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CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY AND PALEOECOLOGY IN OLIGO-MIOCENE OF CALIFORNIA

Calcareous nannoplankton are abundant in some rocks assigned to the California microfaunal stages. Most species are stratigraphically long ranging, although some have restricted stratigraphic ranges in low-latitude tropical regions. These species permit partial correlation of the California stages with the widely recognized plankton biostratigraphic zones of the tropics.

The upper Zemorrian is correlative with the *Sphenolithus distentus* through the lower *Triquetrorhabdulus carinatus* (NP 24-NN1) zones (upper Oligocene) the Saucesian with the upper *T. carinatus* through the lower *Helicopontosphaera ampliaperta* (NN1-4) zones (lower Miocene), the Relizian with the upper *H. ampliaperta* through the lower *S. heteromorphus* (NN4-5) zones (lower-middle Miocene), the Luisian with the upper *S. heteromorphus* through *Discoaster kugleri* (NN5-7) zones (middle Miocene), and the Mohnian with the *Catinaster coalitus* through *D. calcaris* (NN8-10) zones (middle-upper Miocene).

The species diversity of nannofossils in the California Oligocene-Miocene rocks is low. Like the planktonic Foraminifera from the same rocks, the nannofossils are analogous to species now living in the modern transitional water mass off California. There are no elaborate species as in the tropics and the floras tend to be dominated by single species (*i.e., Coccolithus*). These observations indicate that California was under the influence of a current flowing southward, with velocities nearly that of the modern California Current. The dominance of the assemblages by a single species, as well as other evidence from the rocks, indicates that upwelling was likely as important during the Miocene as it is today.

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SEDIMENTOLOGY OF TYPE TEJON FORMATION OF SAN EMIGDIO MOUNTAINS, CALIFORNIA

The type Tejon Formation of the San Emigdio Mountains is a marine clastic sedimentary sequence of middle and late Eocene age that was deposited primarily in a variety of shallow-marine environments during an eastward transgression followed by a westward regression. It lies unconformably on a pre-Tertiary crystalline basement complex and is overlain by the marine San Emigdio Formation and the nonmarine Tecuya Formation. It is more than 4,000 ft thick in the center of the range, but thins and grades laterally eastward into nonmarine conglomerates and sandstones. Paleocurrent data indicate dominant transport of sediments toward the west.

Marks defined four members of the Tejon Formation (in ascending order): Uvas Conglomerate, Liveoak Shale, Metralla Sandstone, and Reed Canyon Siltstone. The Uvas contains medium- to large-scale cross-stratification, ripple markings, well-sorted planar-stratified beach-type sandstones, large burrows, boulder beds, locally abundant megafauna, and was deposited adjacent to the transgressive shoreline. The Liveoak shale is primarily an extensively bioturbated silty shale with locally abundant microfauna and abundant sandstone interbeds in its lower and upper parts; it grades laterally eastward from a deep-water shale into shallow-marine sandstones. The Metralla Sandstone Member is typically a bioturbated silty fine-grained sandstone which contains interbedded conglomerates, medium- and large-scale cross-stratification, ripple markings, beach-type sandstones, and abundant megafauna in its eastern exposures where it was deposited adjacent to the regressive shoreline; however, on the west it grades laterally into thinly bedded flyschlike sandstones and shales deposited in deeper water. The Reed Canyon Siltstone Member is in an extensively bioturbated thin unit that locally contains some megafauna, microfauna, and thin coal interbeds.

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SUBSURFACE STUDY OF FORAMINIFERAL FAUNA OF VAQUEROS SANDSTONE, RINCON SHALE, AND LOWER MONTEREY FORMATION, FROM ELWOOD OIL FIELD, SANTA BARBARA COUNTY, CALIFORNIA

Core samples taken from Texaco's Bishop A-1 well in the Elwood oil field in Santa Barbara County, California, penetrated 4,350 ft of section consisting of sediments of the lower Monterey Formation, the Rincon Shale, and the Vaqueros Sandstone. The two uppermost samples recorded at 558 and 561 ft contained Foraminifera indicating a Luisian age. The Relizian was represented by a thickness of about 700 ft. Approximately 1,500 ft of Saucesian age sediments were present. The upper Zemorrian was represented by 190 ft of section. The bottom 900 ft of preponderantly sandstones proved to be barren of Foraminifera. A foraminiferal faunule of late Zemorrian age, 138 ft below the Vaqueros/Rincon contact indicated an upper bathyal depth in this particular area, as opposed to much shallower conditions, indicated elsewhere at the time of deposition of the Vaqueros Sandstone. Bathyal conditions persisted throughout the subsequent deposition of the Rincon Shale and lower Monterey Formation.

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MIOCENE VERTEBRATE GEOCHRONOLOGY OF WEST COAST OF NORTH AMERICA

Part 1—*Nonmarine vertebrates and marine-nonmarine tie-ins* by Donald E. Savage.

With the conviction that an agreement regarding precise Miocene-Pliocene and Oligocene-Miocene boundaries within the stratal succession of the West Coast region of North America is less important than the establishment of refined age and subage correlations within this region, we assign the following to the Miocene Epoch:

Latest Miocene (10-12 m.y. ago) Clarendonian mammal "age," Cerrotejonian and Montediablan mammal ages, San Pablo (Cierbo-Neroly) of Santa Margarita mega-invertebrate "ages," Mohnian and? Delmontian (in part?) foraminiferal ages.

Late to middle Miocene (12-17 m.y. ago) Barstovian mammal "age," Briones and upper part of Temblor mega-invertebrate "age," later part of Saucesian plus Relizian and Luisian foraminiferal ages.

Middle to early Miocene (17-21 m.y. ago) Hemingfordian mammal "age," earlier part of Temblor mega-invertebrate "age," middle part of Saucesian foraminiferal age.

Earliest Miocene (21-26 m.y. ago) Arikareean mammal "age" (early part may be Oligocene), Vaqueros-Temblor transition plus Vaqueros or Vaquerosian mega-invertebrate "ages," earliest part of Saucesian plus later part of Zemorrian foraminiferal ages.

The Arikareean, Hemingfordian, Barstovian, and Clarendonian "ages" are easily recognized from joint occurrence of fossils representing certain genera of insectivores, rodents, carnivores, mastodonts, horses, rhinos, oreodonts, camels, and other groups of mammals. We are now concerned chiefly with deciphering a more precise time-stratigraphic range for each of the species. We intend to establish a well-disciplined (vertebrate) paleontologic stratigraphy, which can lead to zonation within the basins of nonmarine deposition.

Unfortunately, fossils of land vertebrates are scarce in districts of littoral deposition, but the "classic" sections in the Tejon Hills, San Francisco East Bay, North Coalinga, Sharktooth Hill-Pyramid Hill, Caliente Range-Cuyama Valley, Tecuya-San Emigdio Range, South Mountain, and Santa Ana Mountains districts provide tie-ins between the generalized ma-