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PETROLEUM POTENTIAL OF WILDERNESS LANDS, CALIFORNIA

By Edward W. Scott

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Petroleum Potential of Wilderness Lands in California

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PETROLEUM POTENTIAL OF WILDERNESS LANDS IN THE WESTERN UNITED STATES

GEOLOGICAL SURVEY CIRCULAR 902-D

This chapter on the petroleum geology and resource potential of Wilderness Lands in California is also provided as an accompanying pamphlet for Miscellaneous Investigations Series Map I-1538

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ABSTRACT

California Wilderness Lands having oil and gas potential of varying degrees were grouped into 16 clusters, covering 11.596 million acres. Their potentials range from a medium potential in a few small tracts in producing basins to very low potentials in terranes of mixed sedimentary and igneous and volcanic rocks in the eastern and northern parts of the State. All tracts outside of these clusters, 7.253 million acres of Wilderness Lands making up the total 18.849 million acres in the State, are assessed as having zero petroleum potential and are located primarily in igneous and volcanic terranes in the east and central portions of the State.

INTRODUCTION

California currently ranks fifth overall as a source of conventional petroleum in the United States. Through 1979 approximately 24 billion barrels of recoverable oil and 33 trillion cubic feet of natural gas had been discovered. Nearly all of the known recoverable oil and natural gas is in fields of significant sizes. Nearly 99 percent of the oil and 96 percent of the natural gas occur in 155 fields. Fifteen giant fields have 63.4 percent of the oil and 52.6 percent of the natural gas (Nehring, 1981).

All of the oil and gas fields discovered to date are in sedimentary basins either in the Great Valley or occupying re-entrants into the Pacific border provinces. Most of the rest of the State is underlain by igneous rocks, both lava and intrusive types; metamorphosed sedimentary rock; or metavolcanics (Landes, 1970).

The predominant trap types for the significant oil and gas fields in California are anticlines or faulted anticlines that produce primarily from Tertiary sandstone reservoirs. There are a few sandstone reservoirs in fields producing from the Cretaceous in the Sacramento Valley and some small fields producing from the Jurassic.

Nearly 19 million acres of Wilderness Lands are in the State of California; these lands were evaluated in this study and lie within 511 separate wilderness polygons ranging in size from 4 acres to 700,000 acres. However, the majority of the Wilderness Lands fall outside of the known petroleum producing basins and occur most frequently in the igneous-metamorphic complexes of the northern and east-southeastern parts of the State.

A brief description of the regional geology and geologic history for the entire State of California is followed by a more detailed description of the geology and petroleum potential of the Wilderness Lands within the State.

REGIONAL GEOLOGIC HISTORY

California was part of a large geosyncline during most of the Paleozoic. This was initiated when an early Paleozoic sea advanced from the Pacific area eastward to the midcontinent. Mountain building in California started in the Late Triassic-Middle Jurassic part of the Mesozoic and culminated at the close of the Jurassic with the Nevadan orogeny.

The mountain-building processes continued into Late Cretaceous and included folding, faulting, and uplift, plus granitic intrusions and volcanic activity. The tectonic events during the Mesozoic resulted in the dominant relief of California of a parallel system of north-northwest trending mountain ranges with a long narrow valley between the ranges. This feature, the Great Valley of California, was a basin of deposition and received miogeosynclinal, clastic sediments during the period from Late Jurassic until early Pleistocene. The eastern mountain system includes the Klamath, Sierra Nevada, and Peninsular Ranges. The western mountain system is the Coast Ranges, with San Francisco Bay separating the North and South Ranges.

During the Late Jurassic–Early Cretaceous tectonic activities, a heterogeneous section of eugeosynclinal sediments and volcanics was being deposited in a trench at the base of the continental slope to the west of the present Coast Ranges. This is the Franciscan assemblage of California and the source of the sediments was the growing Sierra Nevada and Klamath Mountains.

At the time of Franciscan deposition, another major sedimentary sequence was being deposited in shallow seas on the shelf-slope. This is the Great Valley sequence which consists of about 50,000 ft (15,240 m) of sandstones, shales, and conglomerates that were deposited under miogeosynclinal conditions and are present under the Great Valley of central California. Much of this section is exposed along the west side of the Sacramento Valley, the northern subbasin of the Great Valley.

A subduction zone developed under the Great Valley in mid-Jurassic time, and the Great Valley Series of rocks on the continental block was thrust many miles westward over the Franciscan oceanic plate rocks. This subduction and thrusting continued until mid-Oligocene time. The overthrust Great Valley sequence was folded, but little disturbed, whereas the underthrust Franciscan Complex has been described as a tectonic jumble and some of the rocks have been metamorphosed.

When the subduction and thrusting stopped in early Tertiary time (middle Eocene and Oligocene) the San Andreas fault system began to develop. The fault is still active and right-lateral displacement of 160 to 310 miles (256 to 496 km) has taken place since movement was initiated. The movement along the San Andreas fault has affected two of the California provinces. On the west side of the San Joaquin Valley, faulting and folding have developed structures both parallel and subparallel with the trace of the San Andreas, and similar features are present in the Coast Ranges to the east of the San Andreas fault.

In early Tertiary time, coastal movements started in the Coast Ranges. There was volcanic activity in the Coast Ranges during the middle Miocene followed by uplift and folding. The Coast Range orogeny culminated in late Pliocene into Pleistocene time.

Emphasis has been placed on mountain building in the discussion on California. The State is quite mountainous and the mountains and some major valleys form the basis for the designation of the various major geomorphic provinces that contain subprovinces or petroleum provinces that were assessed for petroleum resources by the U.S. Geological Survey (Dolton and others, 1981).

Nine provinces, from Dolton and others (1981), assessed for potential petroleum resources are 73—Sacramento Basin; 74—San Joaquin Basin; 75—Los Angeles Basin; 76—Ventura Basin; 77—Santa Maria Basin; 78—Central Coastal Basins; 79—Sonoma-Livermore Basin; 80—Humboldt Basin; and 81A—Eastern California. For the program of assessing petroleum potentials of the Wilderness Lands, two additional provinces have been added, 901—the Santa Lucia Range, and 902—the Northern Coast Ranges.

Brief discussions on the geology of the provinces that contain Wilderness Lands will follow, and the provinces will be treated in numerical order. Four petroleum provinces will not be discussed in this report because there are no Wilderness Lands within these provinces. They are 73—Sacramento Basin; 75—Los Angeles Basin; 79—Sonoma-Livermore Basin; and 80—Humboldt Basin.

CALIFORNIA PROVINCES—SUMMARY OF GEOLOGY

California is divided into 11 petroleum provinces (fig. 1) based essentially on geomorphic outlines. These provinces encompass basins, but they also include mountains and less promising areas of basement and volcanic rocks. Most of the Wilderness Lands are located in the confines of the restricted limits of the basins. A brief review of the geology of the provinces follows.

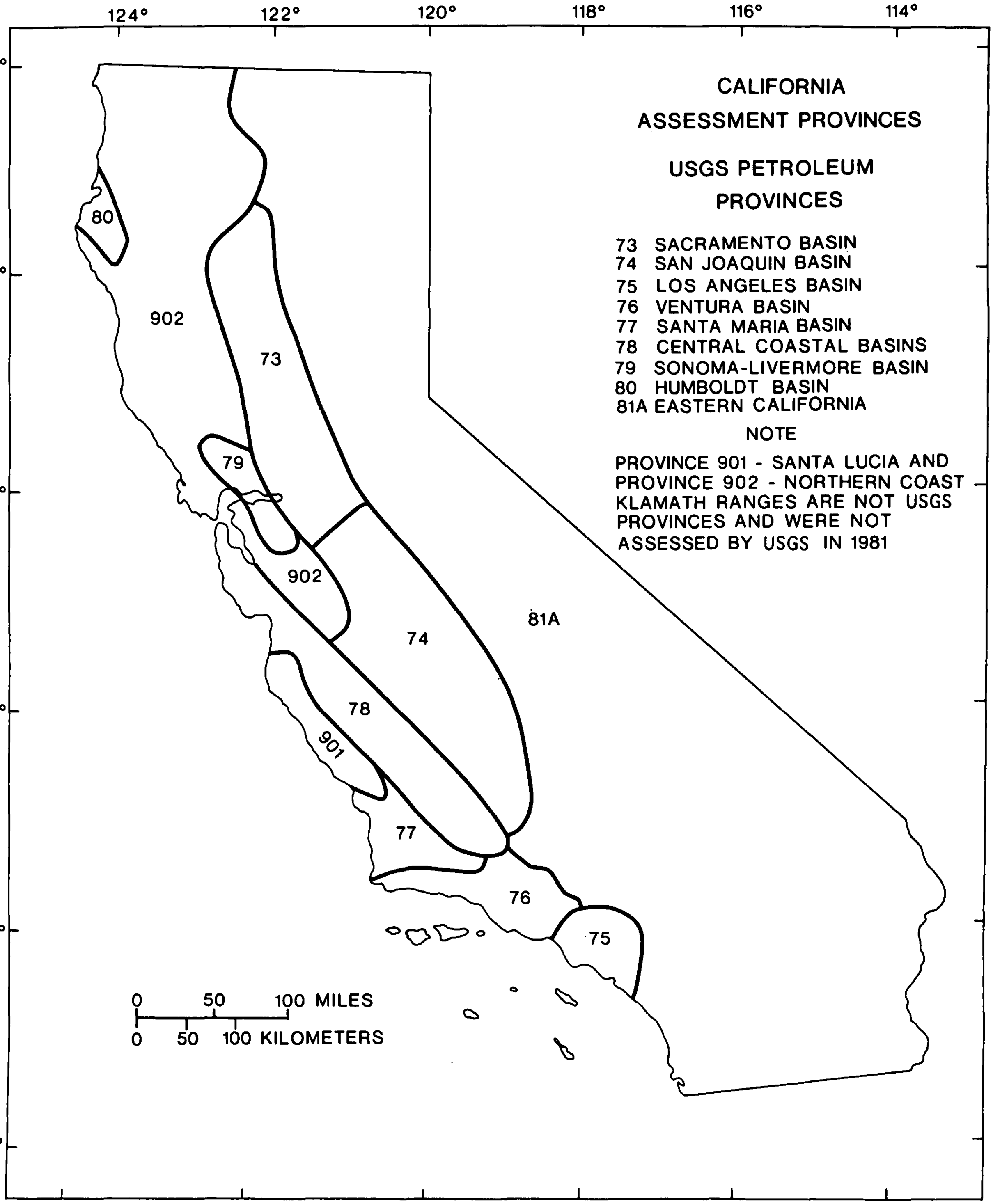

FIGURE 1.—Index map of California showing the USGS petroleum provinces as used by Dolton and others (1981). The petroleum provinces in which Wilderness Lands in California are located are listed in the appendix of this circular.

PROVINCE 74—SAN JOAQUIN BASIN

The San Joaquin Basin is the southern subbasin of the Great Valley of California that lies between the Sierra Nevada Mountains on the east and the Coast Ranges on the west. The San Joaquin subbasin is separated from the northern Sacramento subbasin by the Stockton arch, a subsurface feature.

The San Joaquin Basin is an asymmetric basin with a steep west flank and a gently sloping east flank. It is filled with up to 50,000 ft (15,240 m) (Oakeshott, 1978) of marine miogeosyclinal rocks that range in age from Late Cretaceous through the Pliocene.

There were many sediment sources around the periphery of the basin including the Sierra Nevada Mountains in the east, the Klamath Mountains to the north, and the Coast Ranges to the west. These various source areas, in conjunction with both regional and local uplift, have resulted in complex structural and stratigraphic conditions.

Oil and gas production is mainly from sandstone reservoirs that are present throughout the section from Upper Cretaceous through lower Pleistocene.

The dominant trap type in the San Joaquin Basin is anticlinal, but faulting and stratigraphy are very important, especially in the southern and southwestern parts of the basin where the majority of the fields are located. The unequal distribution of fields in the basin is shown by the fact that approximately 84 percent of the oil and 68 percent of the gas found in the basin to date are in the southern half.

PROVINCE 76—VENTURA BASIN

The Ventura Basin is part of the Transverse Ranges geomorphic province. The basin (fig. 1) as assessed includes the onshore Ventura Basin (Nagle and Parker, 1971) to the east and the onshore part of the Santa Barbara Channel Basin to the west. It is bounded on the north by the Santa Ynez fault, on the east by the San Gabriel fault, and on the south by the Santa Monica Mountains and the Pacific Ocean.

Over 50,000 ft (15,240 m) of sedimentary rocks lie along the Santa Clara trough in the central part of the basin. They range in age from Late Cretaceous through Pleistocene and all of the units have some oil production. By far the most prolific units, however, are the Pliocene (15,000 ft, 4,570 m) and upper Miocene (6,000 ft, 1,830 m). The province can be divided into several tectonic provinces, but the most important is the central east-west trending Santa Clara trough. This trough apparently began during late Miocene time with a downwarp of the basement, which created a deep depositional basin. The basin had several periods of minor downwarp and faulting until the Pleistocene, which marked the onset of the Pasadenian orogeny. This orogeny, which continues to the present, is responsible for the physiographic features of the Ventura Basin.

PROVINCE 77—SANTA MARIA BASIN

The Santa Maria Basin province is a triangular area in the southwest part of the State (fig. 1). It is bounded on the northeast by the Nacimiento-Rinconada fault complex, on the south by the Santa Ynez fault in the Santa Ynez Mountains, and on the west by the Pacific Ocean.

The area is floored by a Jurassic-Early Cretaceous basement complex of metasedimentary and igneous rocks. The main sedimentary Santa Maria basin has up to 15,000 ft (4,570 m) of Upper Cretaceous through Pleistocene rocks. The rocks from the Upper Cretaceous through the lower Miocene are not evenly distributed. Subsidence occurred in the early middle Miocene, at which time there was a transgression of the sea and marine deposition continued until late Pliocene time.

Most of the production in the Santa Maria Basin is associated with structural traps, but a large percentage comes from stratigraphic traps of truncated sands and fractured shales. Producing units range in age from fractured Jurassic and Cretaceous basement to lower Pliocene sands, but approximately 75 percent of the production is from fractured Monterey Shale of Miocene age.

PROVINCE 78—CENTRAL COASTAL BASINS

This province (fig. 1) is a small part of a large, north-northwest trending geomorphic province—the Coast Ranges. This geomorphic province lies between the Pacific Ocean and the Great Valley. It extends from the Klamath Mountains on the north to the Santa Ynez Mountains of the Transverse Ranges on the south and is composed of a complex series of independent ranges and valleys. Province 78 includes two of these valleys—Cuyama and Salinas.

Historically, in early Paleocene time, shallow seas crossed the western part of the State and there was a period of crustal quiescence during the Paleocene and Eocene. In late Eocene to early Miocene time, parts of the Coast Ranges were elevated above sea level. In the late part of the early Tertiary, crustal movements began in the Coast Ranges with different events in different ranges.

Middle Miocene time was the beginning of volcanic activity and large amounts of volcanic material are present in this part of the stratigraphic section. The Miocene closed with uplifting and faulting, and the Coast Range orogeny culminated in the late Pliocene to middle Pleistocene. There has been continued warping, faulting and vertical uplift during the Quaternary.

This Central Coastal province contains two major basins: the Salinas Valley to the north and the Cuyama Valley to the south. The Salinas Valley basin consists of two major features: (1) the Salinas trough, filled with nearly 20,000 ft (7,000 m) of lower Miocene to Pliocene rocks, and (2) an eastern shelf with about 6,000 ft (1,829 m) of upper Miocene and Pliocene rocks. The large San Ardo oil field is located in the eastern shelf and produces heavy oil (11 to 14 degrees API gravity) from upper Miocene sands in a large stratigraphic trap.

The Cuyama Valley Basin contains sedimentary rocks ranging in age from Upper Cretaceous to Pliocene with an estimated maximum thickness of about 6,000 ft (1,829 m). Four fields in this basin produce from lower Miocene sands with faulted anticlines being the major trapping mechanism.

PROVINCE 81A—EASTERN CALIFORNIA

This province is divided into eight subprovinces (fig. 2) on the basis of geomorphology. There are Wilderness Lands within each of the subprovinces and a brief geological summary is made for each.

CASCADE-MODOC SUBPROVINCE

This subprovince lies in the northeast part of the State (fig. 2) and is bounded on the north and east by the California State line, on the south by the Sierra Nevada Mountains, and on the west by the Klamath Mountains. The north-south trending Cascade Ranges form the western margin of the subprovince; the remainder of the province is covered by a thick accumulation of Cenozoic volcanic rocks of varying thickness with limited exposures of marine Cretaceous rocks and scattered Tertiary lake beds.

At least six wells have been drilled in the area without any reported shows of oil or gas. There is only a small chance for any hydrocarbon potential in this subprovince. This slight chance is related to a few outcrops of marine Cretaceous rocks and the presence of two inferred basins beneath the volcanic section.

SIERRA NEVADA SUBPROVINCE

This subprovince is a large block of Mesozoic granitic rocks having roof pendants of metamorphosed Paleozoic sedimentary rocks. The area is not considered to have any petroleum potential.

MONO-INYO SUBPROVINCE

This subprovince, like the Sierra Nevada subprovince, is essentially an area of granitic rocks that includes the Inyo batholith. No hydrocarbon potential is given to the area.

GREAT BASIN AND MOJAVE DESERT SUBPROVINCES

These two subprovinces are in southeastern California (fig. 2). They have a similar geological setting and are characterized by north-northwest trending mountain ranges that alternate with intervening valleys and basins. The ranges are horsts and the basins are sediment-filled grabens. The boundary between the two subbasins is the Garlock fault and its eastward extension to the California State line.

The area was covered by marine Paleozoic rocks and later intruded by granitic batholiths during the Mesozoic orogenies. The Cenozoic rocks are composed mainly of nonmarine lake and stream deposits with some evaporite deposits and volcanic rocks. There are a few limited areas of marine Tertiary rocks along the Colorado River and adjacent to the San Andreas fault that offer very limited possibilities for petroleum.

TRANSVERSE RANGES SUBPROVINCE

The Transverse Ranges of California form an east-west trending geomorphic unit that extends from Point Conception on the west to the eastern end of the San Bernardino Mountains in central southern California. The eastern part that forms the subbasin of the Eastern California province (81A) lies between the Mojave Desert and Imperial subprovinces (fig. 2).

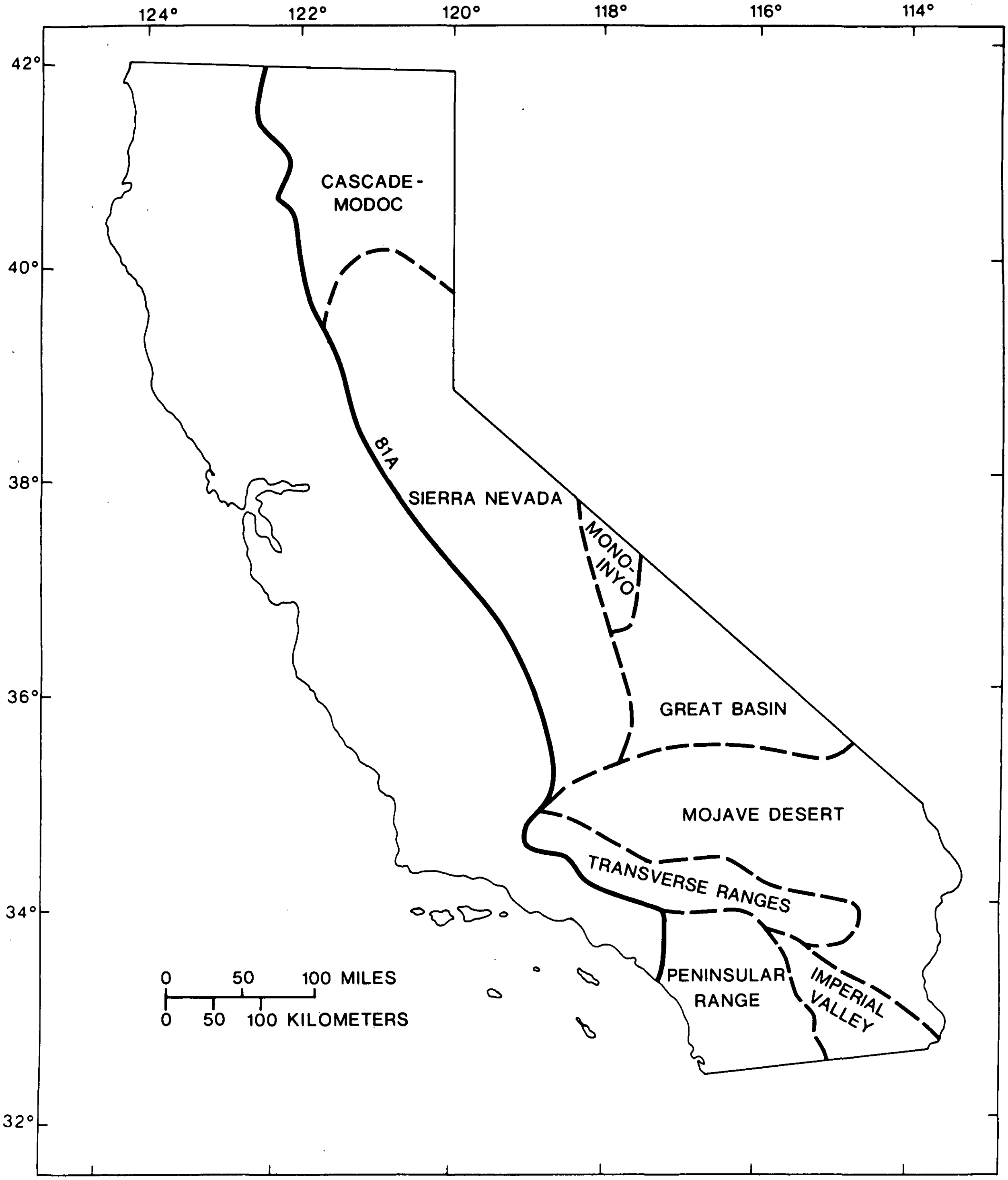

FIGURE 2.—Index map of California showing the geomorphic divisions of the Eastern California province (81A).

This part of the Transverse Ranges includes the San Gabriel and San Bernardino Ranges and is composed of Precambrian and Paleozoic metamorphic rocks and Mesozoic granites. The subprovince is not considered to have any potential for hydrocarbons.

IMPERIAL VALLEY SUBBASIN

This subbasin is in Southern California and lies between the Mojave and Peninsula Range subprovinces (fig. 2). It is a long, north-northwest trending graben bounded on the northeast by the San Andreas fault and on the southwest by the San Jacinto fault. The surface expression is an elongate topographic depression that is the northwest continuation of the Gulf of California.

The basin is filled with more than 20,000 ft (7,000 m) of late Cenozoic rocks (Oakeshott, 1978) that lie on Cretaceous granite and older metasediments. The oldest Cenozoic rocks are nonmarine, coarse clastics of Miocene age that are overlain by coarse, shallow-marine Pliocene rocks.

The subbasin is considered to have very poor source rock possibilities owing to the preponderance of nonmarine rocks and the "apparently sterile environments of the marine sediments" (Tarbet, 1971). This probably accounts for lack of any substantial shows of hydrocarbons in the wells drilled to date. The possibility of commercial accumulations of hydrocarbons is quite low.

PENINSULAR RANGE SUBPROVINCE

This geomorphic subprovince is in the southwestern part of California, between the Imperial Valley and the Pacific Ocean (fig. 2). It extends from the junction with the Transverse Ranges on the north to the Mexican border on the south.

There are two distinct geomorphic units in this subprovince: (1) an eastern mountainous area, and (2) a narrow coastal strip of sedimentary rocks. The eastern mountainous area is underlain by the mid-Cretaceous granite of the southern California batholith and metasedimentary rocks of Paleozoic and Mesozoic age. This part of the subprovince does not have any petroleum potential.

Sedimentary rocks occur in the narrow coastal strip and range in age from Upper Cretaceous through Pleistocene. The distribution is not uniform, especially from late Eocene through Pliocene, where outcrops are discontinuous along the coast. A large part of the sedimentary section is of marine origin and is considered to have some petroleum potential in restricted areas.

More than 175 wells have been drilled in the Peninsular Range subprovince, and about 60 percent of these were drilled in the narrow coastal sedimentary strip. Two discoveries were reported prior to 1960 in the northern part of the coastal strip. Both were noncommercial one-well fields and were abandoned after producing about 4,000 barrels of oil and 11 million cubic feet of gas.

PROVINCE 901—SANTA LUCIA RANGE

This province lies along the south-central coast of California between the central Coast Ranges province and the Pacific Ocean and to the north of the Santa Maria province (fig. 1). It is the Santa Lucia Range of the Coast Ranges. Most of the area is covered by the Jurassic-Cretaceous Franciscan metasedimentary complex and is nonprospective. There are a few areas of Cretaceous to Miocene rocks that offer only very slight possibilities for petroleum.

PROVINCE 902—NORTHERN COAST RANGES

This province covers most of northwestern California (fig. 1). The province consists essentially of the Jurassic-Cretaceous metamorphic complex that is considered nonprospective. There are small, local areas of Tertiary rocks, and oil seepages are known from a very young phase of the least metamorphosed part of the Franciscan that offers only slight chances for petroleum. A possible but extremely remote potential exists in the unaltered Paleozoic rocks beneath the Franciscan assemblage.

QUALITATIVE EVALUATION OF WILDERNESS CLUSTERS

For purposes of this report and the accompanying Miscellaneous Investigations Series Map (I–1538, in press), Wilderness Lands in California with oil and gas potential are grouped or subdivided into 16 clusters of geologically related appraisal areas (see fig. 3). These Wilderness Lands with varying degrees of petroleum potential account for 11.596 million acres of the total 18.849 million acres of Wilderness Lands in the State (fig. 4). The remaining 7.253 million acres of Wilderness Lands have zero petroleum potential and are located primarily in igneous and volcanic rock ter-

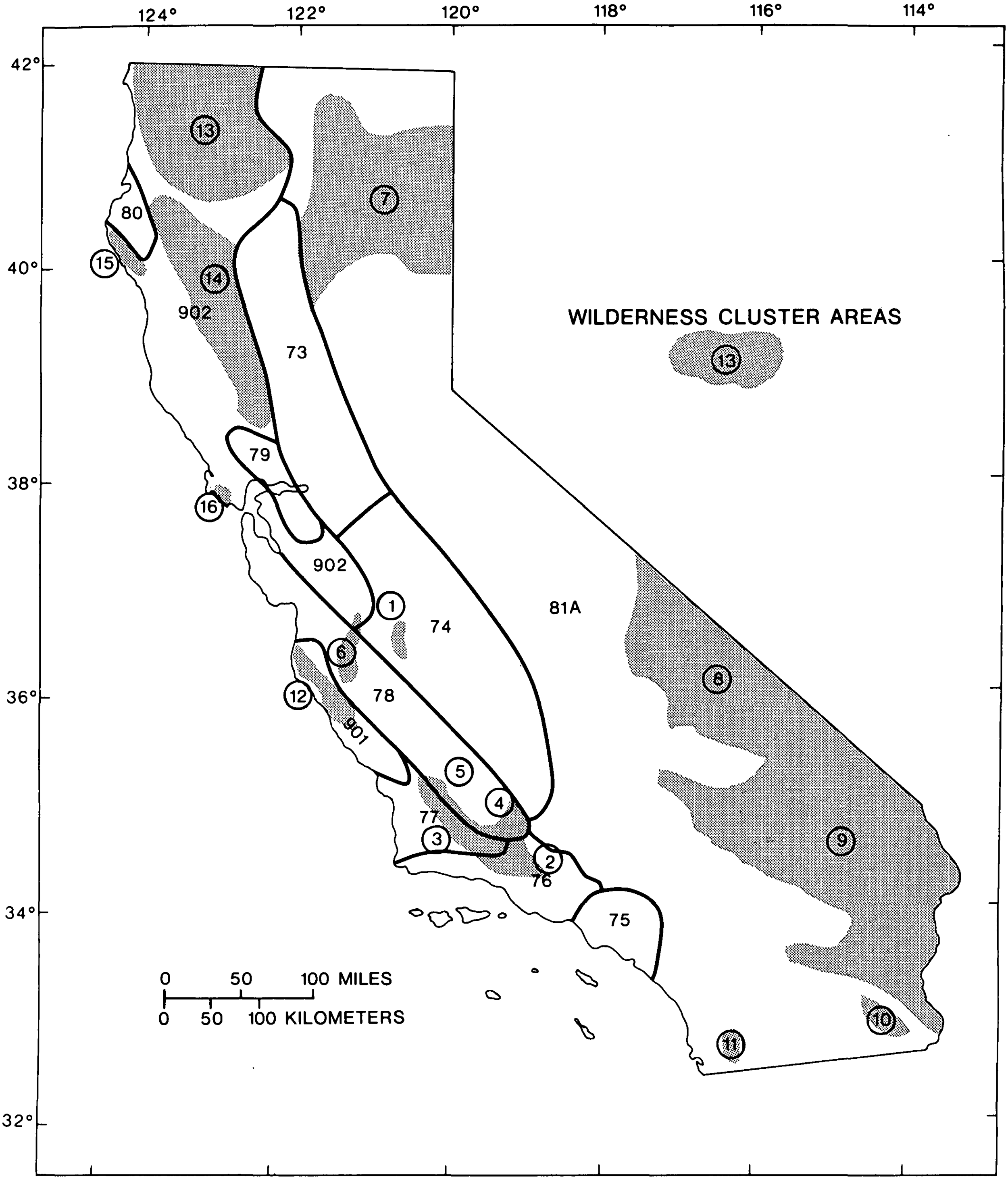

FIGURE 3.—Index map of California showing the USGS petroleum provinces and the 16 clusters of Wilderness Lands with petroleum potential assessed in the State. The clusters are shown in a shaded pattern with the circled numbers and are discussed in the text. The petroleum provinces are listed in the appendix of this circular.

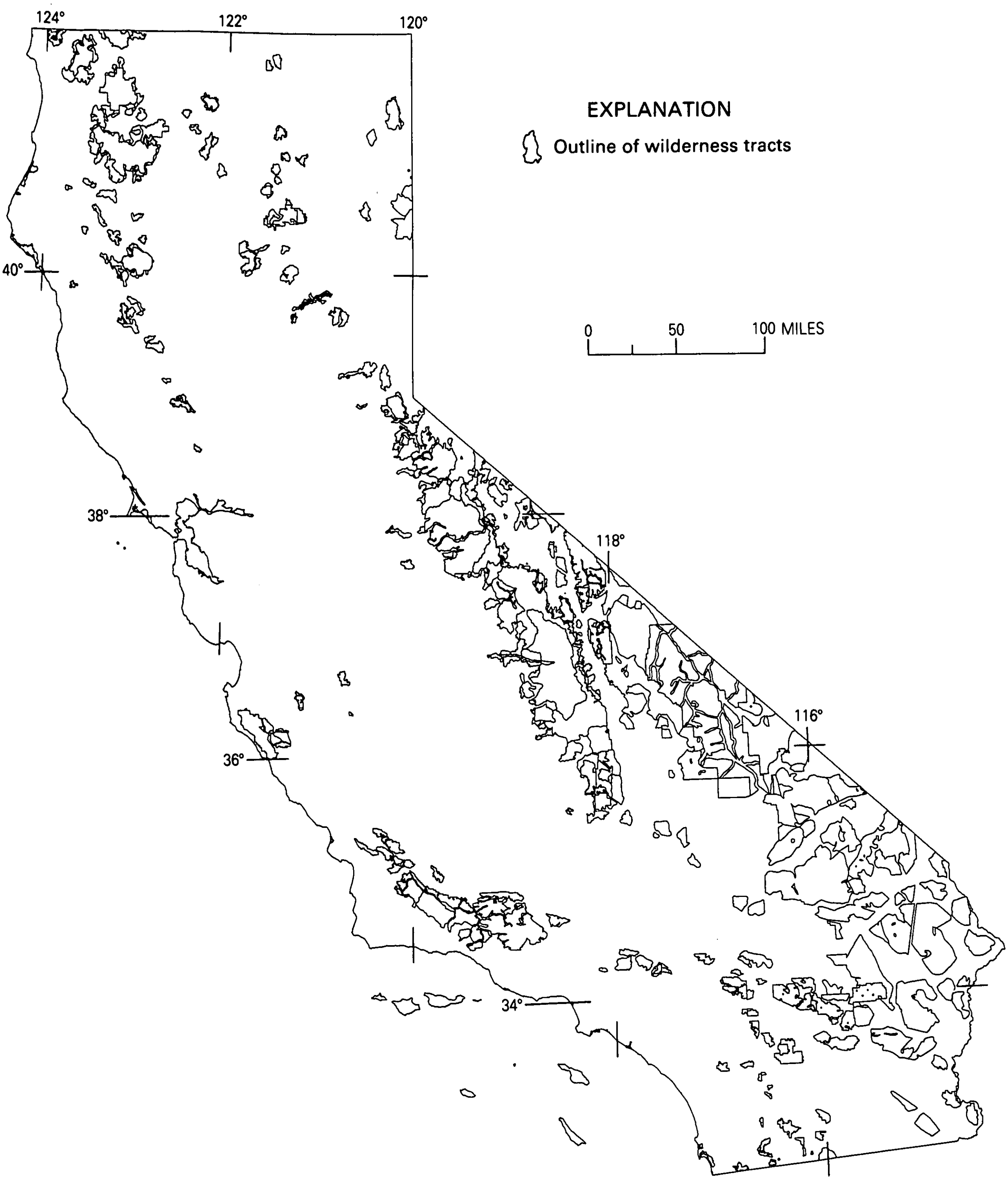

FIGURE 4.—Index map of California showing all the Wilderness Lands included in the analysis for petroleum resources. The map is an example of a machine-plotted map produced from digitized wilderness data reduced from a 1:1,000,000 scale map (BLM, 1981).

ranes. The Wilderness Lands with zero potential are not included in the following discussion.

The presence or absence of possible source rock, reservoir rock, and trapping mechanisms were the most crucial factors used in qualitatively assigning a potential of medium, low, and low to zero oil or gas potential to each of the 16 clusters. An explanation of the geology within the areas of the respective wilderness clusters is briefly described by province along with the ratings of the petroleum potential within the areas of the Wilderness Lands.

Cluster 1—Province 74—San Joaquin Basin

This cluster is located in the west-central part of the San Joaquin Basin province near the western limits of the San Joaquin Valley (fig. 3). The cluster consists of two tracts about 16 miles apart in a north-south direction.

The cluster lies within a petroliferous area, but the geological conditions of reservoir rocks and trapping mechanisms are not favorable for major hydrocarbon accumulations. An example of this is the Vallecitos oil field that lies between the two tracts. This field is a complex of 10 separate producing areas within a 40 square mile area. Maximum total productive area for the 10 units is 360 acres. The estimated ultimate recovery is 5 million barrels of oil and 5.5 billion cubic feet of gas.

Trapping mechanisms at Vallecitos are variable and include three faulted anticlines, one tar seal, and six stratigraphic traps that include both lithofacies changes and truncations. Production is from Paleocene and Eocene sands at depths ranging from 1,000 to 5,300 ft (305 to 1,615 m).

A second field, Cheney Ranch, lies about 16 miles (25 km) to the east and down-dip from the cluster. This field produces gas from a Cretaceous sandstone at a depth of 7,000 ft (2,130 m) and the trapping mechanism is a sandstone pinchout (lithofacies change) on an east-dipping monocline. Estimated ultimate recovery is 4 billion cubic feet of gas.

The conditions of poor field quality as shown by the Vallecitos and Cheney Ranch fields, a low success rate in exploration drilling in this part of the San Joaquin Valley, and the location on the less prospective, western edge of the basin are the basis for a low to medium rating for the cluster.

Clusters 2, 3, and 4—Provinces 76—Ventura, 77—Santa Maria, and 78—Central Coastal Basins

Clusters 2, 3, and 4 include a concentration of Wilderness Lands that is grouped around the common corner of the three provinces, Ventura, Santa Maria, and Central Coastal Basins (fig. 3). This grouping is located in a mountainous area that roughly coincides with the junction of the Santa Ynez Mountains of the Transverse Ranges and the Sierra Madre Mountains of the Southern Coast Ranges.

This area has geological conditions that persist over most of this part of the region and that are quite different from the conditions in the respective basins of these provinces. Briefly, the area of cluster concentration is marked by widespread exposures of Miocene, Eocene, and Cretaceous rocks, whereas the respective productive basins are covered by Pliocene and Pleistocene rocks.

The widespread occurrences of Eocene and Cretaceous exposures and the absence of upper Miocene and Pliocene units preclude the possible presence of the most prolific petroleum-bearing sections in the cluster area. For example, approximately 99 percent of the total recoverable hydrocarbons in the Ventura Basin is in the post-Eocene section. About 65 percent of the total hydrocarbons has been found in the Pliocene section, which attains a thickness of about 15,000 ft (4,600 m) in the central part of the Ventura Basin. In the Santa Maria Basin to the west of cluster 3, all of the hydrocarbons found to date are of post-Eocene age, generally middle Miocene and younger.

Cluster 4 is contained within the most northerly and least prolific province in this group (fig. 3). Four fields have been found in the Cuyama Valley for a total of 286 million barrels of oil and 235 billion cubic feet of gas. The South Cuyama field accounts for 75 percent of the oil and 82 percent of the gas. The oil and gas in all four fields is in the Vaqueros sandstone of lower Miocene age, and this unit is missing over much of cluster 4 because of outcropping of older units.

In summary, the geology within the cluster group is fairly consistent, and the major producing sections of the three provinces (Pliocene in Ventura Basin, middle Miocene in Santa Maria Basin, and lower Miocene in Central Coastal Basin) are missing in the cluster area, and any major production would probably be from older stratigraphic units. The cluster is given a low potential rating for these reasons.

Cluster 5—Province 78—Central Coastal Basins

This cluster is within the Caliente Range in the south-central part of the Central Coastal Basins province (fig. 3). The tract is just north of the Cuyama Valley and within 2 miles (3.2 km) of the Russell Ranch field that has an estimated ultimate recovery of 68 million barrels of oil and 50 billion cubic feet of gas from the lower Miocene Vaqueros Sandstone. Surface beds in the tract area are of Miocene age and the lower Miocene Vaqueros should be present at depth. This accounts for the medium potential rating given to the cluster.

Cluster 6—Province 78—Central Coastal Basins

This cluster is located in the south-central part of the Central Coastal Basins province (fig. 3) along the southwest side of the Salinas Valley. Five fields have been discovered along a northwest-southeast trend in the center of the Salinas Valley. Ultimate recoverable oil is estimated at 360 million barrels with more than 99 percent of this credited to the San Ardo field. Production is from the middle Miocene Monterey and gravity is low, 10 to 13 degrees, API gravity.

More than 30 wildcat tests have been drilled within 5 miles of the wilderness cluster along the north and east side, without success. Nearest production is at the Monroe Swell field about 10 miles to the east of the cluster. This field has estimated reserves of 2 million barrels.

The low potential rating given this wilderness cluster is due partly to the generally poor quality of fields found to date (San Ardo excepted) and partly to the lack of success in the concentrated exploration activities near the cluster.

Cluster 7—Province 81A—Eastern California

Cluster 7 is in the Cascade-Modoc subprovince of northeastern California (fig. 3). The area is given a low to zero potential rating on the basis of the unfavorable geological conditions of widespread Cenozoic volcanic rocks over most of the area and the lack of significant amounts of marine strata that could be source rocks. In addition, none of the wells drilled to date has reported any shows of oil or gas.

The low to zero potential rating is consistent with the evaluation of "little petroleum potential" given in AAPG Memoir 15 (Gay and Streitz, 1971).

Clusters 8 and 9—Province 81A—Eastern California

Cluster 8 is in the Great Basin subprovince and cluster 9 is in the Mojave subprovince of the Eastern California province (fig. 3). The combined subprovinces form a large area that offers very limited possibilities for oil and gas. Because the rocks were subjected to intense tectonism with resulting metamorphism and structural complexities, there is little chance for the presence of source rock, reservoir rock, and suitable trapping mechanisms. A low to zero potential rating is given the two clusters.

Cluster 10—Province 81A—Eastern California

Cluster 10 is in the Imperial Valley subprovince located near the southeastern corner of California (fig. 3). Approximately 40 exploratory wells have been drilled in this subprovince in search of oil and gas and only minor shows of gas have been reported.

The failure to find oil or gas in the wells drilled to date and the apparent lack of suitable source beds justify a low to zero potential rating for this cluster.

Cluster 11—Province 81A—Eastern California

Cluster 11 is a single wilderness tract in the southwest corner of the State (fig. 3). It is located near the eastern limit of the San Diego area of the narrow coastal strip of the Peninsular Range subprovince of the Eastern California province, 81A.

The up-dip location of the tract places it in a position where the sedimentary section is quite thin. Three tests were drilled in 1910 and 1931 with locations about 5 miles west of the tract in a down-dip position. The depths ranged from 1,000 to 3,000 ft (305–914 m) and the results were negative. A low to zero potential rating is given on the basis of a thin sedimentary section and the results of exploratory drilling.

Cluster 12—Province 901—Santa Lucia Range

This cluster is located in the western half of the Santa Lucia Range province (fig. 3) where there are a few exposures of Upper Cretaceous to Miocene sedimentary rocks. These units are quite thin and a low to zero potential rating is given.

Cluster 13—Province 902—Northern Coast Ranges

This cluster is in the northern part of the province (fig. 3) where petroleum possibilities are considered to be very low. The bulk of the area is underlain by post-Nevadan (Late Jurassic to Early Cretaceous) granites and metamorphic rocks and post-Nevadan rocks that include gently folded to flatlying marine Cretaceous and nonmarine Tertiary sedimentary rocks. A low to zero potential rating is given this cluster.

Clusters 14 and 15—Province 902—Northern Coast Ranges

Cluster 14 is in the central part of the province, and cluster 15 is near the coast immediately south of Province 80, the Humboldt Basin (fig. 3). The dominant rocks in this area belong to the Franciscan Complex of Late Jurassic to Tertiary age. This series is composed of graywackes, cherts, limestones, shales, and volcanic rocks that are metamorphosed to various degrees.

Oil seepages and a subcommercial oil accumulation have been found in the youngest and least altered part of the section. Additional small accumulations may be found. These clusters are ranked as having low to zero potential.

Cluster 16—Province 902—Northern Coast Ranges

This cluster lies along the Pacific Coast in the vicinity of Drakes Bay, a few miles northwest of San Francisco (fig. 3). This area lies to the west of the San Andreas fault, and Tertiary beds are exposed along this coastal strip. Several wells have been drilled in the general area, both onshore and offshore, without success. A low to zero potential rating is given this cluster.

SUMMARY

Of the total 18.9 million acres of Wilderness Lands in California the petroleum potential by acreage can be summarized as follows: medium to low potential, 1.347 million acres; low to zero potential, 10.249 million acres; and zero potential, 7.253 million acres. The petroleum potential by acreage of all Wilderness Land categories in the Western United States is shown in this circular by B. M. Miller in table 1, chapter P.

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