ity of the patterns from such diverse areas and sediment types suggests that the distribution of dolomite in these sediments is not due to random groupings and may be a consequence of a common global cause.

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Fibrous Calcium Sulfate in Veins

In an extensional vein, fibrous anhydrite is reported for the first time. It resembles satinspar and is termed "satinspar-A." Satinspar-A contains most features typical for satinspar (subhorizontal attitude of the veins, vertical fibers, a parting separating a lower from an upper seam, incorporated wall-rock fragments), but several observations are new, such as the stacked nature of the fibers, tapering of wall-rock fragments, pressure shadows next to the wall-rock fragments, and parabolic alignment of the fragments.

Previous interpretations of satinspar veins are unsatisfactory and partly contradictory. The combination of the foregoing features leads to a generally applicable interpretation of the mode of infilling of veins of this type. In this process, the veins are opened owing to vertically tensile stress. The vein-filling crystals grow centrifugally outward from the initial plane of rupture (which now forms the parting) keeping pace with the dilation. The mode of incorporation of wall-rock fragments in the fibers requires repeated differential opening of the fissure. Thereby, the wall-rock and fiber interfaces rupture in a statistically alternating fashion.

The source of the calcium sulfate may be adjacent evaporite beds but, at least, in the case of satinspar-A, an external source is indicated by trace-element data and the absence of evaporite deposits in the area. In contrast to previous interpretations, the hydration of anhydrite to gypsum in the host rock is not a prerequisite for the formation of satinspar veins.

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Geology of Fulmar Oil Field, United Kingdom Sector, Central North Sea

The Fulmar field is situated within the United Kingdom sector of the central North Sea, 170 mi (270 km) southeast of Aberdeen, in water depths averaging 265 ft (81 m). The field was discovered in 1975 when Shell/Esso well 30/16-6 established the presence of an important oil play within shallow-marine sands of Late Jurassic age in the southwest Central graben of the North Sea basin. The well encountered an oil column of 668 ft (204 m) within apparently homogeneous sandstones displaying excellent reservoir properties. Commercial production was confirmed by an appraisal well, and 4 development wells were pre-drilled from a subsea template prior to platform production, which commenced in February 1982. The reservoir geology was consequently found to be more complicated than originally thought and has led to a diversity of depositional and structural models. To date, 23 development wells have been drilled. Current recoverable oil reserves are estimated at 427 million bbl with an oil gravity of 40° API.

Fulmar field is operated by Shell U.K. Ltd. on behalf of the Shell/Esso North Sea Venture and the Fulmar Unit.

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Fracture Permeability and High Initial Water Cut in a Carbonate Gas Reservoir

Waveland field in Hancock County, Mississippi, produces gas and condensate from the Lower Cretaceous Mooringsport Formation at approximately 13,400 ft. Total gas reserves have been estimated at 256 bcf. The reservoir is a fractured lime packstone, containing milliolid and orbitolinid foraminifers, mollusk fragments, and echinoderms. Core plug permeability is low, commonly below 1 md, yet productive wells flow at rates of as much as 8,000 MCFGD. Thus, fracture permeability is an important reservoir property. Short-term flow tests can be misleading, as productive wells may initially produce an uneconomically high water cut for several days.

The trap is a south-southwest-plunging anticline with no apparent structural closure to the north. A map of averaged, thickness-weighted porosity values for productive stratigraphic intervals indicates that porosity does not decrease across the northern limit of production. In order to compare the productivity potential of zones with varying porosity and water saturation, Buckles Numbers (product of porosity and water saturation) were mapped for zones within the productive stratigraphic interval. Averaged, thickness-weighted Buckles Numbers indicate that productivity potential does not decline across the northern limit of the field. Thus, it is concluded that the northern (updip) extent of effective fracture permeability controls the northern limit of production at Waveland field.

High initial water cut indicates that water is in the fractures and gas and water are in the matrix. The presence of water in fractures adjacent to rock with much narrower effective pore-throat radii is a normally unstable situation, as capillary pressure would be expected to result in the matrix imbibing water and releasing gas to the fractures. It is proposed that fracturing occurred after hydrocarbon migration and that there is little or no fluid exchange between fractures and matrix prior to wellbore drawdown.

Waveland is an example of a field where limits of productivity are controlled by permeability rather than by porosity, hydrocarbon saturation, or trap geometry. Buckles Numbers maps are a useful tool for describing productivity potential of similar fields.

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Valencia Fan (Northwestern Mediterranean): Channelized Distal Deposition Fan Variant

The Valencia Fan, a large deep-sea depositional system in the western Mediterranean Sea, developed in the structural depression between the Valencia Trough and the Balearic Basin Plain. Six main lithoseismic units are identified from 6,000 km of sparker profiles. Channelized and irregularly stratified units predominate. It is inferred that the sedimentary processes controlling the development of these units include channelized sediment flows that evolve downfan into sheet flows. Three fan depositional provinces are differentiated on the basis of the relative proportions of lithoseismic units and the inferred sedimentary processes.

Regularly stratified seismic units predominate in the non-fan environments. These units are dominated by fine-grained deposits resulting from hemipelagic settling and overbank flows from turbidity currents. Distal flows from the continental slopes of the Iberian Peninsula and Balearic Islands also contribute sediment for the development of these environments. The wavy units flanking the upper fan probably resulted from migrating sediment waves, whereas transparent units are attributed to extensive mass flow. The Valencia Valley is largely an erosional feature across which sediments from several source areas bypassed to the distal, deep-sea depositional system of the Valencia Fan. Deposition begins at the mouth of the valley where it is constricted by a volcano and beyond which there is a break in slope.

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Upper Jurassic Norphlet Eolian Dune, Wadi, and Marine Petroleum Reservoirs, Central and Eastern Gulf of Mexico Regions

The Norphlet Formation (Upper Jurassic) of the central and eastern Gulf of Mexico regions accumulated under arid climatic conditions. Norphlet paleogeography in southwestern and offshore Alabama and the Florida Panhandle was dominated by a broad desert plain rimmed to the north and east by the Appalachian Mountains and to the south by a developing shallow sea. The desert plain extended westward into eastern and central Mississippi. Quartzose sandstones were deposited as dune and interdune sediments. The source of the sand was adjacent and updip alluvial-fan, plain, and wadi deposits. Wadi and playa-lake sediments also accumulated in the interdune areas. A marine transgression was initiated during upper Norphlet deposition resulting in the reworking of previously deposited sediments.

Petroleum reservoir rocks consist primarily of quartzose sandstones that are eolian dune, wadi, and marine in origin. The high-angle (up to 30°) cross-bedded eolian sandstones are moderately well-sorted to well-

sorted subarkoses having subrounded to rounded quartz grains. The dune and interdune sandstones are interbedded with wadi and playa-lake deposits having wavy discontinuous laminae. These water-deposited sandstones are not as texturally mature as the dune sandstones. The upper part of the Norphlet includes massively bedded to horizontal laminated marine sandstones. Porosity is principally secondary dissolution with some intergranular porosity. The secondary porosity is a result of decementation of anhydrite and/or calcite and by grain dissolution. Porosity in the marine sandstones is reduced through calcite cementation in downdip areas. The Permian eolian dune and wadi sandstone reservoirs in the Viking field, North Sea, can be used as analogs for anticipating reservoir performance for the Norphlet sandstones.

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Depositional and Postdepositional History of Stuart City Member, Edwards Limestone (Lower Cretaceous), Washburn Ranch Field, LaSalle County, Texas.

The Stuart City member of the Edwards Limestone (Lower Cretaceous) was cored in 2 wells in Washburn Ranch field, LaSalle County, Texas. Depositional sequences encountered in the cored intervals represent an alternating sequence of reef-derived grainstone, pellet-rich grainstone, near-reef wackestone, and lagoonal mud-rich facies, with a general trend toward more shallow marine conditions. Deposition of the Stuart City member ended abruptly with deepening water conditions and deposition of a pelagic foraminiferal facies.

Porosity in the cored intervals can be related to incomplete cementation of the reef-derived grainstone facies. Four separate and unevenly developed generations of cementation have occurred as determined by standard petrography and cathodoluminescence. Thin, isopachous, syntaxial marine cement is present at some grain contacts. An influx of meteoric waters precipitated a nonluminescent, blocky calcite spar. Following a period of partial dissolution, a brightly luminescent cement lined cavities and indicates deeper burial. The bright cement is followed in optical continuity by an unzoned, faintly luminescent cement forming blocky spar that terminates in rhombic euhedra extending into the remaining pore spaces. It appears that invasion by hydrocarbons expelled meteoric waters and abruptly ended cementation.

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Petrology and Porosity of Devonian Misener Formation, West Kremlin Field, Garfield County, North-Central Oklahoma

The Misener formation is a laterally discontinuous, mixed carbonate-silicilastic unit, comprising dolomite-cemented, quartz-rich arenite, and quartz-bearing dolomite. It reaches a thickness of 60 ft in the West Kremlin field, overlies an unconformity that truncates lower Paleozoic sedimentary strata, and is overlain by the Woodford (black) Shale. Based on petrographic and sedimentary features, it appears to have been deposited in a shallow, tide- and wave-influenced, marine environment.

The quartz-rich arenites are fine to very fine grained and well to very well sorted. They contain mostly monocrystalline quartz clasts, very fine grained, well-crystallized dolomite rhombs, and less than 2% K-feldspar. Lithic fragments, which are rare except for chert pebbles in the basal 1-2 cm, include silicified shale, phosphatic shale, and carbonate micrite. Accessory components include glauconite, phosphatic oolites, conodonts, fish scales, and authigenic pyrite. Devonian outcrops of the Ordovician Simpson Sandstone likely supplied most of the quartz detritus.

The best porosity is unevenly distributed in the mixed quartz-dolomite layers. Authigenic clay is rare, and quartz overgrowths are well developed but partly replaced by dolomite rhombs. Partial dissolution of the rhombs has formed a secondary porosity with good permeability due to pore-throat enlargement. Dolomite-poor, quartz-rich sandstones are well cemented by quartz overgrowths, and the pores contain abundant authigenic clay. The quartz-bearing dolomite is tight and, near the overlying Woodford Shale, is partly replaced by chert.

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Penecontemporaneous Facies Relations in Pennsylvanian (Desmoinesian) Deltas of Southwestern Indiana

Lateral and vertical sedimentologic and paleoecologic analyses of rocks and fossils of the lower part of the Dugger Formation (Pennsylvanian, Desmoinesian) in Indiana has delineated the following deltaic subenvironments: (1) distributary sands, (2) upper-, middle-, and lower-interdistributary estuaries, (3) delta-plain lakes, and (4) swamps. In this part of the Illinois basin, terrigenous influx was from the northeast across an extremely low depositional gradient. Because of high surface area to depth ratio, current and wave energies of this shallow epicontinental sea were diminished. Thus, differential compaction rather than marine reworking dominated the deltaic destructive phase in this area. Differential compaction resulted in accumulation of localized anomalously thick sequences. The thickened units occur directly adjacent to penecontemporaneous distributary sandstones because of the greater degree of syndepositional subsidence in these areas. The dominance by differential compaction produced an unusual situation wherein a slow marine transgressive or deltaic abandonment stage was followed by a rapid marine regressive or deltaic progradational stage. Vertical and lateral changes in body- and trace-fossil communities reflect the encroachment of marine conditions and the relatively sudden onset of freshwater deposition. Maximum marine inundation of the area coincided with carbonate deposition. Maximum water depth in the area is estimated to have been less than 80 ft (25m) based on lateral relationships of interdistributary lithofacies with distributary sandstone and delta-plain sediments. The marine-influenced lithology deposited in shallowest water was black shale, which grades downward into coal and upward into calcareous gray shale and limestone. Lateral facies gradation indicates that these divergent lithotypes were produced penecontemporaneously at the delta margin.

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Bathymetric Distribution of Foraminifera in Jamaican Reef Environments

Recent foraminifera inhabiting Jamaican north-coast fringing reefs display variations in distributional patterns that are related to bathymetry and reef morphology. Sediment samples containing foraminifera were collected along a profile that traversed the back reef (depth 1-2 m), fore-reef terrace (3-15 m), fore-reef escarpment (15-27 m), fore-reef slope (30-55 m), and upper deep fore reef (70 m). Approximately 150 species distributed among 80 genera were identified from the samples. Preliminary analyses indicate that diversity values (S, H′) are lowest on the fore-reef terrace (79, 3.0, respectively), increase similarly in back-reef and fore-reef escarpment and slope settings (93, 3.4), and are highest on the deep fore reef (109, 3.7). Larger groupings (suborders) exhibit distinct bathymetric trends with miliolids occurring more commonly in back-reef (comprising 51% of the fauna) than in fore-reef (28%) zones, whereas agglutinated and planktonic species occur more commonly in deeper reef (> 15 m, 9% and 4%, respectively) than in shallower reef zones (< 15 m, 3%, and 0.5%, respectively). Among the more common species *Amphistegina gibbosa* (Rotolina) is much more abundant in fore-reef (28%) than in back-reef (8%) environments, whereas *Archaias angulatus* (Miliolina) is more abundant in back-reef (15%) than in fore-reef (3%) environments, and *Sorites marginalis* (Miliolina) occurs almost exclusively in the back reef, where it comprises 5.5% of the fauna. Q-mode cluster analysis, involving all species collected, enabled the delineation of back-reef, shallow fore-reef, and deeper fore-reef biofacies, also indicating the potential utility of foraminiferal distributions in detailed paleoenvironmental interpretations of ancient reef settings.

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Sedimentology and Stratigraphy of Mississippian Orogenic Sediments, East-Central Nevada: Proposed Solution to a Paradox

Mississippian orogenic sediments deposited during during the Antler orogeny and exposed in east-central Nevada record the initial breakup of the Cordilleran geosyncline. They also contain one of the thickest, rich-