simultaneous trapping of 2 immiscible fluids. Theoretical analysis of the PVT properties of coexisting immiscible fluids demonstrates that the isochores for the 2 different fluids must intersect at the temperature *and* pressure of entrapment of the inclusions. Calculation of the PVT properties of each fluid requires detailed chemical analyses of both fluids. Recent results from new analytical techniques, especially capillary column gas chromatography to analyze hydrocarbon inclusions and laser Raman spectroscopy to analyze gases in aqueous inclusions, demonstrate that this approach to paleotemperature studies can be widely applicable in sedimentary environments.

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Sonograph Mosaic of Northern California and Southern Oregon Exclusive Economic Zone

During June 15 to July 9, 1984, the third leg of the cooperative U.S. Geological Survey–Institute of Oceanographic Sciences GLORIA survey of the conterminous United States Exclusive Economic Zone (EEZ) collected digital acoustic data off northern California and southern Oregon. The region covered during leg 3 extends from the 200-m isobath westward to the 375-km (200-nmi) EEZ boundary and from about 39° to 43°N. The survey used the IOS GLORIA long-range side-scan sonar, a 2-channel airgun seismic reflection system, and 3.5 kHz and 10 kHz high-resolution seismic systems. The GLORIA data were collected in a pattern that permitted overlapping coverage so that a mosaic of the sonographs could be constructed. These sonographs were slant-range and anamorphically corrected aboard ship, and a mosaic was constructed at a scale of 1:375,000.

Among the most striking geomorphic features revealed in this segment of the EEZ is the Mendocino transform fault, which extends for more than 120 nmi along the northern base of the Mendocino fracture zone and delineates the southern boundary of the Gorda plate. Other features clearly revealed are the complex geometry of the Gorda rift valley, and the subparallel flanking ridges and dramatically deformed base of the continental slope at the eastern boundary of the Gorda plate. The data are presently being processed by image analytical techniques to enhance the fine-scale features such as sediment waves, slumps, and areas of differing sedimentary facies.

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Paleoenvironmental Data as Exploration Tool in Lower Miocene of Offshore Texas

Most paleontological reports based on foraminiferal assemblages in well cuttings include an interpretation of the environment of deposition of the sediments penetrated. For an individual well, these data may be summarized as a paleoenvironmental curve. Data on a group of wells can be synthesized into paleoenvironmental maps and cross sections—useful tools for predicting sand distribution. These maps, used independently or in conjunction with net sand maps, can indicate the locations of ancient delta systems, hence sand sources. Paleoenvironmental cross sections graphically display transgressions and regressions.

The lower Miocene sediments in the Mustang Island and Matagorda Island areas of offshore Texas were deposited in a wide range of shelf and upper slope paleoenvironments. Paleoenvironmental maps, based on about 50 wells, suggest that a number of major delta systems developed in the Mustang Island and Matagorda Island areas during the early Miocene. Electric-log data show that thick pods of sand are associated with each of these ancient delta systems. Paleoenvironmental cross sections indicate that, although the section just above *Siphonina davisi* in southern Mustang Island is strongly regressive, the equivalent section in eastern Matagorda Island is transgressive. Determination of such transgressive/regressive trends is vital to predicting the dip position of potential reservoir sands. A cross section through Matagorda block 622 illustrates that a considerable thickness of deep-water sediments can overlie an older, shallower water, sandy interval. Therefore, the penetration of a thick sequence of deep-water shales does not necessarily indicate that underlying prospective sections will not be encountered.

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Origin of Na-Ca-Cl Brines in Jurassic and Cretaceous Reservoirs of Gulf Coast

Na-Ca-Cl brines in Jurassic and Cretaceous reservoirs in the Gulf Coast have been attributed to the diagenesis of concentrated Jurassic seawater related to Louann Salt deposition and alternatively to the diagenesis of brines produced by halite dissolution. These brines contain up to 35,000 mg/L Ca, up to 4,000 mg/L Mg, from 400 to 2,400 mg/L Br, and up to 13,000 mg/L K. Mutual relationships of Na, Cl, total divalent cations minus sulfate and bicarbonate, K, and Br are similar to those in seawater that has been evaporated past the initial stage of halite deposition, particularly when the K content of the brine exceeds 5,000 mg/L. The concentrations of divalent cations and K increase, and the mutual relationships of all the dissolved salts become increasingly similar to those in seawater with increasing proximity to bedded salt. The abundance of authigenic K-feldspar in rocks above the salt beds explains the relatively rapid decrease in the K content of the brines upsection. The Ca and K contents of Jurassic Gulf Coast brines are similar to those in Na-Ca-Cl brines in feldspar-poor carbonate sequences in other basins.

C. S. Land and D. R. Prezbindowski suggested in 1980 that the Na-Ca-Cl brines in the Edwards formation of Texas originated from halite dissolution and gained Br from halite recrystallization, Ca from the albitization of plagioclase, and K from the alteration of K-feldspar. Since the Br content of the brines is high and the Br content of halite is low (generally < 100 ppm), Br would have to be stripped from an enormous volume of (impermeable) salt and transferred to a relatively small volume of fluid. Mass-balance calculations indicate that Br would have to be stripped from more than 7.5 km of salt to account for the bromide in the brines of the Mississippi salt basin. If Ca and K in Na-Ca-Cl brines are derived from feldspars, these elements should increase in concentration relative to chloride with increasing distance from the source of NaCl. This is the reverse of the field relations in Mississippi, where unaltered authigenic K-feldspar is present in rocks above the salt, and the K content of the brines decreases relative to Cl with increasing distance from the halite. Finally, it is not clear how 3 completely independent processes can operate to produce such an excellent match to the dissolved constituents of evaporated seawater over such a wide geographic area and in strata with varying amounts of feldspar. The simplest genetic model is that Gulf Coast Na-Ca-Cl brines formed from evaporated seawater and evolved to their present composition accompanying the processes of dolomitization and loss of sulfate.

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Hybrid Eolian Dunes of William River Dune Field, Northern Saskatchewan, Canada

A series of northwest-southeast aligned, large-scale (up to 30 m high) eolian dunes, occurring in a confined (600 km^2) desert area in northern Saskatchewan, Canada, was examined in the field. Observations were made of dune morphology and internal structure, and patterns of sand movement on the dunes were analyzed in relation to wind events during the summer of 1981.

Present cross-sectional profiles exhibit steeper northeast slopes, the lower segment of which are intermittently covered by psammophilous grasses. Dune structure is dominated by northeast-dipping accretion laminae. Three ^{14}C dates from organic material cropping out on the lower southwest slopes reveal that the dunes have migrated as transverse bed forms at rates of roughly 0.5 m/yr during the last few hundred years. However, a progressive increase in height, bulk, and symmetry along the dune axis from northwest to southeast, suggests an along-dune component of sand transport. This view is supported by (1) field measurements of airflow and along-dune sand transport patterns on 2 dunes, and (2) the present-day wind regime (1963-78). Dominated by north-northeast to northeast winds from January to June and by west-southwest winds from July to December, the resultant potential sand transport vector is toward the southeast, virtually identical to the dune axis.

The dunes are viewed as a hybrid type, forming in response to a combination of transverse and longitudinal processes and are probably not uncommon in many deserts. The discordance between the dune structure

(and migration direction) and the resultant effective wind vector may have significant implications for paleowind analysis in the geologic record. In this instance, the structure reflects only west-southwest (July-December) winds, owing to a southwest-northeast imbalance in sand movement. This imbalance is due mainly to the effect of sand-trapping by vegetation on northeast slopes, as well as to seasonal differences in sand mobility, the latter correlating partly with the semi-annual shift in the wind regime.

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Neogene Deep-Living Radiolarian Zonation and Its Uses

A Neogene radiolarian zonation using deep-living radiolarians has been developed. This zonation consists of 6 radiolarian zones with the nominant taxa of each zone first occurring at the base of its zone, and that nominant taxa running throughout its zone. These zones are the *Eucyrtidium cienkowskii* (22.5-19 Ma), *Siphocampe arachnea* (19-14 Ma), *Oroscena* with digitate spines (14-11 Ma), *Botryostrobus bramlettei* (11-6 Ma), *Clathrocyclas bicornis* (6-2.5 Ma), and *Cycladophora davisiana davisiana* (2.5-0 Ma) Zones. These zones were developed by using Antarctic, equatorial, and North Pacific Deep Sea Drilling Project holes, and are believed to be cosmopolitan zones due to their being based on deep-living radiolarians. These zones are dated by correlating the first occurrences of the nominant taxa with warm-water radiolarian datums that have been paleomagnetically dated. These zones are not designed for routine use, but rather for tying together other more provincial zonations, and for comparing oceanographic phenomena on global datum planes. To date, this zonation has been used to correlate Antarctic zonations intra- and inter-regionally and to study the evolution of radiolarian lineages.

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Uses of Vitrinite Reflectance in Determining Thermal History in Sedimentary Basins

Vitrinite reflectance (VR), adapted from coal petrology, came into routine use in the petroleum industry in the late 1960s. Initially, the principal goal was to help establish the VR limits for oil and gas generation. Subsequently, VR has become accepted as the most useful measure of burial history and paleotemperature, largely because VR affords the most practical means of measuring the progression of organic metamorphism. VR is used to correlate other measures of thermal history such as chemical maturity parameters, Rock-Eval t_{max}, and burial-history reconstruction. VR can aid in identifying unconformities, geopressured sections, and thermally altered zones. Combined with good temperature data, the determination of VR equivalents from temperature and burial time are used to evaluate the relationship of depth to log VR obtained directly. The time and temperature required for maturation in Tertiary basins stresses the interplay of both factors in the maturation process. Reflectance has been employed in deciphering the burial history and tectonic evolution of many areas, including structurally complex regions as the Alps and the Wyoming Overthrust belt.

Interpretational problems that arise include: (1) VR can be altered by the absorption of hydrogen-rich materials, oxidation, and natural coking; (2) the presence of reworked and caved organic matter produces multiple reflectance populations; and (3) vitrinite is sometimes difficult to distinguish from solid hydrocarbons and some inerts if the particle size is small. Most of these problems are resolved at the microscope. Interpretation is improved significantly by analyzing a series of samples rather than an isolated sample.

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Thermal Subsidence of Santos and Sergipe-Alagoas Basins, Brazil—Application to Hydrocarbon Exploration

A uniform lithospheric extension model has been applied to the subsidence and thermal history of the Santos and Sergipe-Alagoas basins. Thermal subsidence curves were derived from more than 40 exploratory wells, complemented by seismic and gravity sections.

In the Santos basin, the region landward of the hinge zone is dominated by Tertiary marine onlapping sediments. Seaward, rift (continental) and postrift (transitional and marine) sequences are present with predominance of the latter. Crustal thinning by 35% exists just east of the hinge zone and increases to 70% at the shelf break.

Likewise, the hinge zone in the Sergipe-Alagoas basin overlies the largest gradient in crustal thinning, but unlike the Santos basin, rift-stage sediments dominate landward of this hinge zone. Seaward, the ratio of rift to postrift sediments is larger than in the Santos basin. Crustal thinning ranges from 20% to 60%, but this transition occurs over a short distance.

Thermal and burial histories were used to estimate oil windows for potential source rocks in various parts of these basins. Maturation profiles are in good agreement with observed vitrinite reflectance and hydrocarbon maturity data. The areal distribution of maturation stages through time is variable and largely controlled by crustal thinning. Information on timing of hydrocarbon generation was applied to the prediction and evaluation of hydrocarbon accumulation.

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Uniformitarian Hypothesis to Explain Permian-Triassic Life Extinctions

A uniformitarian hypothesis is possible to explain the great Permian-Triassic life extinction event. Unlike the recent "catastrophic" explanations for the Mesozoic-Cenozoic extinctions, this hypothesis does not depend upon extraterrestrial intervention.

The dominant worldwide event at the close of the Paleozoic was the formation of Pangea. The Mesozoic witnessed the sundering of this supercontinent and the formation of the modern continental masses and oceans.

The areas covered by the waters of the Paleozoic oceans surrounding Pangea either were incorporated onto the fringing continents or were subducted. New oceans, which became the present oceans, were forming in the Mesozoic in the areas where the combined continental masses were splitting apart.

If these 2 events were in part simultaneous and yet physically separated in such a way that the waters in the newly forming oceans did not connect with the water in the closing oceans, almost complete extinction of all earlier marine life forms would result.

Radioactive dating of the present ocean floor indicates that the Paleozoic floor was eliminated, and new ocean floor began to form in the Mesozoic. Chemical dating of present ocean water indicates that its time of origin is approximately the same as that of the present ocean floor.

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Computer-Generated Reconnaissance Maps Using Commercial Data

Much well and production-history data are currently available in digital form from commercial sources. These data, when mapped using a computer, can quickly give valuable perspectives to the geologist developing new prospects.

A large data bank has been built from commercial well and production data that can be reported or mapped using either proprietary or commercially available software. Time and manpower reductions experienced using the computer-generated maps give the geologist the ability to evaluate large geographical areas before committing resources to potential prospects. These maps can include not only conventional geologic maps, such as isopach and structure maps, but also maps of abnormal pressure, bottom-hole temperature, or any geologic parameter contained in the data bank.

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Numerical Simulation of Subsurface Flow in a Sedimentary Basin

Pore water in sedimentary rocks is normally in motion. In general, gravity-induced flow driven by the elevation gradient predominates in a basin with orogenic deformation; however, in a basin with continuous deposition, compaction-induced flow driven by the excess fluid-pressure gradient predominates. Subsurface water flow is considered to have a controlling influence on the migration of widely dispersed petroleum. Therefore, the analysis of a basin-wide flow system, particularly its paleohydrogeologic conditions, is essential for understanding the history of petroleum migration and entrapment.

The nonlinear finite element method has been used to simulate coupled processes of sediment deformation and fluid flow in sedimentary