ments which is assigned to the *Bulimina uvigeriniformis* Zone of the lower Mohnian Stage. The *Bulimina uvigeriniformis* Zone can be readily divided into an older subzone designated the *Concavella gyroidinaformis* Subzone and a younger subzone here designated the *Brizalina woodringi* Subzone. The top of the older subzone is marked by the last occurence of *Concavella gyroidinaformis*; the *Concavella gyroidinaformis* Subzone is approximately 210 ft thick at this locality. The overlying *Brizalina woodringi* Subzone is based on the continued occurrence of *Bulmina uvigeriniformis* after the extinction of *Concavella gyroidinaformis*. This subzone is approximately 115 ft thick with its top, and the top of the lower Mohnian Stage, marked by the last occurrence of *Bulimina uvigeriniformis*.

Above the lower Mohnian Stage at Newport Lagoon is approximately 470 ft of foraminiferal Monterey Shale assigned to the upper Mohnian Stage. Among the many species present are *Bolivina hughesi, Brizalina benedictensis, Brizalina decurtata, Brizalina giradensis, Brizalina granti, Cassidulinella renulinaformis* and *Discorbinella valmonteensis*. No foraminifers were found in the uppermost 100 ft of Monterey Shale which overlies the sediments of demonstrable Mohnian age.

Cyclococcolithina neogammation, a fossil coccolith, was found to have its last occurrence coincident with the top of the lower Mohnian *Concavella gyroidinaformis* Subzone at Newport Lagoon. Another coccolith, *Reticulofenestra pseudoumbilica*, was observed to have its first occurrence at the base of the lower Mohnian *Brizalina modeloensis* Zone. The last occurrence of *Sphenolithus heteromorphus* was confirmed to be in the uppermost Luisian Stage.

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EXPLORATORY TECHNIQUES ALONG MARKLEY GORGE, SACRAMENTO VALLEY, CALIFORNIA

The Markley gorge channel, an ancestral Sacramento river channel, is in the central part of the Sacramento Valley of California. This fossil channel was cut subaerially during late Eocene time and filled in a marine to marginal marine environment during late Eocene and Oligocene times. Before the late Eocene transgression, an early mature stage of stream erosion was reached. Terraces, islands, meanders, and tributaries can be delineated by subsurface methods. The slope along the channel banks ranges from 6 to 36°. Variations of the slope along the channel banks depend on the existing faults, structures, and drainage configuration. Because the gorge fill is unconformably overlain by Miocene continental sediments, the original relief is not known, but it at least exceeds 3,000 ft. This channel has been traced in the subsurface more than 80 mi and has a maximum width of 10 mi. The north end of the gorge is the Wheatland Formation cropping out at the foot of the Sierra Nevada Mountains near the town of Marysville. The south end of the gorge is in the Montezuma basin where gorge sediments merge with deeper water sediments of the Sidney Shale and shallower water sediments of the Kirker Formation.

The gorge fill consists predominately of shale with minor amounts of sandstone and conglomerate which have considerable lateral and vertical lithologic variation.

Truncation of the underlying Eocene, Paleocene, and Upper Cretaceous formations by the Markley gorge combine with local structure to form commercial gas accumulations. Examples are: Maine Prairie (75 Tcf, 1,020 BTU); Liberty Island (24 Tcf, 988-996 BTU); Millar (18 Tcf, 980 BTU); Todhunters Lake (57 Tcf, 890-897 BTU); and Greens Lake (8 Tcf, 830-850 BTU). Along the north part of the Markley gorge, in the proximity of the city of Sacramento, gas traps exist in westerly dipping Upper Cretaceous sandstone reservoirs. These reservoirs occur in reentrants and islands within the predominantly shale-filled gorge. These spurlike reentrants were created by easterly trending tributaries which intersected the main southerly trending Markley channel.

Techniques in locating Upper Cretaceous reentrants and islands are well control, drainage pattern analysis, gravity profiling and mapping, seismic profiling and mapping, and differential compaction features.

An understanding of the geologic history of the gorge and of the truncated sediments is also necessary to locating potential future gas fields along the gorge.

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FORMATIONS AND AGE—SUBDIVISIONS OF WEST COAST MIDDLE TERTIARY

Equivalents of Lyell's Tertiary subdivisions were recognized early within the upper part of the West Coast marine sedimentary sequence. Boundaries between these series, however, have long remained controversial. The presence of the Eocene here was established clearly once the disputed presence of ammonites in the Pacific Coast Eocene had been resolved in the negative. The scene was thus set for the eventual recognition of Schimper's Paleocene in what had originally been termed lower Eocene Martinez, as distinguished from the first recognized, and higher, Eocene near Tejon Pass, California. The Pliocene-Pleistocene boundary soon was clarified, at least to the extent that this boundary had ever been clear in the typical terrain of Italy. On the West Coast, the tendency has been to place it between the two faunal zones in the Santa Barbara Formation (*i.e.*, at the base of the original lower San Pedro), or more recently, following Woodring's recommendation, at the base of the Santa Barbara and its age-equivalents.

In the middle Tertiary, however, the lower and upper boundaries of the Miocene, and subsequently of the Oligocene, were not as readily drawn. Some workers have placed the base of the Miocene as low as the lowest beds of the Vaqueros Formation, a Blakeley Oligocene age-equivalent and placed the top to include even the Pliocene Etchegoin Formation.

The persistence on the West Coast of these middle Tertiary boundary problems has been due in part to the common presence in that stratigraphic interval of the organic Monterey Shale, with its sparse and commonly undiagnostic marine megafaunal assemblages. Another source of confusion, as pointed out by Schenck, has been the failure of many workers to note the qualification placed by Conrad on his age-evaluation of those megafossils found in the strata defined subsequently as the Vaqueros Formation; in effect, Conrad had simply said that those fossils indicated an age closer to Miocene than to the Eocene age of Blake's fossiliferous boulder from Tejon Pass. Finally, clarification of these middle Tertiary boundary problems was hampered further by the prevalent use of formational names for time-rock subdivisions of Lyellian series-epochs. These subdivisions were defined on the basis of nothing more than the presence of a fauna or a species thought, on the basis of reconnaissance work, to be an "index species," at some zone within such a formation.

Facies problems, too, were part of the trouble. The term "Temblor-Monterey" came into use when fossiliferous strata of these two formations were seen to interdigitate superpositionally. The major early work on the relations among the Monterey, Vaqueros, and Temblor Formations, attempted to resolve the problem by turning the Monterey into a middle Tertiary time-rock term of series magnitude. This legalism, both confusing and unnecessary, persisted for more than 20 years before the Monterey formally was restored to its original formational status by the U.S. Geological Survey. Meanwhile, terms such as Salinas and Maricopa had been coined for local developments of the Monterey Shale.

Because microfossils are commonly abundant in the offshore, generally finer grained age-equivalents of the mollusk-bearing strata, micropaleontology has played a leading role in the clarification and redefinition of these series subdivisions. Thus, employing the criteria for biostratigraphic correlation summarized by Berry, the type San Lorenzo Formation has been shown to be Eocene at its lower zones, and equivalent in age to the Oligocene lower Vaqueros Formation in its upper beds. In turn, the Vaqueros at its type locality is seen to be in part age-equivalent to the generally still younger Temblor Formation. Locally, the lower parts of the Monterey Shale are correlative to parts of the Temblor, whereas stratigraphically higher intervals have been shown by the late George Richards to be age-equivalents of the type Santa Margarita Formation. Further, the type Santa Margarita is in part age-equivalent to the partly coarse clastic typical Modelo and Puente Formations of southern California, which in turn are partial age-equivalents of the organic shales of the Monterey. The type Santa Margarita is also in part age-equivalent to the Rodeo-Briones-San Pablo sequence of the Berkeley Hills.

Refined microfaunal studies thus have made possible significant progress in our understanding of the complex stratigraphic relations of the West Coast middle Tertiary formations. A residue of confusion remains, however, which can be traced in part to the persistent use of reconnaissance "index species," as well as the dual use of names for the descriptive formational terminology and the interpretive time-rock terminology.

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ECOLOGY AND THE ENERGY INDUSTRY

California is dependent on oil and gas for 98% of its total energy needs. Petroleum is the state's number one mineral commodity, with an annual value of $1.2 billion. Industry's payroll is $1.3 billion, and its tax bill to state and local government is $274 million.

Statewide regulation of the industry, which started in 1915, was directed primarily toward preventing waste and damage. Numerous governmental agencies are now engaged in regulation directed at protection of the environment; at the federal level there are five agencies, at the state level, six. The petroleum resource must be utilized, but at the same time extraction and refining must have minimal effect on the environment.

The "oil patch" philosophy is out of date. Most industry people do not think sumps, derricks, or piles of tubing are ugly, but many other people do. It can be shown that a spill in the ocean has no lasting effect on the biota, but it is a disaster to the person that gets oil on his feet. Industry has done a remarkable job in responding to the new environmental philosophy by starting programs to clean up sumps, beautify drill sites, and install pollution-prevention devices. To clean up the "oil patch" is not just good public relations; it is a necessity in order to stay in business.

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HISTORICAL GEOLOGY OF THE PACIFIC

The development over the past few years of a high-resolution biostratigraphic scheme based on joint occurrences of Radiolaria, nannofossils, and planktonic Foraminifera enables us to make new progress on problems of paleogeography, paleoceanography, sedimentation, and tectonics in the Pacific. Results from the Deep Sea Drilling Project, combined with other geologic and geophysical data, suggest the following post-Jurassic history for the Pacific plate.

Sedimentary facies patterns reflect a northward motion of the plate relative to the equatorial zone of high biologic fertility, as well as progressively increasing sea-floor depths as newly formed crust moves away from the East Pacific Rise. Superimposed on these gross patterns are evidences of fluctuations in the width of the zone of high productivity, changes in the calcium carbonate compensation depth, and variations in the intensity of bottom-water circulation.

Extensive Early Cretaceous volcanism inundated much of the older western part of the plate and was succeeded by the building and subsidence of long chains of seamounts as the plate moved northwestward, possibly over hot spots beneath the lithosphere. Comparison of plate motion, as indicated by equatorial-zone sediments, with motion indicated by trends and age progressions in seamount chains leads to the hypothesis of a south-moving counter flow in the asthenosphere.

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LATE MIOCENE AND EARLY PLIOCENE CORRELATIONS IN CALIFORNIA PROVINCE

The late Miocene of California was divided into four Oppelian zones by Kleinpell. He grouped these zones into larger time-stratigraphic units, the Mohnian and Delmontian Stages. As a discipline for these zones and stages, Kleinpell used benthonic foraminifers and larger invertebrates in continuous stratigraphic sequences. The *Bolovina modeloensis, Bulimina uvigerinaformis*, and the *Bolovina hughesi* Zones represent the Mohnian, and the *Bolovina obliqua* Zone represents the lower half of the Delmontian Stage. No foraminiferal zone was designated for the upper half of the Delmontian Stage. These two stages and four foraminiferal zones can be found in continuous stratigraphic (superpositional) relation with demonstrable middle Miocene, late Luisian, faunas below and early Pliocene faunas above in the following areas: Palos Verdes Hills, Huasna-Nipomo, Monterey, San Pablo Bay area. Additonal continuous stratigraphic sections representing the middle Miocene and early late Miocene, the Luisian and Mohnian Stages, are found in Newport Beach; the Luisian, Mohnian, and Delmontian Stages are found in the Naples Bluff section; the Mohnian and Delmontian Stages are found in Woodland Hills (type Mohnian); the Delmontian and early Pliocene are found in the Reef Ridge area. All of these stratigraphic sections contain one or more of the following groups of microfossils: diatoms, radiolarians, silicoflagellates, and planktonic foraminifers. These microfossil groups, together with the benthonic foraminifers and larger invertebrates corroborate Kleinpell's original zonal sequence.

Membership Applications Approved for Publication

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute election, but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa, Oklahoma 74101. (Names of sponsors are placed in parentheses.)

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