ments which is assigned to the *Bulimina uvigerinaformis* Zone of the lower Mohnian Stage. The *Bulimina uvigerinaformis* 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 uvigerinaformis* 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 uvigerinaformis*.

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 clari-