dragged upward and overturned along the hanging wall block of the Santa Monica fault zone.

Thirteen wells have been completed beneath the Federal lands of the Sawtelle Veterans Hospital and an adjacent town-lot area on the north. Production through 1971 totals 6,470,000 bbl of oil and 5,790 MMcf of gas. Current production is 2,000 bbl of oil per day and 2,600 Mcf of gas per day. Average vertical depth to the top of the zone is 9,500 ft; initial pressures were hydrostatic. Porosity averages 18% and permeability averages 20 md. Connate water averages 27%; and oil gravity ranges from 18 to 26° API.

Minor exploration potential remains, but drilling costs are considered too high to justify additional work, and development is therefore considered complete.

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REEXAMINATION OF MOHNIAN TYPE SECTION

Examination of 471 samples collected from the Modelo Formation exposed along Topanga Canyon Boulevard has shown that two of the foraminiferal zones of the Mohnian as published by Kleinpell are in need of revision. As a result of detailed sampling, many more foraminifer-bearing samples allowed the reevaluation of the faunal ranges through the Modelo lithologic units described by Hoots.

The *Bolivina modeloensis* Zone contains a distinctive fauna represented by *Pulvinulinella gyroidinaformis, Baggina californica,* and *Valvulineria subinaequalis.* With the rare exception of a possibly reworked specimen, this faunal assemblage does not range any higher than Hoots' unit 5.

Bulimina unvigerinaformis, formerly considered not to range above unit 6, has been found through unit 8 and rarely in unit 9. *Bolivina sinuata alisoensis* was not found above unit 6.

The *Bolivina hughesi* Zone which included Hoots' units 7 through 16 is best represented in unit 9. Restricted to unit 9 are *Bolivina hughesi* and *Buliminella semihispida.* Above unit 9 foraminifers are very scarce. The faunal top of the Mohnian is in question because no foraminifers restricted to the Mohnian could be found higher than unit 13.

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LATE CENOZOIC STRATIGRAPHY AND STRUCTURE OF OREGON CONTINENTAL MARGIN IN FRAMEWORK OF PLATE TECTONICS

More than 8,000 km of seismic-reflection survey and 250 rock samples provide the basis for a discussion of late Cenozoic stratigraphy and structure of the Oregon continental margin, a critical boundary region between the North American plate and the Gorda-Juan de Fuca plate. Uplifted and faulted folds along the edge of the shelf, commonly manifested as banks, are dominant shallow structural features of the margin. A persistent, broad, relatively shallow syncline lies between the banks and the shore. The continental slope off southern Oregon is characterized by a major fault and fold system; benches result from the ponding of sediments behind anticlinal folds. The northern slope consists of a series of broad anticlinal folds and intervening synclinal basins with deeper underlying folded structure. Structural elements on the margin generally trend north-south and are either parallel or subparallel with it.

At least two regional unconformities establish a first-order subdivision of the stratigraphic column. The older separates late Miocene diatomaceous sediments from underlying rocks. The younger is Pliocene-Pleistocene. These unconformities appear to correlate with significant plate tectonic events. Second-order subdivision into stratigraphic units on the basis of gross lithologic and faunal trends, reflection characteristics, and stratigraphic succession indicates similarities to the Pullen, Eel River, and Rio Dell Formations of northern California. Generally rich foraminiferal faunas display affinities to the late Miocene to Pleistocene biostratigraphy of California.

Provenance and paleoenvironment of lower slope samples suggest a north component of motion for the Gorda-Juan du Fuca plate. Paleoenvironmental analyses indicate a total range of vertical tectonic movement since the late Miocene of approximately 1,200 m.

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STRUCTURE OF MIOCENE ROCKS IN SIERRA MADRE, NORTHEASTERN SANTA BARBARA COUNTY, CALIFORNIA

Folds in Miocene rocks of the central Sierra Madre commonly are northwest-trending, curvilinear, concentric, and symmetrical; asymmetry and overturning occur in the vicinity of reverse faults. Fold hinges undulate across the area and in places bifurcate or merge. Disharmonic folds and sandstone dikes occur locally in the Monterey Shale.

Faults are of three types: (1) along the northeastern edge of the range is a distributive fault zone consisting of parallel, longitudinal, reverse-slip faults which join both westward and downward and which have a subsurface distributive component that is now obscured by more recent deposits on the northeast; (2) southwest of the reverse-slip faults is a group of parallel, longitudinal, normal-separation faults; and (3) the remaining faults are mostly small, diagonal faults of different types; many are hinged at one or both ends and have slips or separations that indicate contemporaneous folding and faulting.

Folding began during late Miocene or Pliocene while Miocene sediment was still unconsolidated and water laden. Diagonal faulting, intrusion of sandstone dikes, and possibly disharmonic folding accompanied early deformation. Asymmetrical and overturned folds formed later and large reverse-slip faults developed along their hinges. Normal-separation faults possibly formed last as lag faults. Northeast-southwest shortening of the area averages about 22%.

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WHY EXPLORE THE NORTHEAST MARGINS OF LOS ANGELES BASIN?

Significant oil finds recently have been made in the northeasternmost Los Angeles basin. Exploration in the area has lagged because of supposed structural complexity and limited stratigraphic concepts. The development of stratigraphic concepts since the early 1950s now allows us to reinterpret and refine depositional patterns and resolve some of the structural complexity. Unlike other parts of the Los Angeles basin, land is still available in many areas and lease costs are reasonable, hence, a review of older records and recomputation of older geophysical work in addition to application of new and improved field and stratigraphic theory can lead to new oil finds. This is especially true along the basin edge with emphasis on source and distribution of sands. Exploration is best done before urbanization and attendant increased costs of operation.

The new West Mahala pool can be used as a case history. The pool was discovered by M. J. Castro as a stratigraphic trap in late Miocene, Puente Formation sediments. The producing measures are in fan and canyon turbidite deposits in upper to middle bathyal sediments (800-3,000-ft water depth). There are two producing zones—the Willis and Langstaff zones. The sandstone geometries suggest fan deposition for the Willis, and channel or canyon facies for the Langstaff. Recovery factors, gas drive, and decline rates are typical of sands given this interpretation. Porosity and permeability data support these contentions. Reworked and shallow-water foraminifers are considerably more abundant in the displaced shallow-water sands. The probability of finding other fields which are somewhat analogous to the West Mahala pool are good. Geologic models used in exploration should include deep-water turbidite fan-channel complexes which may be distributed along the northeast side of the Chino, Puente, and San Jose Hills.

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GEOLOGY AND FUTURE PETROLEUM POTENTIAL, VENTURA BASIN, CALIFORNIA

The Ventura basin is the western part of Transverse Ranges geomorphic province. It is a complex, highly folded and faulted synclinorium. Maximum thickness of sediments is 67,000 ft. The ages of formations range from Cretaceous through Holocene. In areal extent—including the onshore, the Santa Barbara Channel and the continental shelf—it is approximately 215 mi long, and averages 30 mi wide. Total volume of sediments is estimated at 40,000 cu mi.

Despite its long history as an oil-producing basin, exploration of its ultimate potential is far from complete. Much of the thick sedimentary section has not been penetrated except in limited areas on the basin margins. Large volumes of marine lower Tertiary and Upper Cretaceous rocks are completely unexplored. Evaluation of the known profilic structures has rarely been carried below depths of 15,000 ft.

In areas where the upper Tertiary beds are best developed, the obvious surface features have been drilled, and most are productive. Stratigraphic elements of entrapment occur in virtually all accumulations in the Ventura basin. Several primary stratigraphic accumulations are productive. It is believed that the greatest future potential of the basin lies in stratigraphic accumulations, and in the same general areas and measures which have been most productive to date. Estimates of 20-30 billion bbl of remaining oil in place do not appear unreasonable. Exploration for this potential awaits favorable future breakthroughs in economic, technologic, and political developments.

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GEOLOGY OF SACRAMENTO BASIN AND ITS FUTURE GAS POSSIBILITIES

The Sacramento basin occupies the northern half of the Great Valley of California. It is a long, narrow asymmetric basin, with a steep west flank and a broad, shallow east flank. Sediments range in age from Jurassic to Holocene, with essentially dry gas production coming from sediments of Late Cretaceous, Paleocene, and Eocene age. The basin can be divided into four areas: the northern San Joaquin, Delta, Suisun, and northern Sacramento areas.

In the northern San Joaquin area, production has come from anticlinal closures, mostly along the upthrown sides of two major faults. Future production probably also will be located on anticlinal highs.

In the Delta area, production has come from anticlines, fault traps, some stratigraphic traps, and traps against two major gorges. Future production will probably be found in fault and gorge traps. Production in the Suisun area has been located on anticlines. Future production may come from presently unknown anticlines and from new pools found on known anticlinal trends.

In the northern Sacramento area, production has come mostly from stratigraphic traps in sandstone of the Forbes Formation, with additional production from anticlinal trends and from domes overlying buried volcanic plugs. Future production will probably be from Forbes stratigraphic traps.

Over half the gas in the Sacramento basin probably has been discovered. Future exploration will be concentrated in the Delta and northern Sacramento areas. It is possible, but doubtful, that future major production may come from formations deeper than those presently productive, and from parts of the basin presently considered nonprospective.

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BIOSTRATIGRAPHY AND PALEOECOLOGY OF EARLY MIOCENE THROUGH EARLY PLEISTOCENE BENTHONIC AND PLANKTONIC FORAMINIFERA, SAN JOAQUIN HILLS-NEWPORT BAY, ORANGE COUNTY, CALIFORNIA

A uniquely complete and continuous sequence of early Miocene through early Pleistocene marine sediments is exposed in Bonita Canyon on the western flank of the San Joaquin Hills and at adjacent Newport Bay, California. These sediments are assigned to the early to middle Miocene Topanga Formation, middle to late Miocene Monterey Shale, late Miocene to early Pliocene Capistrano Formation, and early Pliocene to early Pleistocene Fernando Formation. The total thickness of the sequence studied is more than 2,400 m.

Quantitative analysis of benthonic foraminiferal biofacies indicates that: (1) the lower parts of the Topanga Formation were deposited at inner to outer shelf depths, (2) upper Topanga and Monterey Shale diatomaceous sediments were deposited at upper to middle bathyal depths within a closed basin where ambient water contained less than 1 ml/l of dissolved oxygen, (3) lower bathyal depths marked by abundant radiolarian tests occurred during deposition of the Capistrano Formation, and (4) the Fernando Formation was deposited at lower bathyal through outer shelf depths. Stratigraphic variations of gross faunal parameters including foraminiferal number, radiolarian number, planktonic-benthonic ratio, and percent of displaced benthonic species provide additional quantitative evidence of the shelf-to-basin-to-shelf paleobathymetric history of this sequence. Ranges of individual species of benthonic Foraminifera allow the Saucesian, Relizian, Luisian, Mohnian, Repettian, Venturian, Wheelerian, and Hallian Stages to be recognized. Cool to warm temperate planktonic foraminiferal biofacies dominated by *Globigerina concinna* sl. and *G. angustiumbilicata* occur in the Topanga Formation and lower Monterey Shale. Temperate planktonic assemblages dominated by *G. bulloides* sl. dominate in the upper Monterey Shale and parts of the Fernando Formation. A subarctic biofacies containing sinistral populations of *G. pachyderma* is present at discrete intervals within late Miocene, middle and late Pliocene, and early Pleistocene sediments, whereas a subtropical-warm temperate biofacies dominated by *Globoquadrina dutertrei* is restricted to the early Pliocene. Ranges of critical planktonic Foraminifera including *Globorotaloides trema, Globorotalia mayeri, G. menardi, G. crassaformis, G. inflata, G. truncatulinoides, "Orbulina universa," "Sphaeroidinella dehiscens,"* and the radiolarian *Prunopyle titan* provide additional criteria for age assignment and correlation with the paleomagnetic-radiometric time scale.

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ENERGY AND OUR FOSSIL FUELS

America has a high energy society, and as our demand for energy increases, our reserves of fossil fuels steadily decline. Oil provides 43% of our energy needs, natural gas 33%, electric power 20%, and coal 4%. Although electric power provides only one fifth of our energy needs, 83% of all electricity is created by burning the fossil fuels. Hydro (16%), nuclear (1%), and geo-