a large inlet had been formed whose outline is approximated by the occurrence of Meganos

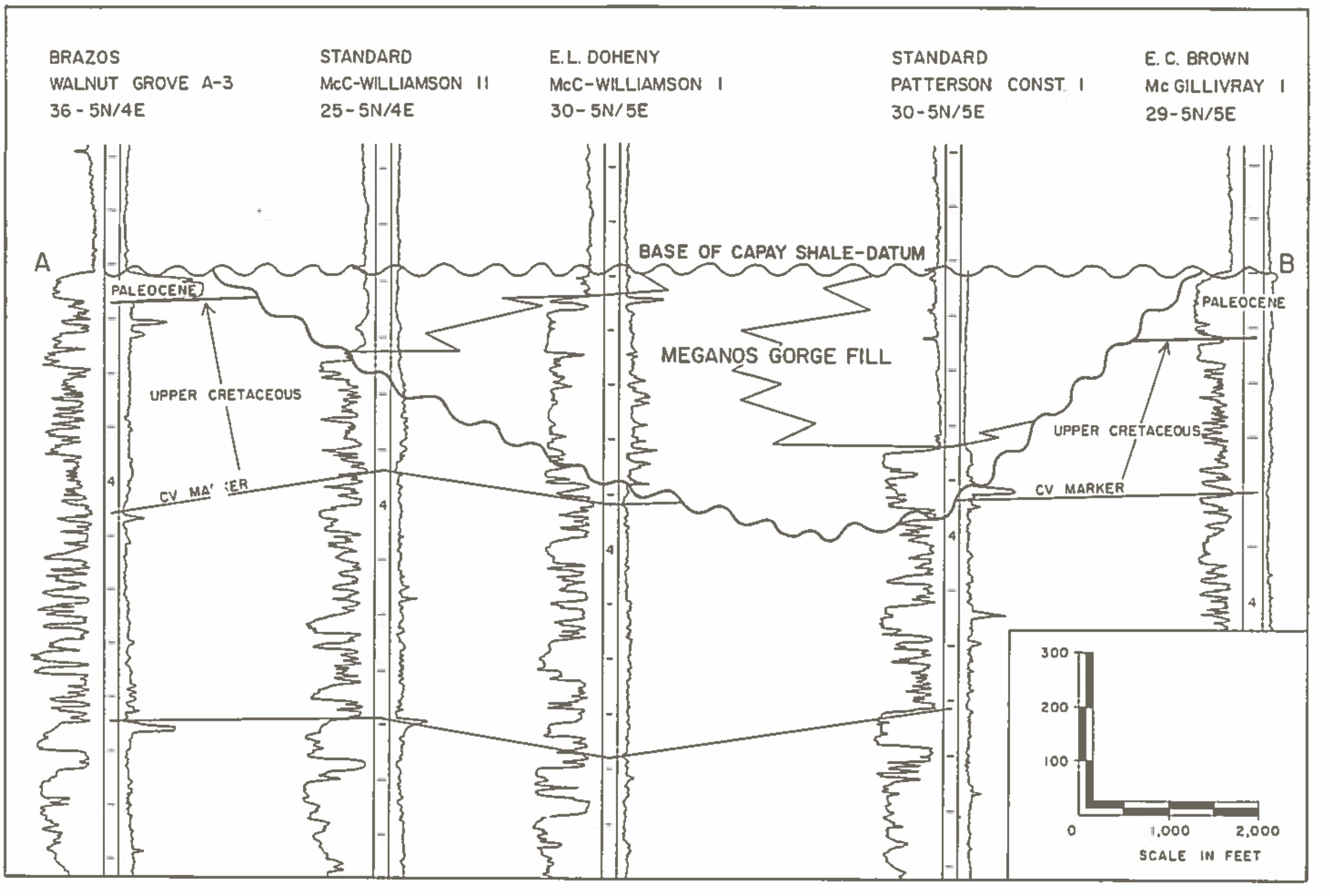


Fig. 5. Correlation section A-B.

Gorge Fill east of the Midland Fault (see Fig. 1). As the inlet increased in size, portions of lesser streams which were originally tributaries to the larger river were incorporated into the inlet (see Fig. 1; T. 1 N., R. 4 E.; T. 4 N., R. 4 E.; T. 4 N., R. 6 E.).

The erosion of the gorge within the inlet east of the Midland Fault was accompanied by even greater erosion west of the fault out in the depositional basin where all of the cutting was submarine. It is theorized that the cut was accomplished by density currents which were initiated by the force of the great river and the sediments it carried.

RELATIONSHIP OF THE MEGANOS GORGE TO THE MIDLAND FAULT

The Midland Fault was active before, after, and presumably during the cut and fill of the gorge; yet there is no indicated offset of gorge isopachs across the line of the fault (see Fig. 2). Because of sparse well control near the fault a minor difference in isopach thickness could not now be determined. This lack of isopach divergence and relationships shown by Figure 4 indicate these interesting conclusions:

1. There has been no large scale erosion of the Gorge Fill on either side of the Midland Fault.
2. The hiatus at the base of the Capay Shale east of the Midland Fault represents a significant length of time (see Fig. 3) but the dominant portion of erosive activity occurred prior to the creation of the gorge.
3. The time required to fill the gorge was not sufficient to allow measurable movement (by existing control standards) along the Midland Fault whose movement is assumed to have been continuous during the Lower Tertiary.

THE MEGANOS GORGE AT WALNUT GROVE

The Standard "Patterson Construction Company #1," Section 30, T. 5 N., R. 5 E., drilled in 1954, encountered 330 feet of Meganos Gorge Fill shale. This well was sufficiently close to others with normal sections that it forced serious consideration of the existance of a gorge. In July 1956, the E. L. Doheny (now Standard) "McCormack-Williamson #1" was drilled in that same section and discovered gas in Meganos Gorge Fill sands, though it was not then recognized that the producing sand was part of

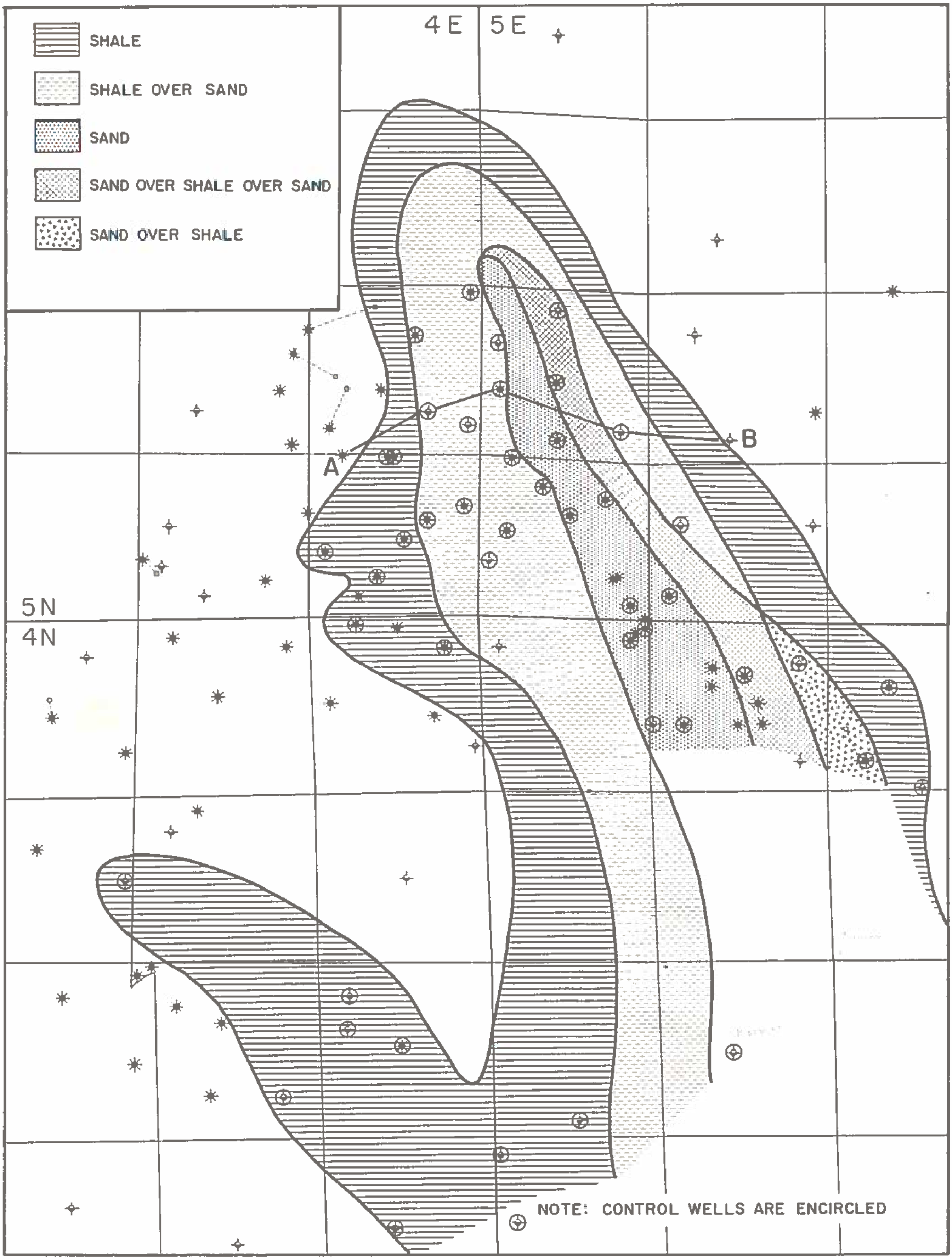


Fig. 6. Distribution of the various types of gorge fill at Walnut Grove.

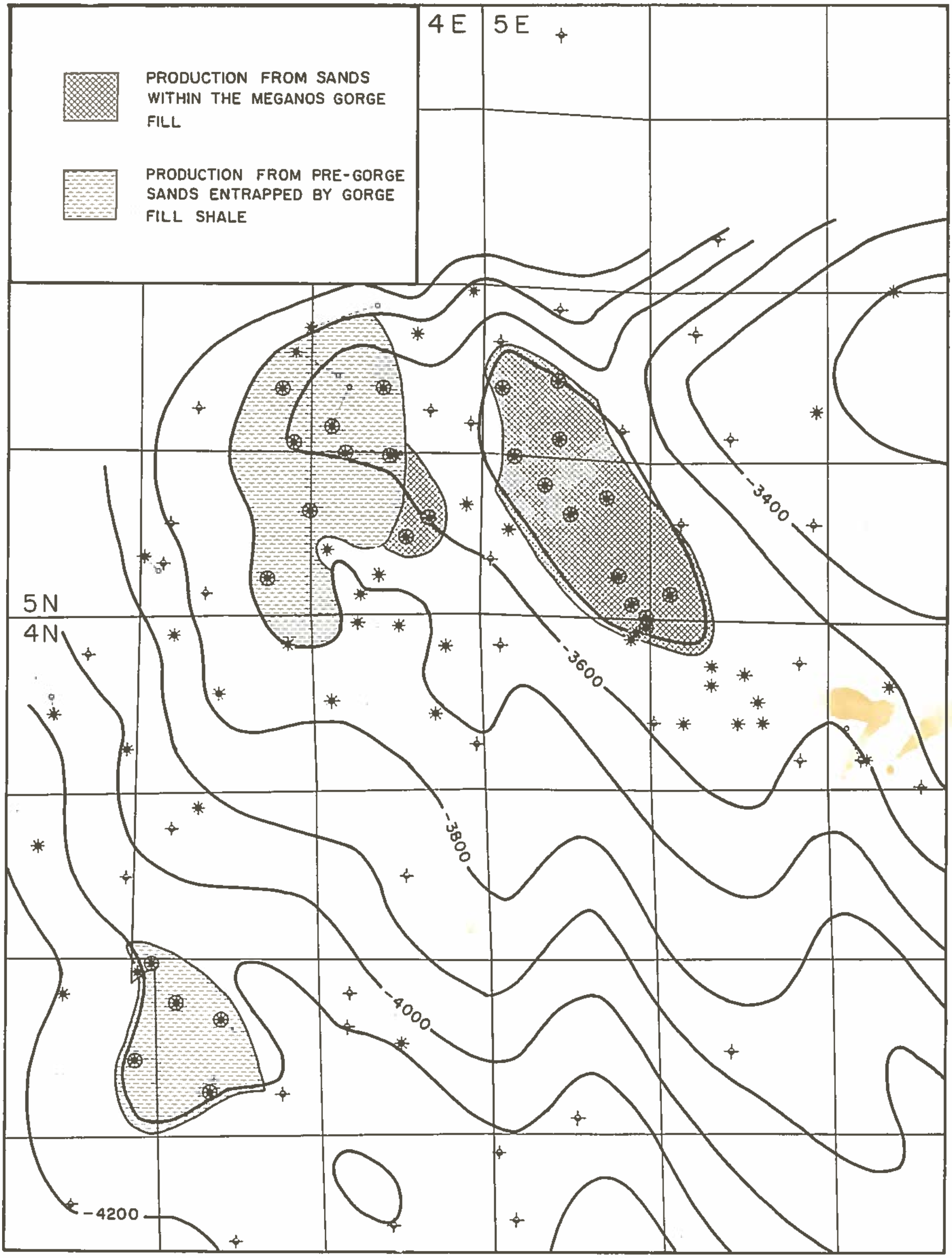


Fig. 7. Contours on base of Capay Shale at Walnut Grove.

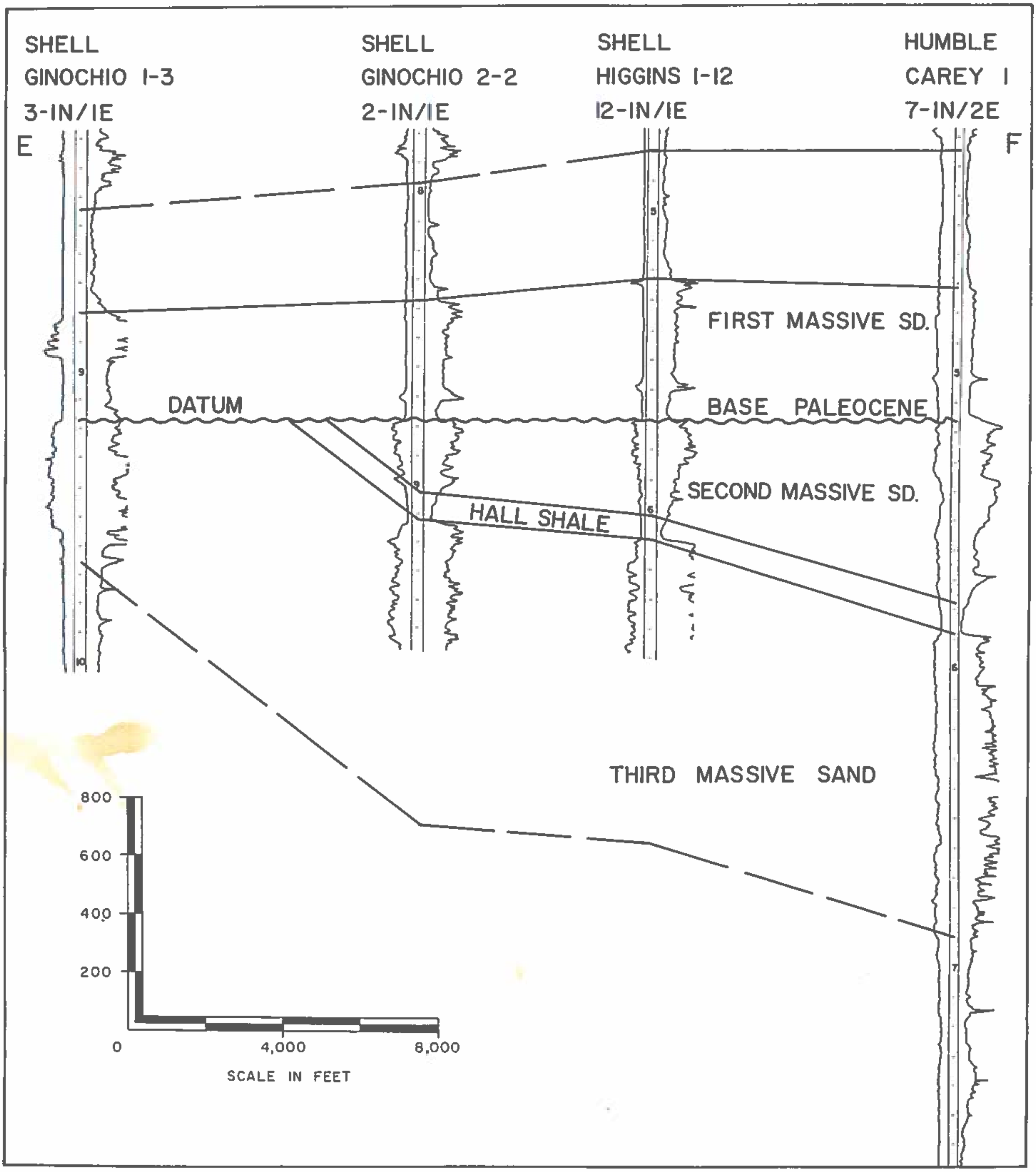


Fig. 8. Correlation section E-F showing Paleocene-Cretaceous contact.

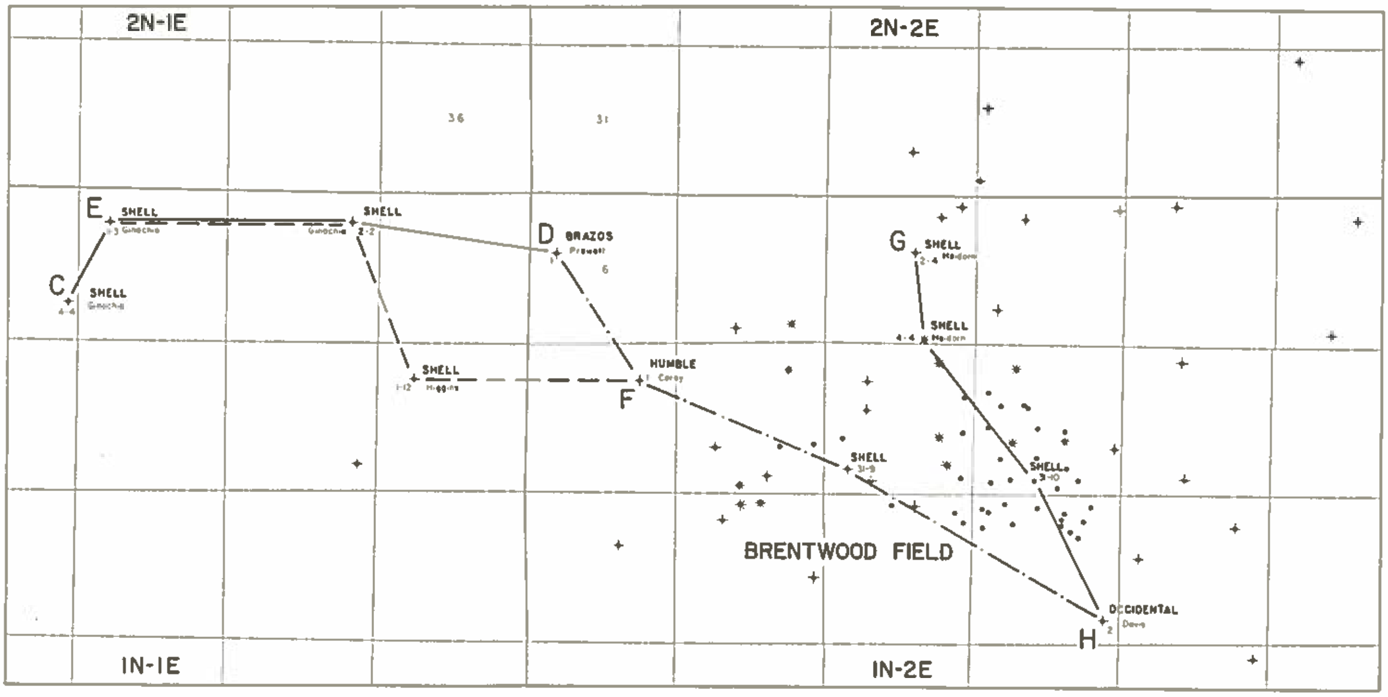


Fig. 9. Base map showing location of correlation sections at Brentwood.

the Meganos Gorge Fill. Subsequent development of the West Thornton-Walnut Grove field provided the detailed data that confirmed the existance of the Meganos Gorge.

At Walnut Grove the Meganos Gorge Fill contains considerable quantities of sand whose distribution follows a clearly defined pattern. The fill in the center of the gorge is all sand and that on the sides is all shale. Between these extremes the gorge fill may be shale over sand, sand over shale, or sand over shale over sand. Figure 6 shows the geographic distribution of these five different sequences of filling material. For any specific datum within the gorge fill in this area measured relative to the base of the Capay Shale (e.g. 200 feet below base Capay Shale) the relationship is simply sand in the middle and shale on the sides and for datums more than 400 feet beneath base of Capay Shale the gorge fill is all sand.

It is likely that variations in the force of depositional currents allowed deposition of coarser material (sand) in the center but not along the sides. The area of substantial sand development extends southward into T. 3 N., R. 5 E. but westward from that township the gorge fill is nearly all shale except for the lowermost portion near its axial trend.

At Walnut Grove the shale in the Meganos Gorge Fill is the dominant factor providing entrapment of gas in that portion of the section affected by the gorge. Some of the production comes from sands that pre-date the gorge with shale in the west side of the gorge fill providing the updip entrapping barrier (see Fig. 7). In Sections 30 and 31, T. 5 N., R. 5 E., the sands in the gorge fill produce on a small anticlinal structure with shale in the east side of the gorge fill assisting in the creation of the trap. This small anticlinal feature very nearly coincides with the area of total sand development in the gorge fill. This occurrence is not a coincidence but rather the anticlinal feature has resulted from differential compaction of the gorge fill; the shale portions being subjected to considerable compaction in contrast to the sandy portions which have undergone very little compaction.

CHARACTER OF THE MEGANOS GORGE FILL WEST OF THE MIDLAND FAULT

West of the Midland Fault the Meganos Gorge Fill is almost all marine shale. A few local sand lenses up to 50 feet thick are present and about 100 feet of basal conglomerate and sand are present, usually in the deeper portions along the axial trend.

Meganos Gorge Fill shale is characterized by exceptionally good and readily correlative electric log markers. These markers can be carried easterly across the Midland Fault to the McDonald Island area (see Fig. 4). One of these (the CX Marker) has been shown on all of the cross sections. The extremely uniform character of the shale indicates that deposition of Meganos Gorge Fill took place under relatively quiet, stable and uniform conditions, the exact opposite conditions of what would normally be expected for a gorge fill formation.

Nothing in the areas studied indicates that the gorge was approaching its western terminous. How far did the gorge extend? Did Meganos Gorge Fill have a sandy forefacies? What happened to the more than 25 cubic miles of sediment excavated by the gorge? These questions can not be answered because the Meganos Gorge Fill has evidently been removed by subsequent erosion west of the areas of known occurrence shown on Figures 1 and 2.

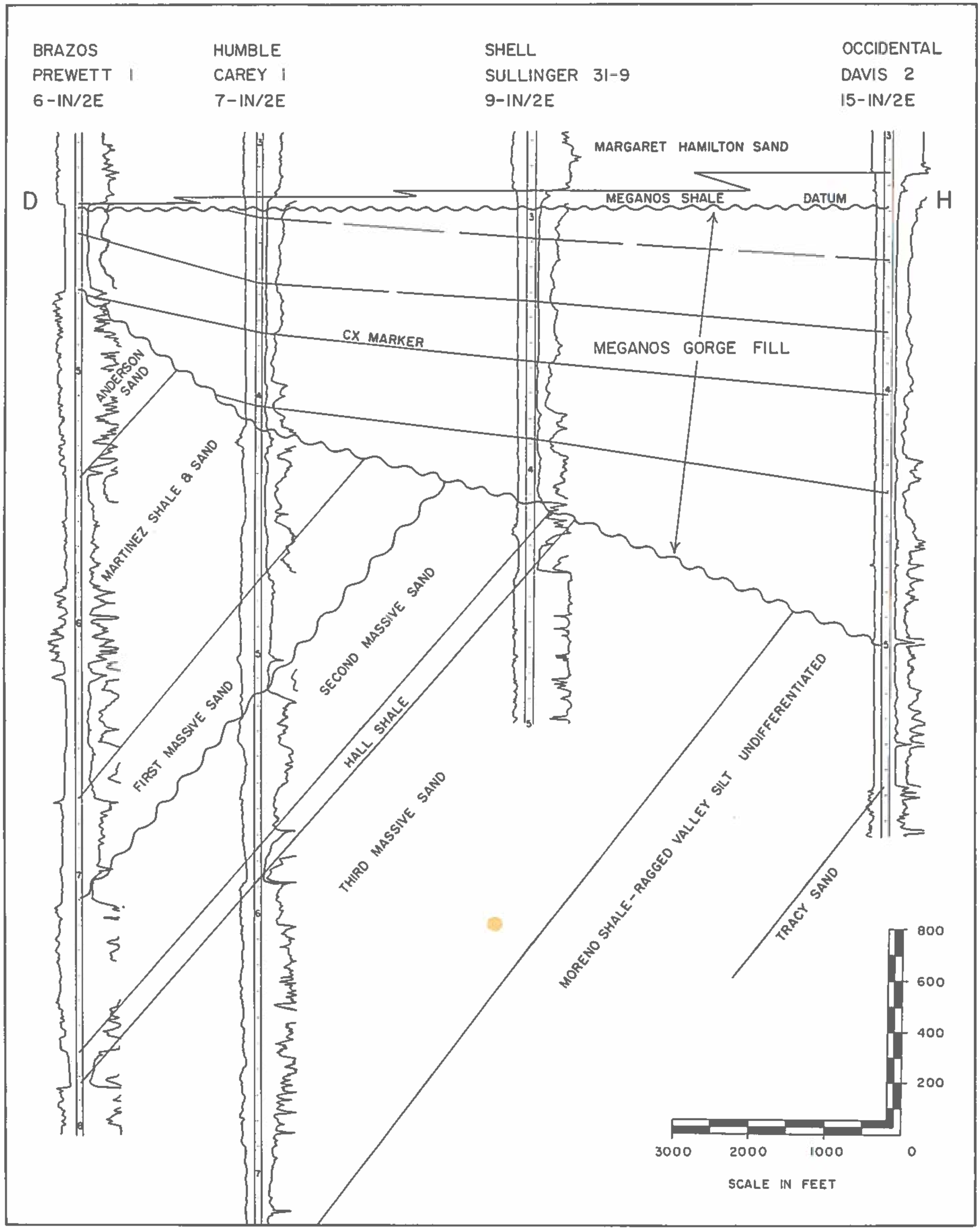


Fig. 10. Correlation section D-H.

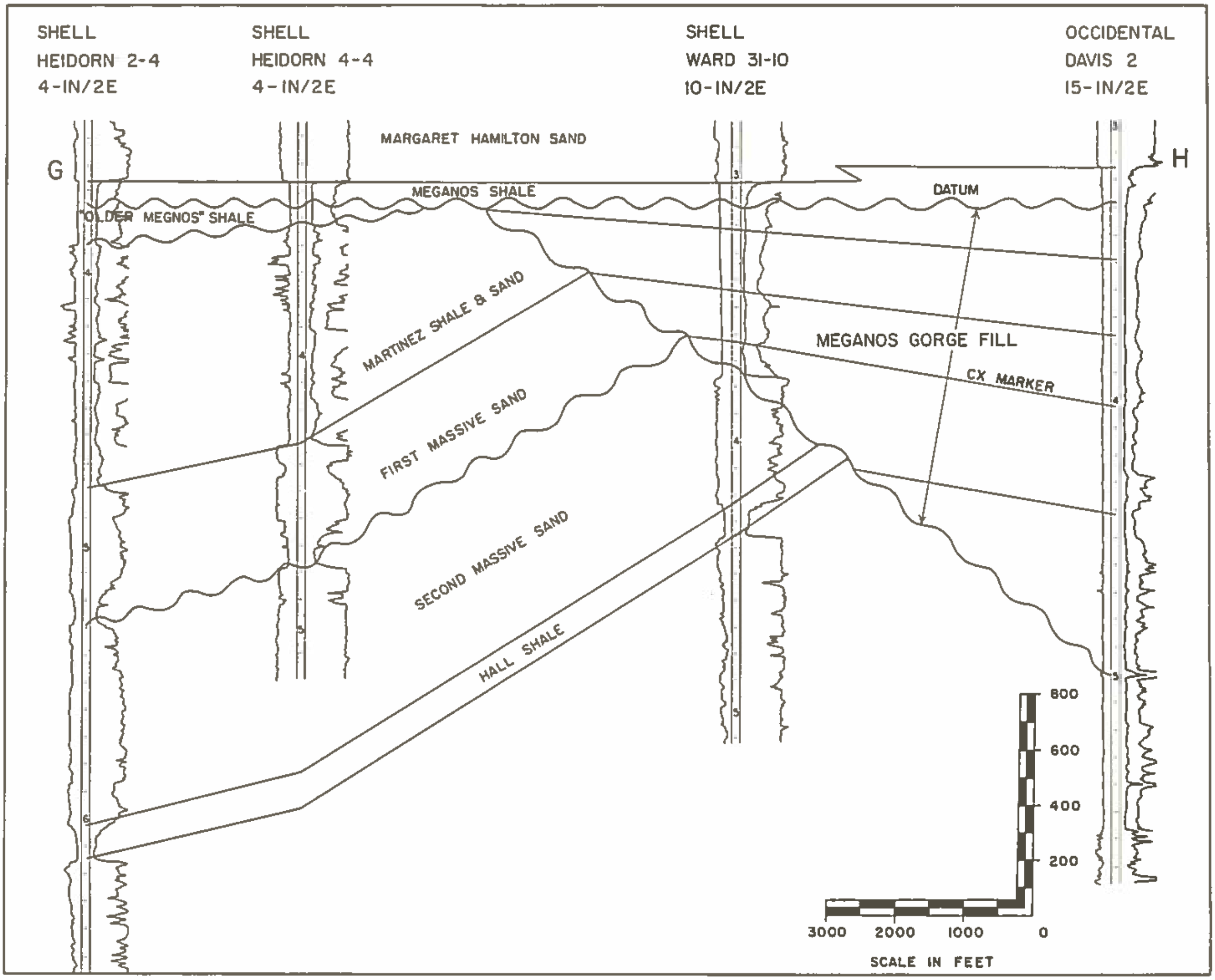


Fig. 11. Correlation section G-H.

Though some remnants of Meganos Gorge Fill may be present southwest of Mount Diablo, the absence of Divisions A, B, C, and D of the Meganos formation at Martinez (Weaver, 1953, p. 30) would seem to diminish this possibility.

PALEOCENE-CRETACEOUS CONTACT

Throughout the subsurface of most of the Sacramento Valley the Paleocene appears conformable to the Upper Cretaceous, but west of Brentwood an unconformity is present at the base of the Paleocene (see Fig. 8). Cretaceous pollens have been found in the Second Massive Sand, and Ivan P. Colburn reports the presence of late Cretaceous megafossils in his Unnamed Upper Cretaceous formation (Colburn, 1961, p. 34 and 37), which is correlative to the Third Massive Sand. A core taken in the Hall Shale at 5,530-5,539 feet in the Seaboard (now Texaco) "Hall #1," Section 6, T. 2 S., R. 5 E., the type well for the Hall Shale, has been reported to contain the radiolaria Dictyomitra multicostata in one report and pyritized Siphogenerinoides fragments in another report. Either occurrence would be indicative of Upper Cretaceous age.

These indications of an Upper Cretaceous age for the units immediately beneath the unconformity shown in Figure 8 and the significance of such an unconformity appear sufficient evidence to justify designation of the base of the shale which separates the First and Second Massive Sands as the base of the Paleocene in the Sacramento Valley. This position for the contact is considerably higher than has been shown in most prior published work. Many authors have placed the contact at or near the base of the H & T Shale which has also been erroneously termed "Martinez Silt."

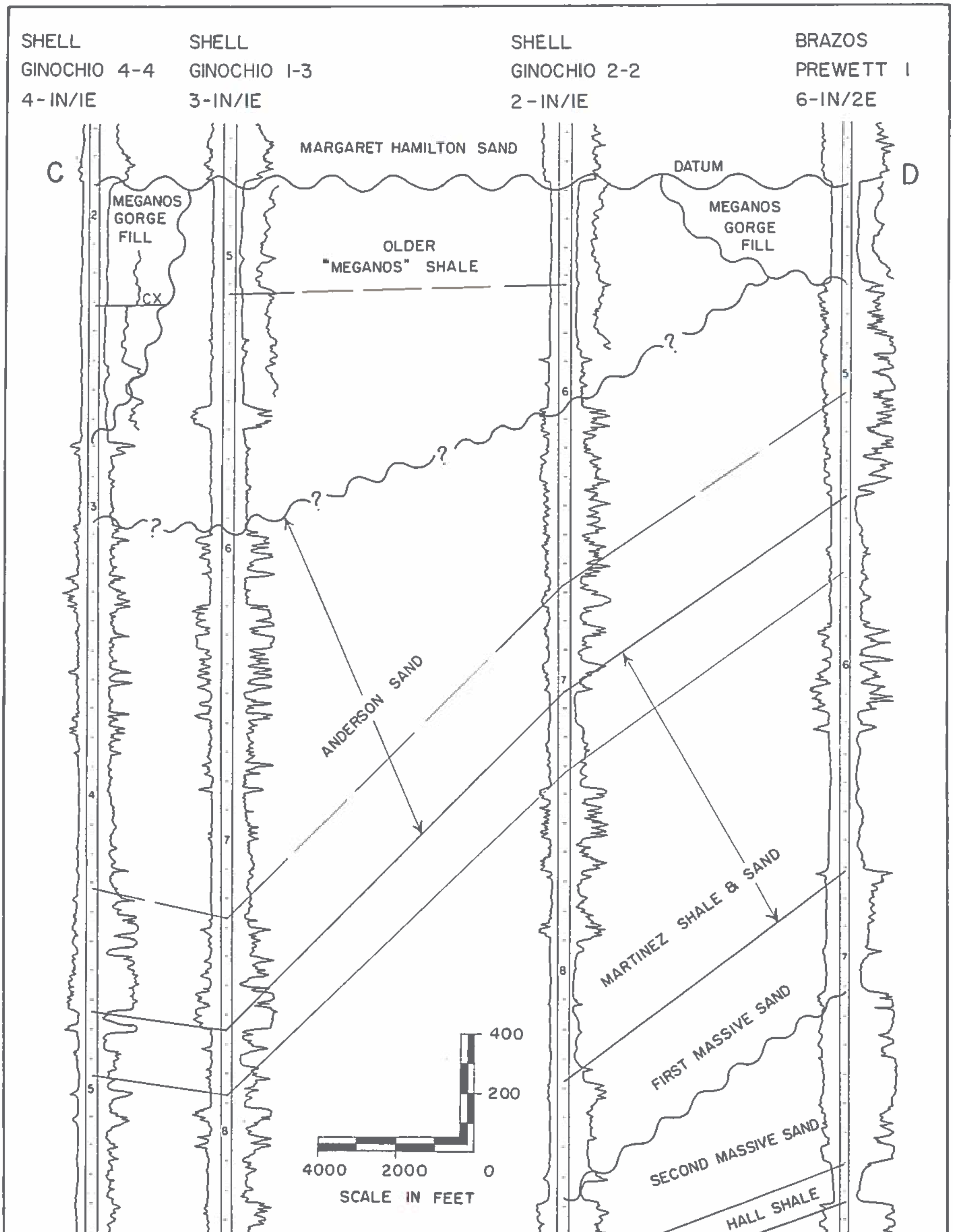


Fig. 12. Correlation section C-D.

RELATIONSHIP TO THE MEGANOS GORGE TO LATE CRETACEOUS AND EARLY TERTIARY FORMATIONS WEST OF THE MIDLAND FAULT

Figure 3 shows type sections for the late Cretaceous and early Tertiary. Some of the formation names used will not agree with that of other authors and the following comments are made to clarify usage employed herein. The names, "First, Second and Third Massive Sand" have not been properly defined and are of limited areal significance but they have widespread acceptance among subsurface geologists and their continued usage is deemed desirable. The top of the McCormick Sand at Rio Vista is correlative to the top of the First Massive Sand at Dutch Slough. The upper portion of the First Massive Sand becomes very silty to the west and this silty portion is included in the overlying Martinez Shale and Sand at Brentwood.

MEGANOS SHALE

At Brentwood and Dutch Slough the Meganos Shale is only about 100 feet thick. There is a significant unconformity at the base of this formation but its importance is largely obscured by the presence of Meganos Gorge Fill. Because the shale of Meganos Gorge Fill is so similar to the Meganos Shale in all aspects, including electric log characteristics, differentiation of the two is difficult. Where the Meganos Shale overlies Meganos Gorge Fill an unconformable relationship has been shown on Figures 10 and 11, but the evidence supporting this is certainly not conclusive and many geologists consider the two to be conformable.

A facies relationship between the Meganos Shale and the Margaret Hamilton Sand appears to exist with the Meganos Shale sanding up to the west (see Figs. 10 and 11).

West of Brentwood there is a shale between the Margaret Hamilton Sand and the Anderson Sand which is several hundred feet thick and which has been cut into by the Meganos Gorge. Stratigraphic position would indicate that this shale is the Meganos Shale, but since it is cut by the Meganos Gorge (see Fig. 12), it must be an older formation than the Meganos Shale at Brentwood and Dutch Slough which overlies Meganos Gorge Fill. Though this unit may deserve definition and naming as a separate formation, it will be simply referred to as "Older Meganos" Shale in this paper. These relative relationships of the "Older Meganos" Shale, Meganos Shale, and Meganos Gorge Fill are shown in Figure 3.

ANDERSON SAND

The Guidebook to the Mount Diablo Monocline (AAPG-SEPM, 1950) correlated the Anderson Sand, a subsurface unit defined at Rio Vista, to Divisions A and B of the Meganos formation at the surface outcrop. Data from wells drilled since 1950 confirm the validity of this correlation. It is probable that the Wagenet Sand at Kirby Hills is also correlative to the Anderson Sand. Figure 13 shows present distribution and thickness of the Anderson Sand and its correlative equivalents, the Wagenet Sand and Divisions A and B of the Meganos formation.

The Anderson Sand is conformable to the underlying Martinez Shale and Sand (see Fig. 12). There is conclusive evidence that the Meganos Shale unconformably overlies the Anderson Sand, and a similar relationship between the Anderson Sand and the "Older Meganos" Shale is inferred from the few wells that have been drilled in T. 1 N., R. 1 E., west of Brentwood (see Fig. 12).

At the surface outcrop in T. 1 N., R. 1 E., the base of the Meganos Gorge Fill is sandy, and locally the uppermost portion of what has been called Division B of the Meganos formation is probably this sandy basal portion of the gorge fill. This would explain local indications that have been noted (Johnson, 1964, p. 26) of a facies relationship between Divisions B and C of the Meganos formation. Wells drilled closeby in the deeper portions of the gorge have encountered only about 100 feet of sand at the base of Meganos Gorge Fill, and a similar quantity is assumed to exist at the surface outcrop. It is therefore assumed that the great majority of Division B, as mapped, is pre-gorge in age and correlative to the Anderson Sand.

The Anderson Sand and its surface equivalent, Divisions A and B of the Meganos formation, are in no way related to the Meganos Gorge or Meganos Gorge Fill. Because the Meganos Gorge happens to cut into this formation at the surface, it is an attractive hypothesis to consider these sands as a gorge-fore deposit representing the material cut out and swept away by the gorge or as a sandy fore-facies of Meganos Gorge Fill. However, a careful examination of formational relationships and physical juxtaposition make such a hypothesis appear unlikely.

UPLIFT PRIOR TO EROSION OF GORGE

After deposition of the Anderson Sand but prior to deposition of the "Older Meganos" Shale there was considerable uplift in the Brentwood area, with the area of maximum uplift being southeast of the Brentwood field. Erosion of the uplifted sediments was followed by resubmergence and deposition of the "Older Meganos" Shale. Following this the Meganos Gorge was cut and filled.

There is evidence which suggests that the southern limit of the Sacramento Valley early Tertiary basin was not too many miles south of the surface outcrop on the north flank of Mount Diablo. It is unfortunate that the trend of the gorge eroded certain units from an area where they might have provided informative data on the geologic history of the early Tertiary in the Sacramento Valley.

PRODUCTION RELATED TO THE MEGANOS GORGE WEST OF THE MIDLAND FAULT

DUTCH SLOUGH GAS FIELD

The Meganos Gorge cuts across the south end of this field and the gorge fill shale has been a significant factor in providing the trap at the sount end of the field.

RIVER BREAK GAS FIELD

To date only two wells have been completed in this recently discovered field. Production from the Domengine Sand in the second well is certainly not affected by the gorge but deeper production appears to have been entrapped by shale in the Meganos Gorge Fill.

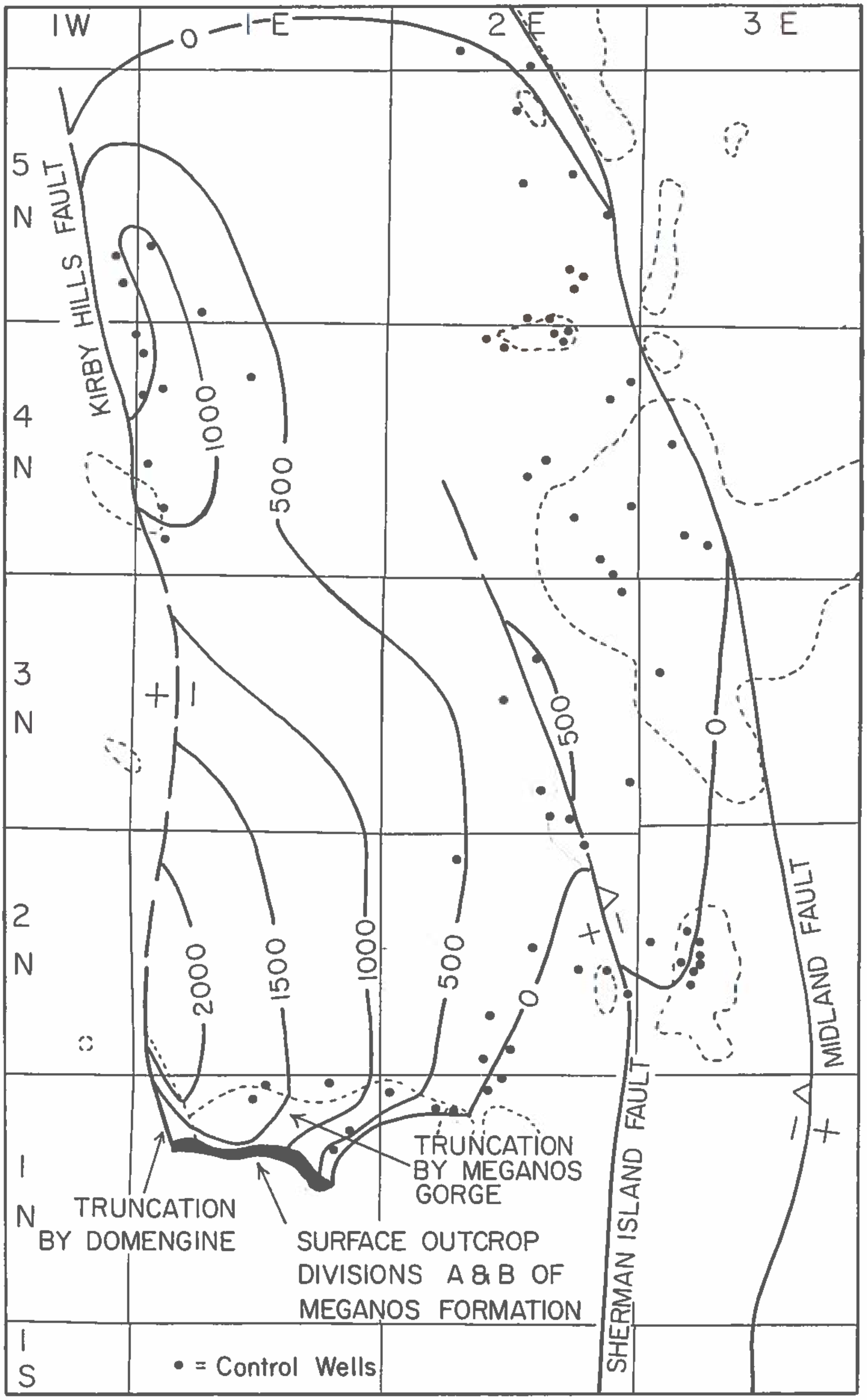


Fig. 13. Isopachs of Anderson Sand and its correlative equivalents.

BRENTWOOD FIELD

At Brentwood the Meganos Gorge is responsible for entrapment of all production. The gorge cuts across northerly dipping sediments along a broad nose and shale of the Meganos Gorge Fill provides the updip barrier on the south side of the field. Gas is trapped in the Anderson Sand (one well), sands within the Martinez Shale, and the three massive sands. Oil is produced from the three massive sands, the only significant oil production in the Sacramento Valley.

The Brentwood field presented an obvious exploratory prospect. The surface section contained a very thick shale (Meganos Gorge Fill) not present in wells to the north, and many sand units were absent at the surface that were present in wells to the north. Furthermore, this area was directly on trend with the gorge as it was known to exist at Walnut Grove and McDonald Island.

A GORGE AT MAINE PRAIRIE?

At Maine Prairie (T. 6 N., R 2 E.) there is a very rapid sand to shale facies change in the Uppermost Cretaceous sediments. Anatole Safonov considered both this and the Meganos Gorge at Walnut Grove and McDonald Island to be related facies phenomena (Safonov, 1962). The possibility that this facies change at Maine Prairie is also a gorge can not be totally dismissed but recent wells drilled at Liberty Island (T. 5 N., R. 3 E.) seem to clearly establish this as a facies change. Even if this were a gorge it could not be related to the Meganos Gorge because overlying Paleocene units which are older than the Meganos Gorge are not affected.

COMPARISON TO OTHER SUBMARINE CANYONS

The physical dimensions of the Meganos Gorge are comparable to those of the Markley Gorge and the Princeton Gorge, the two other major fossil submarine channels of the Sacramento Valley. The Meganos Gorge Fill is far more uniform than the fill of these other two gorges, which were undoubtably deposited under less stable conditions.

Profiles of present day submarine canyons are for the most part considerably more abrupt and irregular than that of the Meganos Gorge though a few (notably the Swatch off the Indus Delta of Pakistan and the Hudson submarine canyon) are generally comparable to the Meganos Gorge.

CONCLUSIONS

1. The Meganos Gorge is a large fossil channel that was rapidly cut and filled during lattermost Paleocene time.
2. Compared with normal gorge fill environment the Meganos Gorge Fill was deposited under unusually quiet and stable conditions.
3. The Meganos Gorge Fill is a factor of major importance in providing entrapment of gas and oil in several fields in the Sacramento Valley.
4. Relationships relative to the Meganos Gorge Fill show that the Meganos Shale at Dutch Slough and Brentwood, which overlies the Meganos Gorge Fill, is a younger unit that the "Older Meganos" Shale west of Brentwood, which is cut by the Meganos Gorge.
5. Sediments beneath the Capay Shale and above the H & T Shale east of the Midland Fault are predominantly Uppermost Cretaceous, and the prior erroneous designation of these sediments as "Meganos-Martinez undifferentiated" was made before existance of the Meganos Gorge was known and was based on paleontological determinations from wells which had penetrated shale of the Meganos Gorge Fill.
6. The Anderson Sand is correlative to the Wagenet Sand at Kirby Hills and Divisions A and B of the Meganos formation at the surface outcrop on the north flank of Mount Diablo.
7. The Paleocene-Cretaceous contact is at the base of the shale which separates the First and Second Massive Sands, at which horizon a major unconformity is observed west of Brentwood.

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CALIFORNIA BLUE SKY LAWS AND THE GEOLOGIST[1]

By Walter L. Rowse[2]

INTRODUCTION

The title of this article, which is based upon the author's recent talk to the San Joaquin Geological Society, is intentionally paradoxical. By definition the work of the geologist would seem to involve little or none of the blue sky, historically the province of astronomers, astronauts, aeronauts and angels.

Strangely enough, however, "blue sky laws" have been enacted for and directed to areas of work and activities in which petroleum and mining geologists find themselves daily engaged. Accordingly, a discussion of these enactments should be of substantially greater interest to professional geologists than to persons whose work, sacred or mundane, occurs within or is directed toward the heavens. "Blue sky laws," as many readers of this article will recognize, is but a synonym, nickname, or generic term for that particular group of statutes enacted by the Federal Government and by most states regulating the issuance and sale of securities. More formally and precisely these laws are known as "Corporate Securities Laws" and "Securities Acts." Their purpose, as one California court has succinctly stated, is "to protect the unwitting investor against his own folly in purchasing securities which are unsound or speculative in nature."

These laws were early categorized by irreverent reporters as "blue sky laws" because they were designed to retard uninhibited promoters of nebulous ventures in too often successful attempts to sell "a piece of the blue sky" to the proverbial widows and orphans whose inheritances and avarice exceeded their acumen.

To the petroleum geologist beginning his career, perhaps as low man on the totem pole of a large major oil company, the likelihood of involvement in the sale and issuance of securities, other than eventually as a wealthy investor in A. T. & T., Tel-Star and, of course, the gilded certificates of his own company, seems too remote to contemplate.

To the contrary, however, it is a certainty that at some time in his career, and perhaps frequently, as he progresses up the totem, he will hear mention of the term "Corporation Commissioner's Permit" in discussions of transactions in which he is engaged either as an advisor or as a principal.

To the mature geologist, petroleum or hard rock, corporate captive, or rugged individualistic independent consultuant, initial contact with securities laws may have been a belated, shocking and almost traumatic discovery that a presumably completed transaction should have first received the blessing of the Government Regulator. More likely and less disturbing, however, is the probability that contact with securities laws will be in the form of advice that a drilling date must be postponed, or that the form of a transaction re-shaped in order that required compliance with securities laws may be effected before drilling money will be available.

PURPOSE

It is, therefore, the purpose of this article to introduce the working petroleum geologist to the existence and nature of securities laws as they apply to transactions in which he frequently participates in the course of his every day professional activities. It is hoped that this article will demonstrate the necessity and importance of compliance with these significant statutues, and that it will impress upon the geologist the requirement of competent legal advice in all matters in which corporate securities laws could possibly have application.

No more than the family doctor is competent to or would write a handy home manual on "Brain Surgery Self Taught" would this author attempt to submit a "do it yourself course" in the recognition of and compliance with securities laws. The discourse which follows most certainly is not so intended.

Notwithstanding the following discussion of a general test for applicability of securities laws, each deal and transaction must be analyzed separately and individually by competent counsel. If a securities regulation problem is involved, compliance with laws must be individually designed by the attorney to fit the circumstances of the particular situation. Because the penalties for failure to comply with the securities laws, or faulty compliance therewith can be severe and range from substantial pecuniary loss and civil liability to criminal conviction, fine and imprisonment, it is imperative to apply the relatively inexpensive ounce of legal prevention, thus avoiding the costly and sometimes unavailable, pound of legal cure.

HISTORICAL BACKGROUND

Statutes regulating in some manner the issuance and sale of securities were enacted in England as early as 1285 and in the United States prior to the Civil War. Before the enactment of specific statutes, laws and decisions relating to theft, fraud, confidence games and the like imposed civil liabilities and criminal penalties upon the most blatant gyps and greedy connivers.

The blue sky laws of a substantial number of states antedated by more than a decade the enactment of Federal legislation in this field, but the greatest impetus for intensive regulation of securities in this country was provided by the 1929 stock market crash and the subsequent public discolsure of rapacious practices of unscrupulous promoters and dealers and traders in securities unearthed by Congressional investigations following. These investigations led to the enactment by the United States' Congress of the Securities Act of 1933 and also to the adoption of drastic revision of their own securities laws by most of the states. Cali-

1. Part one of two parts presented to the San Joaquin Geological Society March 9, 1965.

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fornia's present laws regulating securities stem principally from the Corporate Securities Act first codified in 1917.

Following enactment of the Federal Securities Act of 1933 Congress also adopted the Securities Exchange Act of 1934 regulating securities exchanges, over the counter markets, and persons and companies using these media for distribution, and marketing of securities; the Holding Company Act of 1935 regulating public utility holding companies; and the Investment Company Act of 1940 regulating mutual funds and other companies which invest, re-invest or trade in securities. Other Federal statutes have tangential relationship to securities regulation but the relationship is sufficiently remote to justify the avoidance of any mention of them in this discussion.

FEDERAL REGULATION

The Federal laws regulating securities and the myriad of state laws also regulating securities transactions vary widely in their respective details. It is possible and not too difficult to commit a felony in one state by consummating a transaction which if negotiated and consummated at the other end of the same room but in the adjoining state would have been entirely lawful and devoid of unfavorable legal consequences, either civil or criminal. It is for this reason, among others, that counsel must examine each oil and gas transaction for the possible application of Federal regulations or the requirements of blue sky laws of states other than that in which the physical property is located.

Although the laws vary in detail they are sometimes classified as falling into three primary categories: Anti-fraud acts, which essentially only prohibit fraudulent transactions in securities; registration or disclosure acts. which, in essence, require the furnishing to the public regulatory body of substantial information concerning the nature of the transaction, the parties, the purpose, etc., and "permit" acts which, in addition to requiring complete disclosure, also require the obtaining of a permit from the regulatory body or officer prior to issue of sale of the security. These classifications are not, however, mutually exclusive and it is most likely that a "permit act," in addition to its requirements of disclosure and permit, will expressly prohibit fraudulent transactions. Similarly, "disclosure" acts may contain some of the attributes of each of the other categories.

Notwithstanding the different categories mentioned above, most of the state blue sky laws and the Federal Securities Acts are constructed upon a common framework, i.e., definition of securities, definition of sale or issuance, requirement of filing of substantial information, requirement for securing from the regulatory body or Governmental authority of a permit, approval or release; prohibition of issuance or sale of securities where compliance with the other requirements has not first been effected; civil liability and/or criminal penalty for violation; and exemption of certain types of securities and transactions from the scope of the act.

The Securities Act of 1933 is the basic Federal law regulating the sale and issuance of securities. It is generally regarded as a "disclosure" type act, although it has many attributes of a "permit" type law, and expressly prohibits fraudulent transactions in securities. Section 5 of the act prohibits any person from making use of any means of transportation in interstate commerce or means of communication in interstate commerce, or the mails, to sell any security unless a registration statement for the security is in effect, and renders it unlawful for a person to carry or cause to be transported through the mails, or in interstate commerce, any such security for the purpose of sale or delivery after sale.

This law, as well as the other Federal Securities laws enumerated above, are administered by the Securities and Exchange Commission. The more than twenty-six sections of the "Securities Act" and the many regulations promulgated by the Commission in furtherance of the Act follow, in general, the structural pattern for all securities regulations outlined above.

The Securities Exchange Act of 1934, while seemingly focused upon securities exchanges, actually is quite broad in its scope. Until recently its thrust was primarily directed against Security Exchanges, brokers and securities salesmen, and corporations, their officers, directors and controlling persons, whose securities are listed upon and traded through stock exchanges. Effective as of July 1964 the Act was amended to include within its regulatory scope "over-the-counter" securities markets and traders and to require companies whose securities were traded "over-the-counter" to file with the Commission information. reports and proxy statements similar to those required with respect to securities listed on an exchange.

We will not in this discussion dwell further on Federal securities laws except to emphasize that the Federal Laws apply directly to some types of oil and gas transactions in which the professional geologist may be an active participant and to reiterate that every oil and gas transaction or deal contemplating the use of funds other than the personal funds of the operator should be checked for the possible application of Federal securities law, as well as the various state regulations.

It is doubtful that even passing reference would heretofore have been made in an article of this nature to the Securities Exchange Act of 1934. However the recent widely publicized litigation instituted by the Securities and Exchange Commission against the Texas Gulf Sulphur Corporation and certain of its officers, directors and employees would seem to require a warning to geologists, as well as to officers and directors of companies, that the scope of the "insider trading" regulations and the prohibitions against the use of manipulative devices in trading in securities contained in the "Exchange Act" may be much broader than heretofore commonly supposed. It may well be that company employees and consultants as well, are far more limited in their use of information respecting a property or its potential value as a basis for trading in their own or other company stock than heretofore conceived. It should be emphasized that the Commission's allegations and charges in the Texas Gulf Sulpher Corporation complaint are by no means admitted by the company or the other defendants and, of course, remain to be proved by the Commission. The implications and ramifications inherent in the Commission's complaint should be carefully pondered by all corporate personnel and individuals actively engaged in exploration for or development of mineral resources and could profitably be the subject of a separate discussion or paper, or series thereof.

As heretofore stated, however, no further space in this article will be devoted to Federal securities laws—not because they are not important—they are; not because they do not apply to oil and gas transactions—they certainly do; not because they do not apply to individual geological employees and consultants—they do; but because after a transaction is tested to determine whether or not Federal laws apply, it is quite probable that every day transactions of the nature which we will discuss will fall within an exemption under the Federal laws, but will nevertheless, be subject to the laws of the State of California. A final warning might be appropriate! Do not be lulled into a false sense of security by the requirement that transportation or communication in interstate commerce must be present in a particular transaction before Federal law applies. We are all now sufficiently sophisticated to recognize and appreciate the scope and elasticity of this jurisdictional requirement as construed and repeatedly enlarged by the United States Supreme Court.

THE CALIFORNIA CORPORATE SECURITIES LAW

The California state law regulating the issuance and sale of securities is found in Division 1 of Title 4 of the California Corporations Code and is now known as the "Corporate Securities Law." It is administered by the Commissioner of Corporations, who is the chief officer of the Division of Corporations of the State Government. He is appointed by and serves at the pleasure of the Governor. He has, of course, a large staff of deputy commissioners and supporting personnel to carry out the functions of his department and maintains offices in Sacramento, San Francisco, Los Angeles and San Diego.

THE LAW

The gist of this act and its chief commandment seem simple enough:

> "S 25500. *Permit For Sale of Securities of Company's Own Issue; . . . No company* shall *sell* any *security* of *its own issue* (except upon a sale for a delinquent assessment against the security made in accordance with the laws of this State), *or offer for sale, negotiate* for the sale of, *or take subscriptions for any such security, until it has first applied for and secured from the Commissioner a permit authorizing it so to do . . .*" (Italics added.)

This statement is so simple that only 100 additional sections of the law and 320 related sections of the California Administrative Code, together with Appellate Court decisions and opinions in substantial number are devoted to explaining the meaning of the law and how it is to be administered.

In years past California was, and probably without the Securities Act, both Federal and State, would still be the happy hunting ground of every hustler, promoter, and con man in the business. The reasons are, upon a little reflection, too apparent to justify our dwelling on them. Perhaps the late Frank Lloyd Wright tied them all up in a neat bundle when he allegedly said that if the United States were tilted sideways everything loose would fall into Los Angeles.

The oil business, or as it was more often and perhaps rightly called in its earlier days, the "oil game," has always attracted a disproportionate number of questionable promoters and downright hustlers. The requirements for large sums of money, the great risks involved, and, formerly, and hopefully today, the rich rewards for success have likewise attracted the attention, envy, and too often, the resources of persons unequipped to understand the business, unable to resist the lure, and often unprepared or unwilling to face the consequences of failure. And, of course, California has long been a leading oil producing state.

It necessarily follows that California has had much experience with all kinds of oil promotions—from those where the promoter's sole interest is in using the promise of quick wealth to get gullible investors to part with their money with no intention of actually using the money to find oil, to those varying gradations of legitimate risk sharing arrangements where all or most of the investor's money goes into drilling or development, along with some or a like share of the promoter's.

The impetus given in recent years to speculation in oil and gas ventures by the combination of the confiscatory rates and the wholly legitimate percentage depletion and intangible write-off provisions of the Federal Income Tax Laws has also resulted in a proliferation of plans, schemes and deals—some fair and legitimate, some almost ludicrous. It is not surprising, therefore, to find that the California Corporate Securities Law has by design and application had a great impact upon ordinary oil and gas transactions.

THE PENALTIES

Since we have now seen what, in general, is prohibited, it might be interesting before we venture into details to determine what the consequences of disregarding these prohibitions might be.

CIVIL PENALTY

Section 26100 of the law says:

> "Every security of its own issue sold or issued by any company without a permit of the Commissioner then in effect authorizing the issuance or sale of the security *is void*. Every security of its own issue sold or issued by a company with the authorization of the Commissioner but which has been sold or issued in nonconformity with any provision in the permit authorizing the issuance or sale of the security *is void*." (Italics added.)

This does not sound particularly disastrous does it? "Void" means no good—out! What of that? The venture in all probability will result in a dry hole and the whole business will probably be over and done with so why bother with further compliance of this Act? What can we lose? Here's what: The courts have said that "void" does not exactly mean "void, over or out." They have said that because all of the prohibitions of the Act are against the seller of the security, the deal is valid and in force unless the *purchaser* elects to treat it as void. In other words, the transaction is "voidable" at the purchaser's option. In the absence of a good (but rare) defense on the part of the seller the purchaser alone can elect to treat the deal as firm and in force. If, however, he has not yet paid his money the purchaser can elect to walk away from the deal scot free, or if he has paid his money he can sue to get it back. In other words, he gets a free ride. Well, as the horse bettors say "It's not your life, it's not your wife, it's only your money." If the civil liabilities created by the foregoing provision were the only penalty involved it would be only your money that was at stake.

CRIMINAL PENALTIES

Consider, however, the provision of Section 26103 of the Act which says:

> "Every *company* which directly or indirectly offers for sale, or negotiates for the sale of, or sells, or issues, or causes to be issued any security contrary to the provisions of this division, or of the Constitution of this State, or in nonconformity with a permit of the Commissioner authorizing it so to do, or which applies the proceeds from the sale of any security, or any part of such proceeds, to any purpose other than a purpose specified in the permit in excess of any amount limited in the permit to be used for that purpose, is guilty of a public offense punishable by a fine not exceeding ten thousand dollars ($10,000)." (Added Stats. 1949, c. 384, p. 721, S 1.) (Italics added.)

Consider further and perhaps more importantly the impact of the provisions of Section 26104 of the law which subjects every officer, agent or employee of any company and every other person who does any of the following acts to criminal penalties involving a fine not exceeding $5,000, imprisonment in the State prison not exceeding five years, or in a County jail not exceeding one year, or both fine and imprisonment:

(a) Knowingly authorizes, directs or aids in the issue or sale, or executes or sells any security in nonconformity with a permit of the Commissioner then in effect or contrary to the provisions of the Corporate Securities Law or the State Constitution.

(b) Makes a false statement to the Commissioner in respect to any application or proceeding, examination, audit or investigation respecting a company, its properties, officers or affairs, or sells or causes to be sold or issued any security with knowledge of the falsity of any such statement.

(c) Applies the proceeds of a security in violation of the terms of a permit.

(d) With knowledge that a security has been issued or executed in violation of a provision of the law sells or offers that security for sale.

(e) Makes or publishes statements concerning a security which is false or misleading with knowledge that the statement is false, misleading or deceptive.

(f) Wilfully violates or fails to comply with any provision of the law or with any order or permit of the Commissioner or conspires with one or more persons to violate any permit or order issued by the Commissioner or any provision of the law.

It is here emphasized that the foregoing recital of the provisions of Section 26104 is in summary form and that the thrust and scope of the detailed language of this section is considerably broader than that which can be conveyed in a summary. Accordingly, the foregoing summarization is exemplary only and should not be deemed to be a definitive or exclusive recital of all of the provisions of the section.

INTERPRETATION OF THE LAW—DEFINITIONS

We have now had a good look at the dragon's teeth and they appear sharp and menacing. If this law applies, or could apply, to every day oil transactions in which the geologist is involved it would surely seem that there is good reason for a better understanding of the philosophy and nature of the law.

A review of the principal commandment of the Act is in order:

> 25500 "No *company* shall *sell* any *security* of its *own issue* . . . or negotiate for the sale of . . . until it has . . . secured from the Commissioner a permit . . ."

No one with the education and perspicacity of the professional geologist would be so naive as to take any comfort from the fact that, literally, the quoted portion of the law prohibits only a *company* from *selling* a security. Thus the statutory definitions of these two terms will neither surprise nor shock him:

> S 25003. Company. "Company" includes all of the following:
>
> (a) "All domestic and foreign private corporations, associations, syndicates, joint stock companies, and partnerships of every kind.
>
> (b) Trustees as defined in Section 25004.
>
> (c) *Individuals* selling, offering for sale, negotiating for the sale of, or taking subscriptions for, any security of their own issue.

and

> S 25009. Sale; sell. (a) 'Sale' or 'sell' includes every disposition or attempt to dispose, of a security or interest in a security for value.
> 'Sale' or 'sell' includes all of the following, whether done indirectly or by an agent, circular letter, advertisement, or otherwise. An *offer to sell*; an *attempt to sell*; a *solicitation of a sale*; an *option of sale*; a *contract of sale*; a *taking of a subscription*; . . ."

We may now re-state our commandment in more personal terms to read as follows:

> "No individual shall offer, attempt, contract, solicit or give an option to dispose of a security of his own issue for anything of value, including money, property, or services until a permit has been obtained."

With the law thus re-stated it is readily apparent that if the deal involves a "security" the requirement that a permit be first obtained almost surely applies, whether companies or individuals are involved, so long as something more than a gift or inheritance is the motive for the transaction.

At last we have been led to the heart of the problem. Insofar as our oil and gas transactions are concerned, what is a security? If our deal does not involve a security never mind the Corporate Securities Laws of California.

Your natural acumen must indicate to you that common oil deals could very likely involve the issuance of a security—else this article would never have been written.

Hopefully, we turn again to the law for a defenition:

S 25008. Security. "Security" includes all of the following:

(a) "Any stock, including treasury stock; any certificate of interest or participation; *any certificate of interest in a profit-sharing agreement; any certificate of interest in an oil, gas or mining title or lease*; share, investment contract or beneficial interest in title to property, profits or earnings.

(b) Any bond; any debenture; any collateral trust certificate; any note; any evidence of indebtedness, whether interest-bearing or not.

(c) Any guarantee of a security.

(d) Any certificate of deposit for a security."

Again re-phrasing the law in light of pertinent definitions it might now, for our purposes, read as follows:

"No individual shall dispose of any certificate of interest or participation; any certificate of interest in a profit sharing agreement; any certificate of interest in an oil, gas or mining title . . . or any beneficial interest in title to property, profits or earnings . . ."

Security laws have sometimes been called "shot gun laws" because of the large pattern covered by their definitions of "company," "sale" and "security," but, as re-stated above, the California Securities Law viewed from the position of the oil and gas operator could well be described as a Weatherby .460 Magnum with a 10X scope loaded and zeroed in on every one of our common oil and gas transactions.

TYPICAL "OIL DEALS" AND THE CORPORATE SECURITIES LAW

This discussion might very well end at this point. All that the oil man really needs to know about the Corporate Securities Laws has been said. The information hereinabove set forth should be sufficient to alert every person involved in an oil and gas transaction of the extreme likelihood that his deal will be subject to the Corporate Securities Law and should cause him to pick up the phone and immediately contact his legal advisor.

Nevertheless, this article will continue at some length to examine the various common oil and gas transactions in the light of the law as re-stated. This further examination is not intended (and is not sufficient) to educate the reader to a point where, without professional assistance, he can recognize all of the oil and gas situations on which this law may have a bearing, nor is it intended to provide a working knowledge of the mechanics of obtaining the necessary permit. Rather, it is hoped that the further discussion will demonstrate the desirability of an early contact with legal counsel and of the necessity for the fullest and most detailed disclosure to him of all information known, assumed or suspected concerning the physical and economic aspects, purposes and effects of the transaction, the parties thereto, their finances, experience and background in oil and gas deals, as well as the time requirements involved. Armed with this information counsel will be in a better position not only to determine whether a permit is required, but also what type of permit should best be obtained. If it should appear that time and other factors render the obtaining of a permit impossible or unfeasible the parties then, with counsel, may be able to find an alternative means of achieving to some extent the desired results in a lawful manner but without a permit.

The definition of "security" repeatedly refers to "certificate." Apparently no one yet has seriously argued that the security must necessarily consist of an engraved parchment or other document containing words such as "I certify" or the like. Certainly a deed of realty or a bill of sale of personal property disposes of a "beneficial interest in title to property," while a deed to oil and gas rights, an assignment of an oil and gas lease, a royalty deed or the oil lease itself evidence an "interest in an oil, gas or mining title or lease."

We know that literally hundreds of transactions which seem to fall within the bounds of the definition of security are consummated daily by thousands of persons in this state. Can it be that a permit from the Commissioner is obtained for all of these transactions, or are a large number of our fellow citizens scofflaws? Is enforcement of the Corporate Securities Act as ineffectual and unpopular as was the enforcement of the Volstead Act of the roaring 20's? Is there no "Elliott Ness" on the Commissioner's staff? If most of the foregoing questions are answered in the negative, then there must be something more to the definition of "security" than appears in our quoted portions of the law. How, then, can one tell whether an instrument, transaction or deal is really a security and subject to the Corporate Securities Law?

One way might be to ask the Commissioner. The problem in this approach is that in addition to the time and trouble involved, the Commissioner must necessarily protect his position and take the broadest view of the law lest later he become ensnared by an earlier too narrow opinion, or lest he, for lack of complete information, mislead the questioner. There seems the unspoken ground rule to the effect that if you think you have to ask, the transaction probably involves a security.

Mr. Asa Harshbarger, formerly and for many years a Deputy Commissioner of Corporations and an intelligent and informed watch dog over oil and gas matter in that office, in an address before the Los Angeles Oil and Gas Bar some years ago, said "How can one tell whether or not a transaction is subject to the Corporate Securities Law? If, in the beginning Mr. A has a dollar and Mr. B has a deal, and in the end, after all the action, of whatever sort, has taken place, Mr. A's dollar is now in the deal or in Mr. B's possession, and Mr. A has an interest in the deal, then, in all probability the transaction comes under the Corporate Securities Law."

Obviously, this answer, while perhaps amusing, is too broad to be enlightening. Fortunately, however, a California appellate court more than 30 years ago developed a test which has since been applied in many cases respecting the application of the Securities Act and which is most helpful in determining whether or not a particular instrument or transaction is a security. This test, as it has evolved, is succinctly summarized in the following quotation from a 1962 California Securities Law case respecting an oil and gas transaction:

"The Corporate Securities Law does not contain an all inclusive formula by which to test the facts in every case. And the courts have refrained from attempting to formulate such a test. Whether a particular instrument is to be considered a security within the meaning of the statute is a question to be determined in each case. The courts have held that not all deeds to proven or prospective oil land are securities and that, looking through form to substance, *the test is whether the buyer receives a right to share in the profits or proceeds of a business enterprise to be conducted by others, or whether the buyer expects to reap a profit from his own services or other active participation in a business venture.*" (Italics added.)

There are a number of ways of classifying property interests or beneficial interests in oil, gas and mining titles and leases, depending upon the purpose for which the classifications are made. Geologists are probably most familiar with interests classified as "working interests" and "royalty interests." For the purpose of examination in the light of the Corporate Securities Law this classification is not sufficiently detailed. A more complete and orderly division of oil and gas interests and a logical and progressive analysis of the divisions would begin with the basic interest and progress to the more complex, and most commentators writings on the subject have elected to so base their analyses.

TRANSACTIONS IN LANDOWNER'S INTERESTS FEE SIMPLE

Accordingly, beginning with the landowner's interest we will first consider whether or not the sale, disposition or transfer, by grant deed or other means, of the landowner's entire interest in all of his land, surface and minerals, would constitute a security. Under the test promulgated by the courts as summarized above, in the vast majority of such transfers there is neither the purpose nor intent that the person to whom such interest is transferred will receive a share of the profits or proceeds of a business enterprise to be conducted by another. The buyer's intent is most probably to profit by utilizing the property by occupying the property and through his own efforts increasing the value thereof or the production therefrom. Admittedly, much land is bought on speculation with the purchaser planning to do nothing more than hold it until development in general in the area increases the value. Such speculative purpose, however, is not normally considered the equivalent of a right to share in the profits or proceeds of a business enterprise to be conducted by others. It takes, however, only a minimum of imagination to develop a situation in which a sale by grant deed of a landowner's entire interest in his land might well run afoul of the Corporate Securities Law. If, for example, the parcel of land sold was sold with representation that an oil well would be commenced on off-setting land, and if under the circumstances it was clearly evident that the land had no foreseeable value for use other than oil wildcatting, and if the price paid were so disproportionate to the value of the land absent the certainty of an offset well being drilled, a court might find that the purpose of the transaction was to give the buyer the right to share directly in the profits or proceeds of the business enterprise, i.e., oil production if the promised wildcat discovered commercial production. If the seller of the parcel was also actively involved in the drilling or promotion of the wildcat the likelihood of this transaction, herein considered a security, would be sharply increased.

In a 1945 criminal prosecution, (People v. Chait, 69 CA 2nd 503) the acts of the defendants, upon which charges of grand theft, violation of the Corporate Securities Act and conspiracy to defraud were based consisted of the sale to various individuals of fractional lots of land upon the representation that they were proven oil lands, located in proven oil districts or that negotiations were pending by which major oil companies would lease the lots and the purchasers would thus receive large bonuses, or royalties and a comfortable income. The activities were conducted over a five year period, from 1938 through 1943. The case report indicates a deliberate and carefully conceived typical confidence game. In attacking their convictions for violating the Corporate Securities Law, certain defendants argued that they merely made single sales (in each transaction) of the fee title to land, which were not sales of "securities" in the contemplation of the Act. The court, in upholding the convictions, said that the evidence was undisputed that the lands were not sold as farming or grazing land but as a speculative interest in a promised "dividend" from pending leases on "proven oil land."

In a 1955 California civil case the plaintiff, asserting that she was alone, 75 years old and practically blind, claimed that the defendant, by false representation that certain lands were valuable oil lands, sold her parcels of land or interests therein and conveyed these parcels or interests to her by grant deeds. She alleged that these grant deeds were, therefore, "certificates of interest" within the meaning of the Corporate Securities Act, and alleged further that defendant knew she was unable herself to prospect these parcels, and that defendant had represented that in the future she would profit by leasing her land to the defendant oil corporation, or to some other oil company.

The defendants contended that fee simple transfers of interests in real estate did not come within the purview of the Corporate Securities Act. The court, citing prior decisions held that a deed to real property could be a "security" and inferred that if plaintiff's charges were ultimately proved, a violation of the securities act would have occurred.

In a 1938 California criminal prosecution (People v. Yant, 26 CA 2nd, 725) the defendant, Mr. Yant, subdivided about 400 acres of land, in what later became the notorious (and productive) Placerita Canyon—"Confusion Hill" oilfield. He divided the land into numerous smaller plots and issued and sold grant deeds conveying full title to the parcels, including the minerals and the oil and gas rights in the parcels. Apparently representations that these parcels were potential oil lands were also made. The parcels varied in size from more than 1 acre to as little as 7/1000ths of an acre. As part of the transaction the purchaser was requested to commit his parcel to a community oil and gas lease and thus share in the royalties if production were obtained. Presumably as the result of the complaints of some of the purchasers who felt that they may have been defrauded and, of course, long before the Placerita discovery well was drilled, Mr. Yant and his associates were prosecuted and convicted of a violation of the Corporate Securities Act. The court concluded that the transaction, viewed as a whole, indicated clearly that the purchasers were led to believe that they would profit from oil and gas development in the area to be conducted by others than themsleves and that, accordingly, and notwithstanding the fact that the conveyances were inform deeds to real property, they also constituted securities within the purview of the law.

Landowners frequently sell undivided fractional interests in land to others for a variety of reasons. Many of such transactions do not involve a corporate securities problem. There is no reason, however, why a sale of an undivided interest in realty could not also constitute the issuance and sale of a security under an appropriate set of circumstances.

Consider the activities of one overly ingenious "promoter." According to the report (People v. Daniels 1938, 25 CA 2nd 64) Mr. Daniels paid $500.00 an acre for land in the N/2 of the NW/4 of Section 22, Township 21 South, Range 17 East, M.D.B. & M., in an area known as "Kettleman Oil Acres." With what was considered at the time an inordinate amount of "puffing," including representation that purchasers would receive royalty of from $35 to $40 per month for each unit purchased, he sold units of 1/100ths of one-fourth of an acre for $32.50, which the court concluded would have resulted in a total of $13,000 for the acre—a profit of $12,500. It should be remembered that in those depression days such a profit from 1 acre of "wild unimproved land," as the court described the parcel, was considered substantial and almost prima facie evidence of some kind of flim-flam. Mr. Daniels conveyed these "units" by grant deeds of the undivided interests. To his argument that these grant deeds to real property could not constitute "certificates of interest" in an oil, gas or mining title, although they carried with them the right to explore for, drill and produce oil. or join with others in the conduct of such venture, the court replied that the amount of the unit interest was so infinitesimal as to exclude any other possibility than that the intent of the seller and the "investors" or purchasers was to sell or purchase interests in possible oil production operations, which necessarily would have to be conducted by a lessee of enough of the land and other lands to warrant the expense. The court said ". . . what in fact is a grant deed is also, in substance and effect a 'certificate of interest in an oil, gas or mining title' within the evident intent and purpose of the Corporate Securities Act."

We have thus far examined cases where sellers sold and conveyed by "Grant Deed" title to the entire landowner's interest (surface and minerals), as did Yant, in separate parcels of land and in undivided fractional interests in parcels of land (as did Daniels) were found to have issued certificates of interest in oil, gas and mining titles in violation of the Corporate Securities Law.

MINERAL INTERESTS

Petroleum geologists all are familiar with so called "Mineral Deeds" by which a landowner may sell all, or fractional interests in the oil, gas or mineral rights in his land, keeping for himself the right to use his land for all other purposes, but granting, either expressly or by implication, the right to the mineral interest purchaser to enter upon the land and explore for and produce the oil, etc. Sometimes the size of the parcel of mineral rights sold, or the percentage sold, is large enough for the purchaser himself to undertake the exploitation of the minerals, and sometimes such is the intent of the parties. The situation, as exemplified by the activities of a group of San Diego individuals and companies, as reported in the 1937 case of *People v. Jackson* (24 CA 2nd 180) is more familiar to the petroleum geologist. Here, under a not too complicated scheme, the defendants, by instruments entitled "Mineral Deed" sold undivided fractional interests varying in size from an undivided one-half interest to an "undivided" 20/1280ths in oil, gas and other minerals in, under and which might be produced from the described parcels of land. These deeds, covering lands in Oklahoma and Texas, expressly gave to the grantee (purchaser) the right of ingress and egress for the purpose of mining, drilling and operating the lands for oil, gas and other minerals. At the time the mineral deeds were issued the lands were already subject to existing oil and gas leases. Apparently a substantial number of persons were induced to pay good hard depression dollars, or exchange blue chip investments for these mineral deeds upon representation that they would receive a substantial monthly lifetime income. Needless to say, such income as may have been originally received from the purchaser interests dropped sharply and soon ceased. Criminal prosecution and conviction followed.

The appellate court, writing its opinion before the cases of Yant and Daniels had been decided, recognized that a landowner could divest himself of his entire interest, or part of his interest, in whatever minerals lie beneath the sufrace of his parcel and found no inherent vice in such a transaction. The court also found however little difficulty in logically concluding that although the instruments of sale were entitled "Mineral Deeds" and were in fact transfers of interest in real property, they were also, for the purposes of the law, "certificates of interest in oil, gas and mining title." The court stated that the right expressed in the deed of ingress and egress for mining, drilling and developing was, because of the very small size of the fractional interest, not in fact a substantial right, but only a formal right which the purchasers never expected to utilize.

Because the transactions, as viewed by the court, appeared to be intended solely to convey to the purchasers a right to a share of income from oil operations which, if conducted, must be conducted by someone other than the purchasers, the court sustained the conviction of the sellers.

In 1938 one Mr. Stella was the owner of the mineral rights in 1500 acres in Tehama County, California, and 5,700 acres in Glenn County, California. The Tehama County land had been subdivided into 2½ acre parcels, and the Glenn County land into 1 acre parcels. The court's opinion, in the civil case of *Moore v. Stella* (1942 53 CA 2nd 166), refers to the land as being located in unproven territory, but further recites that there was a producing gas well controlled by Stella in the vicinity and that Stella was financing the drilling of a well in the area. Mr. Stella offered his mineral rights in the parcels for sale to the public and apparently conveyed them to the purchasers by mineral deeds in the 2½ acre units. Mrs. Moore of Los Angeles bought the mineral rights in the 2½ acre parcel described as the NE/4 NE/4 SE/4 NE/4 of Section 24, Township 23 North, Range 4 West. Stella executed an assignment of the parcel to Mrs. Moore. Mrs.

Moore also paid for other parcels, but apparently no additional conveyances were made.

Apparently Mrs. Moore became dissatisfied with her deal and not too long after the transaction was consummated brought suit to recover the moneys she had paid, alleging, among other things, that the transfers of mineral rights constituted securities within the meaning of the Corporate Securities Act and were issued without a permit.

Notwithstanding the facts that the mineral rights sold by Stella were not under lease to anyone, the parcels were of a legal drill site size under California law and no "lease back" arrangement was involved, the appellate court sustained the finding in the trial court that Stella had issued and sold securities without the necessary permit.

The appellate court said that whether the transaction were clean cut transfers of interest in real estate to be held, used or sold by the grantees (purchasers) without participation with others in a profit sharing venture, or whether, while they were conveyances of definite interests in real property, they were intended by both the seller and the buyer to transfer rights to participate in earnings or profits in the nature of landowner's oil royalties that might inure to the benefit of numerous lessors under community leases was a question of fact for the trial court. The appellate court, after reviewing the evidence, concluded that the trial court's finding that a security had been issued without a permit was based on sufficient evidence that the purchasers never intended to drill their own wells and that Stella never assumed that the purchasers would do so. Mr. Stella was ordered to return the purchase price and to pay costs of suit. Mrs. Moore was directed to re-convey the mineral rights. In this case as in numerous past and future decisions, the court purported to look through form to determine the substance of the transaction in applying the test of participation in the profits of a business to be conducted by others.

THE LEASE

By far the most common transaction engaged in between landowners and oil men with respect to oil and gas rights is the making of the oil and gas lease. The lease is the working tool by which oil and gas operators acquire rights to drill for and produce oil and gas in most of the producing or prospective oil and gas lands in the United States and Canada. The nature of the lease, imposing on the lessee, as it commonly does, express and implied obligations to drill and develop, and to pay rent and royalty, seems to negate any objective in the transaction that the lessee, who is buying the lease from the landowner, intends to profit from anyone else's efforts but his own. At least, customarily as between the landowner-lessor and the operator-lessee, it is the apparent intention that the lessee will undertake the development of the property or surrender the lease. That in fact the man leasing the property from the landowner may have no such intent, but is leasing as an undisclosed agent for a third party, or is taking the lease as a speculation, or as "protection acreage" is not normally known to the lessor and the landowner certainly is not the moving party in such a plan.

Accordingly, although a lease surely transfers an interest in an oil and gas title, it is not of itself regarded as a security within the purview of the Corporate Securities Law.

It should not be assumed, however, that under a particular set of circumstances a court might not find a leasing transaction to be also the issuance of a security. Suppose, for example, a promoter owning a tract of land offered, for an attractive price, to lease to the public many small parcels, each too small for practical individual development, with the offer or intimation that he or others would develop the parcels under a pooling or unitization arrangement by which the individual lessees would do not more than receive their net shares of the purchase price of the oil allocated to their parcels under the pooling agreement. Depending to some extent upon the degree of sophistication of the "lessees" and other facts surrounding the transaction, a court should have no trouble, after applying our now familiar test, in finding that the leases were in fact also securities.

LANDOWNER'S ROYALTY

There remains for examination one further and common type of transaction involving the landowner's interest in his oil and gas rights. After the landowner has leased his land for oil and gas development, and while the lease is in force, his principal interest or estate in the oil and gas in, or which may be produced from his land, is his right to receive, either in kind or in cash, as the case may be, his "reserved" share of the substances produced from his land by the lessee. This is customarily a fractional one-eighth or one-sixth and is often referred to as "landowner's royalty." (In addition to describing the lessor's reserved, expense free, non-working fractional interest in the landowner's leased land, which normally endures only so long as the apposite lease is in force, and which is more exactly called "lessor's royalty," the term "landowner's royalty" is often used to describe a fractional expense free, non-working interest in oil and gas which may at any time be produced from a parcel of land by the landowner himself, or under any lease thereafter given by the landowner on the described parcel. The term "landowner's royalty" or "royalty" is often commonly and, it is submitted, inaccurately and to great confusion, used to describe a landowner's fee simple estate in minerals. It is not so used in this article, but refers only to "lessor's royalty" unless the context clearly states otherwise.)

Quite obviously in most instances where a landowner sells all or a portion of his landowner's royalty it is the intention of both seller and buyer that the buyer is buying a share or interest in the proceeds of a business (i.e., the operation of the lease) conducted by another (i.e., the lessee) since the landowner's royalty interest carries neither the obligation nor right to drill for or produce oil or enter upon the land or operate the lease. Under our test then, such interest would seem in most circumstances to be a security. The California Supreme Court has so held.

In upholding the conviction of person, who admittedly, knowingly and intentionally sold landowner's royalty interests to the public without a permit, the California Supreme Court, in a 1933 decision (People v. Craven 219 Cal 525) countered the defendan't argument that a permit requirement in such cases is opposed to the free exercise of individual property rights, and is oppressive and burdensome, with a quotation from a 1917 opinion of the United States Supreme Court relative to the purposes of "Blue Sky Laws" as follows:

". . . the name (blue sky law) that is given to the law indicates the evil at which it is aimed, that is, to use the language of a cited case, 'speculative schemes' which have no more basis than so many feet of "blue sky"; or . . . to stop the sale of stock of fly-by-night concerns, visionary oil wells, distant gold mines, and other like fraudulent exploitations."

In subsequent decisions the Supreme Court of California has firmly reiterated the principle that the transfer of a landowner's royalty interest is the transfer of a security.

An interesting "switch" occurred in the 1949 Kern County Civil case of *Blackburn v. Union Oil and others* (90 CA 2nd 775). In the middle nineteen thirties Mr. Blackburn issued and sold to various purchasers "per cents" by hydrocarbons produced from specified parcels. The documents of transfer were entitled "Landowner's Royalty Contract." Apparently no permits were obtained from the Commissioner. Following the death of Mr. Blackburn in the 1940's his executor sued to quiet title to the parcel of land against the effects of the Royalty Contract. In other words, the seller's "estate" was suing to have the Landowner's Royalty Contracts declared void, thus gaining title to the "per cents" of production sold. This was, in effect, the reverse of the more common situation where the purchasers, on finding that their deals were worthless, sued to get their money back and surrender their oil interest. The report of the case does not inform us whether or not the properties were productive in the Blackburn case, but such must have most certainly been the fact for the purchasers of the landowner's royalty interests successfully defended the validity of their royalty. Mr. Blackburn had argued that these Landowner's Royalty Conveyances were securities and were void because of lack of a permit, and that the purchasers of the securities were as guilty in purchasing the securities knowing that no permit was issued, as was the seller in selling without a permit. The court agreed that the Landowner's Royalty Contracts were securities and that a violation of the act had occurred. It said, however, "Plaintiff, as executor of the decedent's estate, seeks to take advantage of the decedent's wrong in selling securities without a permit. This he cannot do. To hold that he could do so is to allow a premium for the wrong by Blackburn (the decedent) and to defeat the purposes of the statute."

We have completed, for the purposes of this article, our review of the more common methods by which landowners convey, sell or otherwise attempt to derive profit from the transfer of ownership or interests in their oil and gas rights. We have seen that deals ranging from what appears to be a single direct sale of a parcel of real property by a grant deed of fee simple title through the various types of sales of undivided interests in fee title, sales of mineral deeds to separate parcels, mineral deeds to undivided interests in oil and gas, the making of an oil lease, and the sale of reserved landowner's royalty, all can under the appropriate set of circumstances, and some by their very nature always will, involve the transfer of an interest in the nature of an investment (or speculation) in the profits or proceeds of a business to be conducted by another, and thus fall within the purview of the Corporate Securities Law.

There remain to be examined under the fluorescent lamp of our judge-made test, samples and specimens (cores and cuttings) of those transactions perhaps more familiar to the working geologist, and probably more likely to be encountered by him in his daily work. These transactions arise out of transfers and sales of and dealings in the lessee's interest in his leasehold rights, interests and estate under his oil and gas lease. Included are assignments of the entire lease as to all of the land; partial assignments of the entire leasehold in separate parcels of the leased land; assignments of undivided interests in the leasehold estate; the sale of all or fractional parts of overriding royalty interests either retained upon an assignment of the leasehold or carved out of the leasehold the creation, sale and transfer; of "production payment" interests, net profits interests and carried working interests. Also to be examined are "farmouts," "farm-ins," joint operating agreements and some other arrangements often undertaken by persons desiring to re-use funds for a profit from oil and gas exploration and production. Finally, we will discuss some welcome exemptions from the Act available for some oil deals under limited circumstances, and we will only briefly and in passing mention some defenses to charges of violations. We will conclude with a brief summary of our discussion and our oft herein repeated caveat respecting the "ounce of prevention."

To be concluded in next edition of selected papers.