hydrate were recovered at subbottom depths of 238 m (Site 533) and 404 m (Site 568). The principal gaseous components of the gas hydrates were methane, ethane, and CO_2. Residual methane in sediments at both sites usually exceeded 10 ml per liter of wet sediment. Carbon isotopic compositions of methane, CO_2, and ΣCO_2 followed parallel trends with depth, suggesting that methane formed mainly as a result of biologic reduction of oxidized carbon. Salinity of pore waters decreased with depth, a likely result of gas hydrate formation. The small samples of gas hydrates observed visually in cores confirm that gas hydrates are present at these sites, but much of the direct evidence for gas hydrates may be destroyed during the coring and recovery process.

LAGOE, MARTIN B., ARCO Exploration Co., Denver, CO

Benthic Foraminiferal Biofacies in Stevens Sandstone: Relationships to Water-Mass Oxygen Levels in Late Miocene San Joaquin Basin, California

The Stevens sandstone is an extensive and complex sequence of late Miocene turbidite sandstone and mudstone within the Monterey Formation of the San Joaquin basin. To date, the paleoenvironmental analysis of benthic foraminifera in such facies is limited largely to general inferences of paleobathymetry. A different approach uses multivariate analytical methods to classify biofacies and interpret them with respect to modern ecologic concepts derived from studies of Holocene faunas in the southern California borderland. Cluster and factor analysis help define 4 recurrent biofacies in the Coles Levee area: an agglutinated species biofacies (ASB), *Uvigerina subperegrina* biofacies (USB), *Bolivina vaughani* biofacies (BVB), and mixed calcareous biofacies (MCB). Ordination (principal components) plots of environmentally significant species indicate that the biofacies reflect a gradient in oxygen concentration of late Miocene water masses. The BVB and MCB represent the highest oxygen levels, the USB low but not dysaerobic levels, and the ASB the lowest oxygen concentrations. Ordination also shows that downslope transport of faunas and carbonate dissolution are also important in forming Stevens biofacies. Stratigraphic distribution of biofacies defines systematic shifts in oxygen concentration, probably linked to climate. These late Miocene biofacies variations were previously attributed to paleobathymetric changes. The distribution of species not restricted to the defined biofacies, plus the paleoenvironmental analysis presented here, argues against paleobathymetry as a complete explanation. This analytical approach shows the potential for greatly increasing our understanding of foraminiferal biofacies in submarine-fan environments.

LAMB, JAMES L., Consultant, Houston, TX, and THEO H. MILLER, Exxon Production Research Co., Houston, TX

Stratigraphic Significance of Uvigerinid Foraminifers in Western Hemisphere

Uvigerinid foraminifers increasingly are recognized as particularly useful paleobathymetric indices, and current data also provide easily applied bases for their use in biostratigraphic interpretation. Thus, use of many forms of the family Uvigerinidae occurring in the Western Hemisphere can expand utilization of these important forms and provide uniformity in nomenclature and classification.

Uvigerina and related genera illustrate lineage concepts and facilitate paleobathymetric considerations. These biostratigraphic interpretations, based on life ranges of commonly occurring benthonic species, are applicable widely in areas lacking the critical warm-water planktonic organisms normally used in dating.

The genus *Tiptonina* (type species *Siphogenerina nodifera*) and the species *Uvigerina praehubbardi* are proposed as new.

LARSON, DANA C., Mobil Oil, Dallas, TX

Depositional Facies and Diagenetic Fabrics of Falmouth Formation (Upper Pleistocene), Jamaica

The upper Pleistocene Falmouth Formation of Jamaica was deposited in shallow, open-marine environments similar to those on the modern northern shelf. Depositional facies include coralgal boundstones, coral-algal grainstones, foram-algal packstones, echinoid molluscan wackestones, and terrigenous grainstones. Submarine cementation of Falmouth sediments occurred as micritic and/or isopachous bladed rinds composed of magnesian calcite, as well as aragonitic coral overgrowths. The Falmouth limestones were subsequently exposed to meteoric water because of eustatic sea level fall and regional tectonic tilting related to the Cayman shear zone to the north. Isotopic reequilibration and carbonate-mineral stabilization are presently at an intermediate stage. Meteoric and mixing-zone diagenetic processes that have affected this unit include: sparry calcite cementation, aragonite dissolution and inversion, incongruent dissolution of high-magnesian calcite, selective dolomitization, and neomorphism of micritic matrices. Neomorphic fabrics within the Falmouth are spherulitic sparry calcite, microspar, and structure grumuleuse. Isotopic reequilibration coincides with the degree of diagenetic alteration. Carbon and oxygen delta values are lighter in precipitative meteoric cements than in neomorphic constituents. The trend toward negative isotopic composition with increasing age of limestone strata can be shown here to be disguised by exposure to sea spray, organic involvement, and abnormally rapid (nonequilibrium) rates of precipitation. Modern subsurface hydrogeologic environments contain distinctive diagenetic fabrics and isotopic signatures, and are defined by water-flow rate, pore-water chemistry, and rock permeability and porosity.

LEMONS, DAVID, Baylor Univ., Waco, TX

Geomorphic Indicators of Deeper Seated Structure on the Southern Margin, East Texas Basin

Surface geomorphic features are frequently difficult to relate to potential productive structures, but in the East Texas basin there appears to be a significant correlation between surface features and oil fields.

The surface topography overlying the East Texas basin gives little indication of subsurface structure. However, conspicuous to southeastern Houston County on the southern margin of the East Texas basin, and to a large part of the entire basin, is a series of northwest- and northeast-trending stream and topographic alignments. These mappable linear geomorphic features (termed lineaments) may indicate fracturing, faulting, and jointing, and thus may be a clue to subsurface structure.

The lineaments of southeastern Houston County were mapped and analyzed on a local scale, and those of Houston, Cherokee, Trinity, and Angelina Counties were mapped and analyzed on a more regional scale. Both the local and regional scale lineament analyses indicated preferential orientations of north 30° west and north 30° east. These lineaments are thought to reflect fracturing and faulting although field reconnaissance could not confirm this.

It is suggested that gravity slide of the East Texas basin gulfward from the updip edge of the Louann Salt provided the tensional forces necessary for major lineament formation. However on a more local scale there is a correlation between lineaments and productive fields.

Areas of minimum lineament density on the lineament-density contour maps represent subtle subsurface structural highs and, conversely, areas of maximum lineament density on the lineament density contour maps represent subtle subsurface structural lows. Therefore, petroleum potential is generally limited to areas of minimum lineament density.

LERCHE, I., Univ. South Carolina, Columbia, SC, and J. J. O'BRIEN, Sohio Petroleum Co., San Francisco, CA

Processes Involved in Salt-Dome Development I: Dynamic Effects

In a study of the dynamical interplay of salt and sediment using buoyancy pressure as the driving force, we find that (a) salt cannot become buoyant until a critical depth of sediment is reached corresponding to a porosity of 25-30%, (b) viscosity plays virtually no role in the development of diapiric salt structures on a geologic time scale, (c) both overpressure and the lateral cohesive strength of overlying sediments retard the development of a dome by delaying the initiation of diapirism and suppressing the later growth of the salt structure, (d) the formation of a "mushroom cap" on a diapiric structure can be caused both by differential impedance provided by the sediments and by differential buoyancy of salt, although relative importance of the 2 mechanisms is unknown at present, and (e) the draping of sediments over a diapiric structure and rim synclinal development can be modeled easily provided that the sediments