systems result in sediment bypassing the old middle-fan region. At the lower end of the main valleys on Monterey fan, channels and isolated depressions are observed but the characteristic morphology of suprafans is not clearly developed. Large sediment waves are present on the upper fan valley levee and at various locations on Monterey fan, but are absent on the smaller Navy and La Jolla fans.

HICKMAN, CAROLE S., and ELIZABETH A. NESBITT, Univ. California, Berkeley, CA

Holocene Mollusk Distribution Patterns in Northern Gulf of Alaska

Three recurring mollusk association types are defined in the northern Gulf of Alaska: (1) the shallow-water *Yoldia-Siliqua-Lyonsia* sand association; (2) the shallow to intermediate depth *Cyclocardia*-boreal turrid mud association (with a typical phase developing in offshore muds and a *Clinocardium-Nitidella* nearshore mud phase developing in Yakutat and Icy Bays); and (3) the deep-water *Cadulus*-thin shelled protobranch mud association. Associations are defined from 148 bottom samples containing 113 species.

Substrate exerts a strong influence on shallow-water species composition. An unidentified depth-related factor, independent of substrate type, influences both species composition and taxonomic structure. Dramatic changes in taxonomic structure that occur with depth on fine-grained glacial marine sediments in the Gulf of Alaska provide a model for paleobathymetric interpretation of high latitude late Cenozoic fossil mollusk faunas. The major structural shifts include: decrease in the proportion of heterodont, suspension-feeding bivalves; increase in the proportion of thin-shelled, deposit-feeding protobranch bivalves; and increase in the proportion of carnivorous neogastropods, particularly small-shelled, toxoglossate turrids.

The most abrupt and most readily recognized faunal break occurs at 200 m, separating the typical *Cyclocardia*-boread turrid mud association from the *Cadulus*-thin shelled protobranch mud association. Although the two associations have species in common, many species drop out as the 200-m isobath is approached and others appear at or not far below it. More precise definition of this faunal break should be explored because of its potential application in paleoecologic analysis.

INGLE, JAMES C., and GERTA KELLER, Stanford Univ., Stanford, CA

Benthic Foraminiferal Biofacies of Eastern Pacific Margin Between 32°S and 32°N

Quantitative analyses of benthic foraminifera from the Peru-Chile Trench area, off Central America, and the Gulf of California allow assessment of general faunal trends between 32°S and 32°N along the eastern margin of the North Pacific and South Pacific. Six widespread faunal divisions can be recognized in this broad region reflecting major variations in substrate and water-mass character across the neritic-to-abyssal gradient. The 50-m isobath represents the average line of wave touchdown on open shelves, in turn separating inner and outer neritic substrates, mixing, and biofacies. Inner neritic biofacies (<50 m) are characterized by *Bulimina denudata, Hanzawaia nitidula, Nonionella basispinata,* and *N. stella.* The 100 to 150-m depth interval encompasses the base of the mixed (surface) layer, the base of the effective photic zone, and average point of shelf-slope declivity in turn separating outer neritic and upper bathyal biofacies. Outer neritic biofacies (50 to 150 m) include *Cancris panamensis, Cassidulina* spp., *Uvigerina juncea,* and *Valvulineria inflata.* A well developed oxygen minimum layer intersects the upper and middle slope areas between depths of 150 and 1,500 m with the core of this feature commonly found at depths of 200 to 600 m. Upper bathyal biofacies (150 to 500 m) reflect this association and include high relative and absolute abundances of *Bolivina interjuncta, B. rankini, B. seminuda, Buliminella exilis tenuata, Martinotiella communis, Suggrunda eckisi,* and *Trifarina carinata.* Middle slope faunas are influenced by the deeper portions of the oxygen minimum, the base of the permanent thermocline, and the presence of Pacific deep water. Middle bathyal biofacies (500 to 2,000 m) include *Bulimina striata mexicana, B. rostrata, Cassidulina cushmani, Cibicides mckannai, Uvigerina peregrina dirupta,* and *U. hispida.* A lower-slope bathyal biofacies (2,000 to 4,000 m) includes *Gyroidina neosoldani, Melonis pompilioides,* and *Uvigerina senticosa.* Increasing relative and absolute abundances of agglutinated species between 3,000 and 4,000 m reflect the elevated calcium carbonate lysocline and compensation depth in this region with the abyssal biofacies (>4,000 m) dominated by various species of *Alveolophragmium, Bathysiphon, Cystammina, Glomospira, Reophax, Rhabdammina, Spiroplectammina,* and *Trochammina.* Deviations from these general trends occur in conjunction with substrate anomalies, complex water-mass associations (i.e., double oxygen minima), and in marginal basins where sill depth effectively controls water-mass character, substrate, and biofacies.

ISAACS, CAROLINE M., U.S. Geol. Survey, Menlo Park, CA

Monterey Rocks Along Santa Barbara Coast, California

Along the Santa Barbara coast, field characteristics of individual Monterey rock vary greatly, relating to two principal factors: silica phase and bulk chemical composition.

In terms of silica phase, field characteristics are most affected by whether silica is dominantly biogenous (opal-A) or diagenetic (either opal-CT or quartz). Diatomaceous rocks differ from compositionally equivalent rocks bearing abundant diagenetic silica in hardness, density, cohesiveness, surface texture, and resistance to erosion. By contrast, opal-CT rocks differ from compositionally equivalent quartz rocks mainly in bulk density, and differentiation between the two groups is usually impractical in the field.

Monterey rocks contain: biogenous or diagenetic silica (5-90%), detrital minerals (5-70%), carbonate rocks (0-80%), apatite (0-30%), and (carbonaceous) organic matter (1-25%). Field characteristics are affected mainly by the silica/detrital ratio. As this ratio decreases among diatomaceous rocks, bulk density and color saturation (darkness) tend to increase. As the ratio decreases among rocks with abundant diagenetic silica, effects are more pronounced: bulk density systematically varies; cohesiveness, hardness, and brittleness all decrease. Carbonate rocks have comparatively little effect, although cohesiveness and resistance to erosion increase somewhat with the presence of dolomite.

Rocks most likely to be misinterpreted are: (1) quartz porcellanites (due to matte surface, viewed as opal-CT rocks); (2) opal-CT cherts (due to vitreous surface, viewed as quartz rocks); (3) carbonate-bearing mudstones with low (10-15%) detrital contents and high (60-80%) diagenetic silica contents (due to resistance to erosion, viewed as dolomites or limestones); (4) organic shales with low (10-25%) diagenetic silica contents (due to friability of weathered rock, viewed as diatomaceous—even where silica is quartz).

Overall lithologic characteristics suggest that diagenetically-produced boundaries may be more prominent, geophysically, than stratigraphic boundaries within—or formational contacts of—the Monterey Formation. Facies trends interpreted from diagenetic boundaries, however, may be highly misleading.

KRYSTINIK, LEE F., U.S. Geol. Survey, Menlo Park, CA

Pore-Filling Cements—Products of Shale Dewatering in Upper Miocene Stevens Sandstone, Elk Hills Field, Kern County, California

Scanning electron microscopy shows that the formation of pore-filling authigenic minerals in the deep-water fan deposits known as the Stevens sandstone at Elk Hills field is related to the expulsion of ion-charged water from siliceous shale into adjacent sandstone bodies. Extensive authigenic clay, quartz, and carbonate cements occur in the sandstone reservoirs within the first few meters of the upper or lower contact with a thick shale. All detectable authigenic phases in the Stevens sandstone, including kaolinite, quartz, calcite, ferroan dolomite, iron-rich smectite, and albite, are common to both sandstone and shale units. Cementation is most rapid and extensive in the thin sandstone beds typical of outer fan, levee, or overbank deposits.

Although many low permeability sandstone samples studied appear to contain a high percentage of detrital matrix, SEM examination shows that the "matrix" is actually a dense aggregate of authigenic kaolinite (euhedral booklets up to 30μ). Authigenic kaolinite, which is commonly intermixed with authigenic quartz, calcite, and ferroan dolomite, occurs in both pore lining and pore bridging forms. Parts of the Stevens sandstone adjacent to thick shale, or below the oil-water contact, have authigenic albite and iron-rich smectite intermixed with the other cements. Permeabilities in the albite-smectite cemented zones are commonly less than 0.3 md.

Petroleum exploitation in zones with low sand to shale ratios and sandstone sequences less than 15 m thick may be difficult in the Stevens sandstone. Thin permeability zones, left open after the initial injection of pore fluids, commonly are occluded by later carbonate cementation. Pore-filling cements related to shale dewatering, if consistent across the basin, may limit significant finds to inner and middle fan depositional regimes in the Stevens sandstone.

LAGOE, MARTIN B., Stanford Univ., Stanford, CA

Recent Arctic Foraminifera: an Overview

The quantitative analysis of recent foraminiferal distributions in the Arctic Ocean indicates that major biofacies reflect broad water-mass relations. Shelf biofacies may also be influenced by substrate variability.

Shelf biofacies, within the Arctic Ocean surface water layer (0 to 200 m), show the most variability. Marginal marine environments, characterized by extreme variability in physical and chemical factors, are inhabited by low-diversity assemblages (predominantly *Elphidium* spp.). The permanently ice-covered shelf of the Canadian Arctic contains a dominantly agglutinated fauna while the seasonally ice-free Beaufort shelf is characterized by dominantly calcareous assemblages. These regional differences are basically variations in species abundance and dominance.

Slope biofacies are mixed agglutinated and calcareous assemblages lying beneath the Atlantic water layer (200 to 900 m). Agglutinated species generally become less abundant with depth. Lower slope and basin-plain environments are dominated by calcareous assemblages with agglutinated species virtually absent. These assemblages are indicative of the bottom water layer (deeper than 900 m).

Planktonic foraminiferal assemblages are overwhelmingly dominated by sinistrally coiled *Neogloboquadrina pachyderma*. The distribution of planktonic foraminifera in death assemblages also reflects water-mass structure. Tests are absent or rare in sediments deposited beneath the surface water layer and rapidly increase in abundance below about 200 m.

Species diversity trends in the Arctic Ocean show rapid increase in diversity across the inner shelf, a leveling off from the outer shelf to upper slope, and a decline in diversity into deeper water. Overall diversity is lower than similar depths at lower latitudes. Carbonate dissolution is not a factor in determining diversity or biofacies trends.

Comparison of Arctic Ocean assemblages with foraminiferal faunas in the Gulf of Alaska shows decreasing similarity with depth, reflecting the influence of the Bering Strait as a barrier to faunal migration.

LOHMAR, JOHN M., Exxon Co., USA, Long Beach, CA, KEITH B. MACDONALD, Woodward-Clyde Consultants, San Diego, CA, and STEPHEN A. JANES, Univ. California, Santa Cruz, CA

Late Pleistocene-Holocene Sedimentary Infilling and Faunal Change in a Southern California Coastal Lagoon

Goleta Slough (Santa Barbara County, California) is typical of several small estuaries and lagoons located along the semiarid southern California coast. The slough presently consists of dendritic, shallow subtidal channels surrounded by intertidal salt-marsh vegetation (mostly *Salicornia virginica*). It is the last remaining remnant of a large marine embayment that spread into the Goleta Valley basin as sea level rose toward the close of the last glacial period.

Stratigraphic data from numerous Goleta Valley water wells indicate that the late Pleistocene embayment