trending belt of high density Tertiary igneous rocks and low density tuffs or pyroclastic volcanic and sedimentary rocks along the southern margin of the basin.

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Distribution and Depositional History of Neogene Phosphorites Along Pacific Coast of North America

Pelletal and nodular phosphorites occur commonly to abundantly in neritic (shelf) and bathyal (slope) deposits of uppermost Oligocene (25 Ma) to upper Miocene (10 to 7 Ma) age from 23°N on the peninsula of Baja California, Mexico, to 39°N near Point Arena, northern California, encompassing a belt of deposition about 1,430 mi (2,300 km) in length. In addition, pelletal phosphorite sands are commonly present within adjacent middle and lower bathyal deposits of similar age range representing redeposited material in conduits, feeding basins, and submarine fans. In some areas, pelletal phosphorites reach 200 ft (60 m) in thickness. Mining of Miocene phosphorites is now well under way in Baja California. The age of peak formation and accumulation of Pacific Coast phosphorites appears to become younger from south to north implying variations in patterns of upwelling and/or eustatic, climatic, and tectonic control of shelf character and flux of terrigenous clastics to the margin. Later reworking of the Miocene deposits has allowed reconcentration of the phosphorites in adjacent Pliocene, Pleistocene, and Holocene neritic units.

Paleontologic, isotopic, and sedimentologic evidence indicate that the widespread Neogene phosphorites formed under a special set of climatic, oceanographic, eustatic, and tectonic conditions associated or coincident with a major climatic threshold occurring in mid-Miocene (15 Ma) time and commencement of a glacial climatic state. Three key factors were apparently responsible for allowing the unusually prolific formation of Miocene phosphorites as well as simultaneous widespread deposition of diatomaceous sediments in this region including (1) vigorous upwelling of nutrient-rich water and accelerated productivity as a function of deteriorating Neogene climate, (2) associated development of intense oxygen minima impinging against the various slope and shelf areas creating appropriate biogeochemical conditions for phosphorite precipitation, and (3) the absence or severe reduction in delivery of terrigenous clastics to sites of phosphorite precipitation as a function of Neogene eustatic, climatic, and tectonic events.

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Diagenetic Relationships Between Inorganic Matrix and Kerogen in Wilcox Group, Southwest Texas

Eighteen core samples of shale from the Eocene Wilcox formation in the Gulf Coast of Texas were extracted in organic solvents and digested in hydrofluoric acid in order to examine the bitumen and kerogen fractions. The kerogen was found to be largely terrigenous in origin with stable carbon isotope values ranging between -26 and -29 ppt (PDB). Smectite dehydration in the area begins at less than 1 km depth (60°C). At the depths of initial petroleum generation (1.5 km and 85°C), expandable layers comprise only 30% of the illite-smectite clays. It therefore does not seem likely that water expelled during smectite dehydration can mobilize significant amounts of hydrocarbons.

Geopressuring of pore fluids occurs toward the end of the main stage of petroleum generation, below 3 km. In the gas zone, hydrocarbon concentrations increase between 3.6 and 4.6 km from a low of 7 mg/gC to 15 mg/gC. Two samples in this region showed anomalously high concentrations of hydrocarbons (100 mg/gC). These observations may indicate subsurface migration of hydrocarbons, perhaps in a methane and carbon dioxide-rich fluid phase. In addition to facilitating hydrocarbon migration, carbon dioxide generated from kerogen may also be involved in the precipitation of ankerite cement in sandstones below 2.5 km.

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Exploring for Subtle Sandstone Channels By Use of Electrical Geophysics

Electrical methods can be used directly as a resistivity tool which not only defines structure but also provides information, such as rock type, fluid content, and porosity, necessary to resolve lithologic and stratigraphic problems.

To help meet the challenge of today's petroleum exploration problems, a multi-methodology electrical resistivity system has been developed. This system uses various source-receiver arrays and multiple source and receiver types.

Seismic roll-along cables and an eight-channel digital recording system are used to achieve rapid field coverage. Measurements are made in profile every 220 ft (67 m).

Five decades of frequency can be covered to produce soundings from the surface to a maximum of 30,000 ft (9,100 m) in depth. A powerful transmitter is used to obtain near-zone (late time) and far-zone (early time) electromagnetic soundings as well as DC soundings. Magnetotelluric measurements are used to reach depths below 20,000 ft (6,100 m) if necessary.

The data are displayed as profiles of closely spaced pseudo E-logs and induction logs that are correlatable to existing well logs.

Two case histories of exploration for subtle sand traps include one located in the D J basin of Colorado. The other describes the detection of a 30 ft (9 m) sand sequence at a depth of 2,500 ft (760 m) on the eastern shelf of the Permian basin in west Texas. The approaches used in these case histories have direct application to many problems of the central valleys of California.

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Lithostratigraphy and Diagenesis of Monterey Formation near Ojai, California

Lithostratigraphy and diagenesis of the middle Miocene Monterey Formation were studied at seven localities parallel with the axial trend of the Miocene Santa Barbara basin between Goleta and the North Sulphur Mountain area of the Ojai oil field in Santa Barbara and Ventura Counties, California. The lithologic sequence of the Monterey Formation does not change markedly within the area except for the addition of discrete sand layers, as much as 1.6 ft (0.5 m) thick, in the east near the Ojai oil field. The most complete, accessible, and representative section studied is 1.2 mi (2 km) south of Oakview, where the formation can be divided into five units, which correlate well to C. M. Isaacs' five informal members along the Santa Barbara coast. At the base of the Monterey, distinctive, resistant, thick beds of siliceous calcareous shale and porcelanite are interbedded with soft poorly exposed calcareous shale containing sparse silica. Above this basal unit is a sequence dominated by very poorly exposed, organic-rich calcareous shale, mostly containing sparse silica, and in some layers, abundant phosphate. Overlying is a transition unit within which the poorly exposed organic-rich calcareous shale is interbedded with resistant calcareous chert and porcelanite. The upper two units both consist of interbedded porcelanite, siliceous mudstone, and chert; however, the uppermost unit is noncalcareous and has interbedded tuff layers ranging in thickness from 1 cm to more than 30 cm.

The regional pattern of diagenesis was evaluated by determining the diagenetic maturity of a single stratigraphic unit (the transition unit) at each of the seven localities. At Goleta the section is completely diatomaceous (opal-A), whereas preliminary results indicate that diagenetic quartz as well as opal-CT are present in the North Sulphur Mountain area. Although this pattern is complicated by local structural deformation, diagenesis generally increases eastward from Goleta producing a trend opposite to that in the Santa Barbara coastal area, where diagenetic maturity increases westward from Goleta. This regional pattern of diagenesis, influenced mainly by Pliocene depositional trends, is consistent with paleogeographic reconstruction of the post-Miocene breakup of the ancestral Santa Barbara basin.

KELLOGG, WILLIAM C., Kellogg Exploration Co.

Airborne Geophysical Surveying; Don't Forget to Look at the Data

The writer's experiences in airborne geophysical surveying date from the late 1940s to the present. Misconceptions about airborne geophysical surveying, errors in its use, and the digital computer have all affected the attitudes and conclusions made by interpreters.

KELLOGG, WILLIAM C., Kellogg Exploration Co.

Current Technology in Airborne Radioactivity Surveying

Airborne gamma-ray surveying was used during government projects in the ERDA and NURE programs. These programs are now drawing to a close.

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Sedimentologic, Stratigraphic, and Tectonic Significance of Neogene Sedimentary Megabreccias, Western Salton Trough, California

Two massive, very thick (165 ft or 50 m), essentially tabular sedimentary megabreccia beds, exposed in the Vallecito Mountains, Split Mountain, and Fish Creek Mountains, are comprised of very poorly sorted, large boulders up to 33 ft (10 m) in diameter, suspended in a comminuted silty sand matrix. Many boulders can be visually reconstructed, like pieces of a giant jigsaw puzzle. Upper bed boundaries are hummocky, and lower bed contacts are undulatory. Where present, subjacent sedimentary strata are typically disrupted, locally deformed into mega-flaps (-flames) and also locally occur as large rip-up blocks. Each megabreccia bed is thought to represent a catastrophically emplaced, air-cushioned landslide, perhaps triggered by a strong seismic event.

The stratigraphic position, paleotransport data, and provenance suggest that these catastrophic landslides were deposited during mid-Neogene tectonic readjustments in the Salton Trough. The lower megabreccia bed culminates early Miocene nonmarine sedimentation in a Basin-Range(?) rift basin and was derived from the Vallecito Mountains and transported eastward. The upper megabreccia bed occurs within the lower Pliocene basal marine and nonmarine deposits of the Gulf of California, and is thought to have been transported southward from a "phantom-porpoise" structure of the San Jacinto fault zone, indicating a minimum early Pliocene age for the San Jacinto fault.

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Sedimentology of Late Paleocene through Middle Eocene Poway Clast-Bearing Marine Depositional System, Southern California Borderland

Remnants of a late Paleocene through middle Eocene depositional system are preserved in the stratigraphic record on San Miguel and Santa Cruz Islands and in coastal San Diego.

On San Miguel Island, upper Paleocene starved-basin mudstones were deposited on Maestrichtian middle submarine fan sandstones. Lying conformably on the Paleocene deposits is a lower Eocene sequence of starved-basin to fan-fringe mudstones and Poway rhyolite-bearing, middle submarine-fan depositional lobes of conglomerate. These facies are in turn overlain by an upper lower Eocene through lower middle Eocene retrogradational sequence of shale-filled channels, levees, fan-fringe, and starved-basin deposits. The remainder of the middle Eocene strata are braided, middle submarine-fan sandstones and mudstones.

Paleogene sedimentation on Santa Cruz Island began in the late Paleocene and continued uninterrupted through the entire Eocene Epoch. Upper Paleocene strata are composed of detritus washed from paralic environments to the east-northeast. These inner shelf deposits form a sequence of sublittoral sheet sandstones which coarsen upward into an interval of Poway rhyolite-bearing channelized conglomerate. Lower Eocene outer shelf mudstones overlie the conglomerate and the remainder of the depositional facies record sedimentation under progressively deepening marine conditions. These environments include passive slope, fan-fringe, and inner submarine-fan channels containing Poway rhyolite-bearing conglomerate.

In San Diego, the Mount Soledad Formation is composed of six sedimentary facies: (1) paralic (upper estuarine), (2) deltaic, (3) alluvial fan and fluvial channels, (4) submarine canyon head, (5) inner fan channel, and (6) slope. Poway rhyolite clasts are found in facies 2 through 5.

Based primarily on lithostratigraphic correlations, deltaic facies of the Mount Soledad Formation are proximal equivalents to the sublittoral sand sheet facies on Santa Cruz Island. Alluvial fan, fluvial channel, submarine canyon head, and inner submarine-fan conglomerate portions of the Mount Soledad sequence are equivalent to lower Eocene middle submarine-fan conglomerates on San Miguel Island.

The Paleogene sequence of facies on San Miguel and Santa Cruz Islands are equated lithostratigraphically to equivalent facies of the Mount Soledad Formation. Comparison of the changes in depths of deposition of the vertical sequence of facies with Tertiary eustatic changes suggests that the succes-