section. With different depositional units readily distinguishable in such a display, a clearer understanding can be obtained of the represented depositional environment. Further, well-to-well correlation is easier to make.

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Morphology of Central California Continental Margin, Revealed by Long-Range Side-Scan Sonar (GLORIA)

Leg 2 of the 4-leg USGS EEZ-SCAN 84 program used GLORIA long-range side-scan sonar to survey the region from Pt. Conception to just south of Pt. Arena, from the shelf break to the 200-nmi coverage. The overlapping digital sonographs were slant-range and anamorphically corrected, and a photomosaic of the sonographs was constructed at a scale of 1:375,000 (1 in. = 11.1 km).

The underlying bed rock appears to be an important control in shaping the morphology of this margin. Several faults have sea-floor expression and lie subparallel to the margin. The density of canyons and gullies on the slope varies from south to north, probably because of variations in the characteristics of the bed rock. The slope west of San Francisco is the most dissected segment of the central California slope.

Monterey Fan is covered by large-scale bed forms (5-15 m amplitude and 1.5-2.0 km wavelength) over much of its surface. Monterey channel crosses southwestward across the fan, but abruptly turns south along a 40-km long surface fault that coincides with a well-mapped meander loop. The channel loops to the north then turns southward crossing the entire Monterey Fan and, at its distal reach, changes to a broad, braided pattern. Major slumps on the margin have long (> 30 km) scarps, some have slump folds, and one has a debris-flow deposit that can be acoustically traced for more than 75 km.

Seventeen new seamounts were mapped. Taney Seamounts are large, rimmed, calderas with diameters of about 15 km each; these appear to be very large explosive or summit-collapse features.

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Prolific Overton Field Gas Reservoirs Within Large Transverse Oolite Shoals, Upper Jurassic Haynesville, Eastern Margin East Texas Basin

Late Triassic rifting along a northeast-southwest spreading center in east Texas resulted in basement highs along the eastern margin of the East Texas basin that became sites of extensive ooid shoal deposition during Late Jurassic time. Reservoirs within oolite facies at Overton field contain over 1 tcf of natural gas. These large shoals, each approximately 15 mi (24 km) long and 3 mi (4.8 km) wide, trend north-south as a group and northeast-southwest individually. They are oblique to the basin margin but parallel with Jurassic diffracted tidal currents within the East Texas embayment. Modern Bahamian ooid shoals of similar size, trend, and depositional setting occur at the terminus of the deep Tongue-Of-The-Ocean platform reentrant. Overton field reservoirs are in ooid grainstone shoal facies and in transitional shoal margins of skeletal-oolitic-peloidal grainstones and packstones. Adjacent nonreservoir facies are peloidal-skeletal-siliciclastic wackestones and mudstones.

Early diagenesis of grainstone reservoir facies included meteoric dissolution and grain stabilization, resulting in abundant "chalky" intraparticle porosity and equant and bladed calcite cements filling interparticle porosity. Subsequent burial diagenesis resulted in intense solution compaction and coarse equant calcite and saddle crystal dolomite that occluded remaining interparticle porosity. Whole-rock trace element analysis indicates greatest diagenetic flushing (less magnesium, strontium) in porous zones. Stable isotopes for grains and cements show strong overprint of later burial diagenesis, with greater depletion of $\delta^{18}O$ in reservoir facies. However, hydrocarbons were emplaced prior to late cementation, and unlike other Jurassic Gulf Coast reservoirs, deep burial diagenesis provided no late-stage formation of porosity.

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Gas Monitoring During Drilling Substantiates Hydrogen Occurrence and Eliminates Corrosion as Source

Chromatograms from the simultaneous use of 2 gas "sniffers," one monitoring hydrocarbon gases and one monitoring H_2, while drilling 5 uncased exploratory bore holes in Paleozoic rocks in Kansas substantiates that H_2/N_2-rich gas emissions are from the sedimentary rocks above the Central North American rift system and are not the result of corrosion of casing pipe. The gases extend over an area of more than 100 mi^2, within which they appear to be migrating through formation waters along permeable zones at the silty to sandy base of pyritic shales. H_2 was detected in various zones from ±500 ft depth in the Indian Cave Sandstone (Pennsylvanian) to depths of 2,100 ft in the Hunton Limestone (Silurian-Devonian). Negative peaks (noncombustible), which overlapped the H_2 positive peaks on the Wheatstone Bridge chromatograms, are thought to indicate N_2 gas. Possible N_2 gas occurs from about 1,300 to 2,100 ft, from the Heebner Shale Member (Pennsylvanian) to the Hunton Limestone. H_2/N_2 peaks on the chromatograms correlate well with the crossover peaks indicative of gas zones on open-hole wireline logs.

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Diagenesis in Upper Miocene Sandstones, Louisiana Gulf Coast

Study of diagenesis in upper Miocene sandstones of coastal Louisiana documents depth-related cementation and geochemical changes of primary detrital mineralogy. Samples were collected from depths of 8,000-20,000 ft (2,600-6,500 m) in an area roughly corresponding to the upper Miocene depocenter in the Terrebonne trough of southeast Louisiana. Sandstones are primarily subarkoses and sublitharenites with minor amounts of feldspathic litharenites and lithic arkoses. Plagioclase feldspar (oligoclase/andesine composition) composes approximately 60% of the detrital feldspar. Dominant rock fragments are siltstone or mudstone, silicified volcanic rock, and chert.

Authigenic minerals and cements occur in the following order: dolomite, chlorite grain coats, albite overgrowths on plagioclase and K-feldspar, quartz, calcite, kaolinite, and ankerite. Calcite composition remains nearly constant with depth, but ankerite composition differs both with depth and within individual samples. In general, the mineralogy and order of cements resemble that of the lower Tertiary sandstones of the Texas Gulf Coast; however, in the upper Miocene, the volume of each cement is much less and the depth of first occurrence is greater.

Feldspars have reacted substantially with pore fluids. With increasing depth, feldspar becomes more sodic because of albitization and dissolution of calcic plagioclase. At approximately 20,000 ft, 75% of the plagioclase is nearly pure albite. Alteration of K-feldspar is not common above 17,000 ft; below 17,000 ft occurrences are rare because of dissolution.

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Compactional Features in Cambro-Ordovician Carbonates of Central Appalachians and Their Significance

Compactional features are well known from siliciclastic rocks, but it is generally believed that carbonates have undergone little burial compaction. However, in the 3.5-km thick Cambrian-Ordovician carbonates of the Central Appalachians, many small-scale compaction features have been recognized. Evidence for differential compaction is: (1) wrapping of thin beds around meter-scale early-cemented algal bioherms and (2) sedimentary boudinage and pinch-and-swell features in interlayered thin beds of carbonate grainstone and mudstone. The grainstone layers have deformed in a brittle manner (cracking or yielding boudins), whereas mudstone layers behave ductily (flowing and bending around boudins), indicating that at the time of burial, grainstone layers were lithified but mudstone layers were unlithified. Burrows and shells in sandy layers are preserved, but burrows are deformed and shells broken in muddy layers. Pervasive, rather than differential, compaction in muddy carbonates is evidenced by flattened burrows, rotation of platy allochems parallel with

bedding, telescoping of mudcracks, and anastomosing wispy argillaceous seams. Pervasive compaction in peloidal grainstone is evidenced by warping and cracking of internal layers that are outlined by wispy seams. Ooid and skeletal grainstones and algal bioherms do not show these compaction features.

Time lines in these Cambrian-Ordovician carbonates converge across depositional strike from east to west, and this coincides with a change in facies from shelf-margin algal bioherms and grainstones showing little compaction to lagoon-peritidal mudstones with abundant compaction features. Volume reduction by compaction is clearly facies controlled and also has influenced the geometry of the time lines.

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Initiation and Reactivation of Proterozoic Aulacogen, Northern Mexico

Geochemical and petrologic affinities of late Proterozoic (~1Ga) bimodal igneous rocks of the Franklin Mountains, west Texas, suggest a rift origin. Scattered occurrences of similar rocks southward into the state of Chihuahua, Mexico, indicate a southerly trend for the feature. The feature is bounded by stable blocks: the stable craton of west Texas to the east and northeast, and the Sierra del Nido block to the west and southwest. Separation of the Sierra del Nido block from the craton occurred about 1 Ga. Gravity gradients mark the boundaries of the blocks, and a northwest-trending Bouger gravity high may mark the axis of the aulacogen. The aulacogen and the Sierra del Nido block are truncated to the south by the Mesozoic Mojave-Sonora discontinuity.

The aulacogen was reactivated, at least in part, in the late Paleozoic as the Pedregosa basin and in the Mesozoic as the Chihuahua trough. These reactivations were apparently not full-fledged rifting events, but did result in basin development. The Sierra del Nido block was a paleographic high throughout the Paleozoic, and the Aldama platform developed on this block during the Cretaceous. The most recent reactivation of the aulacogen is as the southern extension of the Rio Grande rift, as evidenced by trends of high heat flow, recent mafic magmatism, and regional extensional faulting.

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Carbonate Dissolution During Late-Burial Diagenesis of the Terumbu Limestone (Miocene), East Natuna Basin, South China Sea, Indonesia

The Terumbu Limestone is the reservoir for 200 tcf of gas (72% CO_2) in the Esso D-alpha block, offshore Indonesia. During the middle to late Miocene, 5,000 ft (1,500 m) of platform-reef carbonates were deposited. These limestones have a complex diagenetic history determined from study of 960 ft (290 m) of core from 3 wells.

Partial marine cementation and micritization of grains occurred in platform environments during deposition. Freshwater diagenesis followed, presumably below subaerial unconformities within and at the top of the Terumbu. Aragonitic grains were leached, high-magnesium calcite grains were converted to low-magnesium calcite, and pores were partially cemented by low-magnesium calcite. Pressure solution and further cementation during burial of the Terumbu to 10,000 ft (3,000 m) left only minor amounts of preserved primary and moldic porosity.

During late burial, grains that were originally high-magnesium calcite were leached, forming "interpenetrating" pores and stylolites "floating" within pores. Ferroan-calcite and dolomite cements line these pores and fluorite crystals occlude many pores. Whole-rock stable isotopes are depleted in O^{18} (-8.0 ‰ δO^{18} PDB, 0.0 ‰ δC^{13} PDB), suggesting high-temperature alteration of carbonate. The isotopic composition of the CO_2 in the reservoir is similar (-0.8 ‰ δC^{13} PDB), suggesting this CO_2 is derived from dissolved Terumbu Limestone. We envision that fluoride-bearing hydrothermal fluids, derived from the underlying granitic basement, selectively dissolved constituents in the deeply buried Terumbu.

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Stratigraphic Dipmeter Interpretation—Fort Worth Basin Submarine-Slope Systems

Submarine-slope systems pose several exploitation problems. Previous Dipmeter interpretation techniques using the standard Dipmeter with CLUSTER (mark of Schlumberger) processing are highly successful in fluvial to deltaic sequences, but lack accuracy in the anastomosing depositional environment associated with submarine-slope systems. Both the delineation of individual depositional units and the precise trend determination of each are essential for optimum exploitation. A new interpretation technique has been devised to provide accurate and consistent answers to these problems. The technique involves the use of multiple logging passes and detailed stratigraphic correlation to provide a paleocurrent and depositional analysis.

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Correlating Organic Facies and Turbidite Facies in a Hoh Turbidite Sequence (Miocene), Western Olympic Peninsula, Washington

The distribution of organic facies is a function of the environment of deposition. Within each turbidite facies, diverse depositional regimes are present that affect both the preservation and dispersal of organic matter. Proper identification of turbidite facies can lead to a proper prediction of organic content within a particular turbidite facies or turbidite facies association.

The type section of the Brown's Point formation, a turbidite sequence within the Hoh rock assemblage, demonstrates the correlation between organic facies and turbidite facies, as defined by E. Mutti and F. Ricci-Lucchi. Turbidite facies can be matched to organic facies throughout the entire 4,000 ft (1220 m) thick vertical section. Outer and middle fan turbidite associations have been analyzed and correlated for organic facies lateral continuity.

Distribution of organic carbon concentrations and organic carbon types suggests a dominance of terrestrial input. TAI and R_o analyses reflect a marginally mature thermal maturation level (R_o = 0.5-0.6). Visual kerogen inspection reveals a mixed to structured kerogen with a predominance of type III/IV over type IV kerogen. Overall, maturation indices suggest a gas source with poor source potential for oil. Individual turbidite facies display a significant relationship to the amount, type, and level of maturation of organic matter present within each facies and facies association.

Frontier basin analysis of turbidite sequences can be expedited by proper field identification of turbidite facies and subsequent geochemical analysis of the content, type, and maturation level of the organic matter present within each turbidite facies.

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Diagenetic Destruction of Primary Reservoir Porosity in Viola Limestone, South-Central Oklahoma

The Viola Limestone in south-central Oklahoma is a Middle and Upper Ordovician carbonate unit interpreted as being deposited on a carbonate ramp within and peripheral to the Southern Oklahoma aulacogen. Depositional environments within the study area ranged from anaerobic deep ramp through aerobic middle and shallow ramp. TOC analyses of the lower anaerobic deep-ramp facies suggest that, at least locally, the Viola is a potential hydrocarbon source rock. Detailed petrographic examination of the Viola indicates that primary porosity in the shallow-ramp skeletal packstones and grainstones was initially quite high. This combination of source potential and original porosity should make the Viola an attractive target for hydrocarbons in southern Oklahoma. The Viola, however, has been subjected to a complex sequence of diagenetic events that have extensively altered the sediments and occluded much of the primary porosity. A thorough understanding of the timing and nature of these events can be critical in evaluating the economic potential of the Viola.

Petrographic evidence combined with the use of cathodoluminescence indicates that several generations of calcite cementation occurred within the shallow-ramp packstones and grainstones. An initial phase of very early, possibly synsedimentary, marine cementation is evidenced by cloudy, inclusion-rich syntaxial cements on echinoderm fragments. This early phase of cementation was followed by several generations of clear syntaxial calcite, prismatic calcite, blocky mosaic calcite, and bladed mosaic calcite, all of which indicate changes in the pore-water chemistry after precipitation of the inclusion-rich cements. This phase of meteoric-