laminar crusts with pisolites. Fractures are filled by micritic laminae, microspar, spar, and terra rossa.

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Estimating Unconformity Thicknesses from Vitrinite Reflectance Data

Combining variations of vitrinite reflectance with depth and burial history information enables estimation of the paleoheat flux-time derivative, β. In the presence of an unconformity, the residual r.m.s. fit of the paleoheat flux to the observed data is significantly improved when the unconformity thickness (h) is allowed to be a free variable. A best unconformity thickness that minimizes the residual r.m.s. fit to β can be determined, providing a new method of determining simultaneously paleoheat flux and unconformity thickness.

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Seismic Expression of Catastrophic Slope Failure: Lower Cretaceous Torok Formation, North Slope of Alaska

Seismic geometries in the deep marine Torok Formation illustrate that catastrophic slope failure involving both slope and basin-plain sediments occurred during Early Cretaceous time on the North Slope of Alaska. The magnitude of the failure emphasizes the importance of slumping and sliding as processes of mass transport of sediment in the deep marine environment.

Torok sandstones and shales were deposited on continental slopes, basin plains, and submarine fans. Fluvial-deltaic sands and shales of the Nanushuk Group are the time-equivalent shelf deposits. The Nanushuk-Torok relationship is expressed seismically as offlapping reflectors that record shelf-edge progradation. Slumps and slides are common on Torok slopes where gradients of up to 10° are documented.

The largest such feature, located near Harrison Bay, is 1,500 mi^2 in area and 2,000 ft thick. The disturbed zone is lobate in plan view, wedge shaped in cross section, and thins basinward from a dramatic scarp deeply incised into Torok foreset beds. Seismically, the slide is expressed as a series of remnants of undisturbed or rotated glide blocks that strike parallel with the slump scarp and are encased in chaotically bedded slump debris. Geometric similarities to the Turnagain Heights slide (Anchorage, 1964) suggest block gliding as the mechanism of slope failure.

Because the Torok was initially sand-poor, wells drilled through glide blocks and slump debris encountered predominantly shale. Understanding similar seismic geometries in other slope systems will aid in their evaluation as hydrocarbon traps. Favorable reservoir and trap scenarios include turbidite sands in remnant blocks trapped against slump fill and younger turbidite sands ponded behind remnant topography.

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Low to Intermediate Subsurface Temperatures Calculated by Chemical Geothermometers

The concentrations of silica and proportions of sodium, potassium, lithium, calcium, and magnesium in water from hot springs and geothermal wells have been combined into 14 chemical geothermometers that are used successfully to estimate the subsurface temperatures of the reservoir rocks. Modified versions of these 14 geothermometers and a new chemical geothermometer, based on the concentrations of magnesium and lithium, were used to estimate the subsurface temperatures (40°C-200°C) of more than 200 formation-water samples from about 30 oil and gas fields located in coastal Texas and Louisiana, Central Valley, California, and North Slope, Alaska. The new Mg-Li geothermometer, which can be used to estimate subsurface temperatures as high as 350°C, is given by:

$$t = (1{,}900/(4.67 + \log[(C_{Mg})^{0.5}/C_{Li}]) - 273$$

where t is temperature (°C) and C is the concentration (mg/L) of the subscripted cation.

Quartz, Mg-Li, Na-K-Ca-Mg, and Na-Li geothermometers give concordant subsurface temperatures that are within 10°C of the measured values for reservoir temperatures higher than about 70°C. Mg-Li, Na-Li, chalcedony, and Na-K geothermometers give the best results for reservoir temperatures from 40°C to 70°C. Subsurface temperatures calculated by chemical geothermometers are at least as reliable as those obtained by conventional methods. Chemical and conventional methods should be used together where reliable temperature data are required.

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Sketching Cross Sections with a Portable Microcomputer

Computer applications have been carried to the field long ago by geophysicists and their "dog houses." The advent of inexpensive battery-powered microcomputers promises to allow the field geologist to participate in this application. The field geologist may record data directly onto a computer-readable medium and calculate statistics or plot a cross section. A program for routine plotting of cross sections in the field has been developed and field-tested. The program proved to be useful to 30 computer-illiterate geologists on a 6-week mapping project in New Mexico. The program allows the user to control vertical exaggeration and displays the correct apparent dip along the chosen line of section. Cubic-spline interpolation is used to plot both topography and folded bedding planes. The program executes in Pascal on an Apple IIc in a few seconds.

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Regional Cement Stratigraphy and Diagenetic History of Waulsortian Limestones, Eastern Midlands, Republic of Ireland

The Lower Carboniferous Waulsortian Limestones, eastern Midlands, Republic of Ireland, contain 7 distinct luminescent zones in clear calcite cements that overlie inclusion-rich, marine cements in cavities and also fill fractures and aragonite-skeleton molds. The luminescent sequence, which records precipitation from increasingly reducing pore waters, is regionally and stratigraphically consistent over an interval more than 1,200 ft thick. Zone 1 cements are nonluminescent; zone 2 cements are brightly luminescent; and zones 3-7 cements are ferroan with a moderate to dull luminescence. Zone 1 cements (mean $-2.6‰\ \delta^{18}O/+3.3‰\ \delta^{13}C$ PDB) are slightly depleted in oxygen relative to radiaxial-fibrous cements (mean $-1.8‰\delta^{18}O/+3.5‰\delta^{13}C$ PDB) which have a composition that reflects Lower Carboniferous seawater. Zone 4 cements (mean $-4.1‰\delta^{18}O/+3.1‰\delta^{13}C$ PDB) are depleted in oxygen relative to zone 1, whereas zone 5 cements (mean $-11.8‰\delta^{18}O/+1.1\delta^{13}C$ PDB) are extremely depleted in oxygen and somewhat in carbon.

Locally intense dolomitization includes 2 regionally extensive generations of ferroan saddle dolomite. Petrographic relationships demonstrate these dolomite generations were replaced by zone 5 cement. Sulfide mineralization, principally pyrite and sphalerite, occurred after the precipitation of zone 5 cement.

Much of diagenesis occurred during a brief period in the Lower Carboniferous. Zones 1-6 and saddle dolomites are contained in Chadian (upper Osagean), shallow-marine facies overlying the Waulsortian. Fractures filled by zone 5 cements are truncated at the margins of Waulsortian clasts contained in a conglomerate overlying an early Arundian (early Meramecian) unconformity.

In the proposed model, marine pore waters were displaced by oxidizing meteoric waters, which became reducing with shallow burial. Warm brines were introduced during later stages of diagenesis and were involved in late calcite cementation (zone 4?-7), saddle dolomitization and sulfide mineralization.

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Algeria: Structural Evolution and Hydrocarbon Potential of a Complicated Tectonic Province

During most of the pre-Carboniferous, Algeria was part of a stable foreland platform on which a thick clastic sequence was deposited. Caledonian tectonics were primarily epeirogenic, but they established structural alignments that were further reinforced by the much stronger movements of the Carboniferous Hercynian orogeny.

In northern and eastern Algeria, a variable basal sandstone and a thick sequence of Triassic and Lower Jurassic evaporites were deposited over the eroded Hercynian surface. This provided a seal for subsequent hydrocarbon migration from the underlying Silurian and Devonian source rocks. Important epeirogenic events and tensional faulting occurred during the Jurassic and Cretaceous.

Compressional forces in the Tertiary culminated in the Alpine orogeny. A broad zone of uplift and southward-directed imbricate thrusting formed along the northern margins of Algeria obscuring much of the sub-Tertiary depositional and structural features.

Hydrocarbon accumulation in Algeria has been predominantly controlled by the relationships among the Silurian-Devonian source rocks, the Hercynian unconformity, and the distribution of the overlying Triassic clastic and evaporite sequence. More than 65% of the recoverable oil reserves and 90% of the gas reserves are trapped immediately below or above the Hercynian unconformity, with the evaporites providing the seal.

Heretofore, the complex geology of the Tertiary overthrust zone has been a deterrent to exploration in both the autochthonous Miocene basins and the sub-Tertiary sequence. However, improved seismic techniques and renewed interest in the potential of overthrust provinces point to increased activity in this area.

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Downslope Transportation of Metalliferous Sediments Along East Pacific Rise During Messinian

The distribution of metalliferous sediments adjacent to active spreading centers is of both scientific and economic interest. Metal-rich waters emanating from active hydrothermal vents have been traced in intermediate level water masses far beyond the ridge crest, but the greatest concentrations of metal oxides in sediments occur near the vents. There, however, it is possible that the oxides may be redistributed and possibly further concentrated by redeposition. We document one such case of redeposition for Messinian sediments cored at Deep Sea Drilling Project Site 599, which, along with the other DSDP Leg 92 sites, was the first on the East Pacific Rise to be drilled using the hydraulic piston corer.

Site 599 (19°27.09′S, 119°52.88′W; water depth = 3,654 m), drilled in a small basin about 600 km from the present ridge crest, recovered 41 m of mostly Miocene calcareous oozes characterized by alternating light (mostly yellowish brown to dark yellowish brown) and dark (mostly dark reddish brown) zones from 10 to 100 cm thick and/or bands 2-5 cm thick. A sharp contact at sample point 599-3-3, 21 cm, separates fine-grained light-colored in-situ sediments of calcareous nannofossil Zone CN9b below from a coarser grained and darker metalliferous-rich unit above, which contains older nannofossils derived from Zone CN8b. Indicative of downslope transport of metalliferous materials during the Messininan, this example may explain much of the sediment banding seen throughout the section.

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Eolian Reservoir Characteristics Predicted from Dune Type

The nature of eolian-dune reservoirs is strongly influenced by stratification types (in decreasing order of quality: grain-flow, grain-fall, wind-ripple deposits) and their packaging by internal bounding surfaces. These are, in turn, a function of dune surface processes and migration behavior, allowing for predictive models of reservoir behavior. Migrating, simple crescentic dunes produce tabular bodies consisting mainly of grain-flow cross-strata, and form the best, most predictable reservoirs. Reservoir character improves as both original dune height and preserved set thickness increase, because fewer grain-fall deposits and a lower percentage of dune-apron deposits occur in the cross-strata, respectively. It is probable that many linear and star dunes migrate laterally, leaving a blanket of packages of wind ripple laminae reflecting deposition of broad, shifting aprons. This is distinct from models generated by "freezing" large portions of these dunes in place. Trailing margins of linear and star dunes are prone to reworking by sand-sheet processes that decrease potential reservoir quality. The occurrence of parabolic dunes isolated on vegetated sand sheets results in a core of grain-flow and grain-fall deposits surrounded by less permeable and porous deposits. Compound crescentic dunes, perhaps the most preservable dune type, may yield laterally (1) single sets of cross-strata, (2) compound sets derived from superimposed simple dunes, or (3) a complex of diverse sets derived from superimposed transverse and linear elements.

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Impact of Stylolites on Carbonate Reservoir Continuity: Example from Middle East

Growth of stylolites may adversely affect the continuity of carbonate reservoirs by producing barriers to fluid flow. The impact of stylolite development on reservoir performance, however, may differ from one part of a reservoir to another. Therefore, for effective reservoir management, the distribution and the permeability of stylolite-bearing beds should be known. In an example from the Lower Cretaceous of the Middle East, 3 zones of stylolites (D1, D2, and D3) are important to reservoir management. Only the uppermost zone (D1) is a significant barrier to fluid flow. Because the impermeable zone (D1) formed largely before oil entrapment, local precipitation of calcium carbonate occurred at abundant crystal-nucleation sites adjacent to the stylolite zone. The other stylolite zones (D2 and D3) were formed largely during or after oil entrapment. Oil inhibited carbonate precipitation by coating crystal nucleation sites. Calcium carbonate, dissolved at pressure-solution surfaces, was then transported away from stylolite zones prior to precipitation. Consequently, stylolites formed after oil entrapment do not constitute significant barriers to fluid flow.

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Controls on Porosity and Dolomite Distribution in Upper Smackover Formation (Upper Jurassic), Southwestern Alabama and Western Florida

Upper Smackover carbonates of southwestern Alabama and western Florida exhibit arcuate trends of porous dolomitized grainstones separated by areas of impermeable muddy limestones. The origin of these porous trends is related to the depositional and diagenetic history of upper Smackover carbonates and overlying Buckner evaporites. Shoal-water oolitic and peloidal grainstones of the upper Smackover were deposited across basement and salt-related topographic highs. Subsequent aggradation and stepwise progradation of oolitic shoals over low-energy packstones and wackestones produced a complex sea-floor topography of arcuate oolite ridges (highs) and elliptical muddy lagoons (lows). Marine regression during Buckner deposition led to the formation of saline ponds and sabkhas that were initially located over Smackover lagoonal lows and rimmed by Smackover oolite ridges. Precipitation of evaporites within these depressions created magnesium-rich brines that selectively dolomitized adjacent Smackover carbonates. Both the outflow of brine and the pattern of dolomitization were controlled by the fluid transmissibility of Smackover sediments. Consequently, permeable oolitic and peloidal grainstones were preferentially dolomitized over less-permeable muddy carbonates. A possible hydrologic analog for the study area exists within the MacLeod Evaporite basin, western Australia.

Following burial, dolomites maintained greater effective porosity on the flanks of basement and salt-related topographic highs than on the crests.

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Modern Analog for Deep-Water Deposition of Shallow-Water Pliocene Sands, Gulf of Mexico

Paleoenvironmental studies using benthic foraminifers and total fauna can be used to identify displaced shallow-water sands. A productive sand in Eugene Island field, which has a high resistivity but suppressed spontaneous-potential, was conventionally cored to determine reservoir characteristics and environment of deposition.