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TERRESTRIAL TO MARINE TRANSITION OF HEAVY MINERALS

Heavy-mineral analyses show that the main supply of sand for the beaches and sea floor off Southern California is provided directly by the adjacent land areas. The longshore movement of sand is only of local importance because obstacles along the coast, such as submarine canyons and points of land, limit the longshore movement of sand to small segments along the coast. A close examination of a coastal segment shows marked differences between Recent marine and nonmarine sediments, and suggests that longshore drift of sand within a segment is prominent. The concept of time, as used in correlation of heavy-mineral samples, should include consideration of source rocks and drainage patterns, and should not be based solely on depositional features.

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CALIFORNIA OFFSHORE GEOLOGY AND EXPLORATION

During the years 1948 to 1961 the oil industry spent more than $150,000,000 exploring the submerged oil potential of offshore California. Seven oil or gas accumulations were discovered, but none appears to be of sufficient size to yield a significant profit to the operator. Prior to 1948 four giant California offshore oil fields (Elwood, Rincon, Wilmington, and Huntington Beach) had been developed with total estimated ultimate reserves exceeding 1,500,000,000 barrels. Published reports had outlined unexplored offshore basins with vast volumes of sediments. Producing fields onshore but close to the ocean are estimated to yield ultimate recoveries ranging from 150,000 to 550,000 barrels per acre.

Hypothetical offshore extensions of these producing trends led to enthusiastic multi-million-barrel estimates of the offshore potential. In 1953 the "Tide and Submerged Land Act" triggered a hectic exploration campaign. Sophisticated, costly tools were developed. Estimates indicate that 40,000 miles of seismic lines were shot. Several hundred coreholes were drilled. Bonus bids at State offshore sales reached new highs in 1958 when approximately $55,000,000 was paid for five parcels of land at prices ranging up to $6,175 per acre. Drilling during the following year resulted in four discoveries. From the oil finders' view, 1959 was a very successful year in California exploration history but from the economic viewpoint the results do not appear impressive.

Many major companies continue the offshore campaign with improved methods and tools, yet the California offshore potential remains largely unexplored. Economic development of this oil to serve our companies and the exploding West Coast population requires reassessment of exploration methods, more advancements in technology, less expensive drilling and completion techniques, a better understanding of offshore economics, and more realistic appraisals of individual prospects.

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CENOZOIC FORAMINIFERAL ZONATION AND BASINAL DEVELOPMENT FOR PART OF PHILIPPINES[1]

Foraminiferal analyses of Cenozoic strata of Central Valley, Luzon and southern Iloilo, Panay, indicate a general planktonic zonation for the middle and later Cenozoic which is similar to that recognized in equivalent strata of other tropical areas of the world.

There is generally parallel basinal development in Central Valley and Iloilo beginning in the Late Oligocene-Early Miocene interval. The cycle commenced with shelf conditions and orbitoidal facies giving way upward and with time to increasingly deeper-water facies of the bathyal zone. Maximum water depths of at least 1,000–2,000 meters were attained during the Miocene as indicated by *Pullenia bulloides*, *Osangularia bengalensis*, *Laticarinina pauperata*, and others. The parallel history in the two areas stops in the Late Miocene when Central Valley experienced prominent basin-filling and a transition to shallow-water paralic facies. In Iloilo, deep basinal conditions prevailed into the Middle Pliocene before basin-filling occurred.

The more complete planktonic sequence is that of Iloilo. Late Oligocene time is suggested by *Globigerina ciperoensis* in at least one part of the basin. Early Miocene is represented by a lower *Globigerina dissimilis* zone and an upper *Globoquadrina rohri* zone. Middle Miocene time is indicated by a lower *Globorotalia fohsi fohsi* left-coiling zone giving way upward to the right-coiling populations of *Globorotalia fohsi robusta* and *Globorotalia menardii* (primitive form). From bottom to top, the Late Miocene zones include a basal *Globoquadrina dehiscens advena* zone, a *Globoquadrina altispira altispira* zone (top of occurrence), a *Globigerina nepenthes* zone (top of occurrence), and at the top a *Globoquadrina altispira globosa-Globoquadrina dehiscens dehiscens* zone.

Early Pliocene populations are characterized by *Sphaeroidinella dehiscens dehiscens* and *Globigerina eggeri*. Middle Pliocene populations lack these but include an abundance of *Globorotalia truncatulinoides* and *Globorotalia menardii*. *Pulleniatina obliquiloculata* is common to abundant in the Middle and Early Pliocene and rare in the Late Miocene. It is dominantly right-coiling in the Middle and most of the Early Pliocene, left-coiling at the base of the Pliocene, right-coiling and rare in the latest Miocene, and mostly left-coiling and very rare below.

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PHYLOGENETIC TRENDS IN MISSISSIPPIAN *Pentremites*

Recognition of thecal modifications in the Mississippian blastoid *Pentremites* through geologic time has expanded its stratigraphic usefulness. Of particular stratigraphic significance are changes in the exterior shape, in the cross-sectional outline of the ambulacra, and in the number of hydrospire folds beneath each ambulacral side. *Pentremites* of Osage and early Meramec age have nearly flat bases, slightly convex ambulacra, and a low number of hydrospire folds per ambulacral side (normally three). In the late Meramec two divergent phylogenetic lines occur: *Pentremites* with flat or nearly flat bases and those with pyriform exterior shape. Both lineages persist to the end of the Mississippian. The lineage characterized by species with flat-based thecas have flat to slightly convex ambulacra from the late Meramec to the early Chester, and have progressive concavity of the ambulacra from the middle to late Chester. The number of hydrospire folds per ambulacral side in flat-based species changes from three in the late Meramec to four or five in the middle Chester; surprisingly, late Chester forms have a reduced number of folds (commonly three to four). The

[1] Publication authorized by San Jose Oil Company, Manila, Philippines.