

during deeper burial. Calculations of the total amounts of CO₂ released by kerogen in sedimentary basins suggest that secondary porosity is favored by high contents of humic kerogen, but that the CO₂ produced and/or pore-water flow in many types of basins are too small to create significant amounts of secondary porosity. Reactions with clay minerals may, however, provide additional sources of acid.

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Three-Dimensional Seismic Interpretation of a Piercement Salt Dome

Eugene Island Block 77 field is a shallow (1,100 ft, 335 m) piercement salt dome with a low relief overhang which is productive from upper Miocene sands at depths between 13,300 and 15,800 ft (4,054 and 4,816 m, or between 3.260 and 3.690 sec). These hydrocarbon accumulations are trapped in steeply dipping beds (10 to 40° by dipmeter) between the salt mass and the rim syncline. Small radial faults (50 ft, 15.2 m, of throw) also affect reservoir limits, as is evidenced by varied gas/water contacts and reservoir production performance.

This combination of factors (piercement dome, salt overhang, deep objective, steeply dipping beds, tight rim syncline, small faults) makes Block 77 field difficult to map accurately with 2-D seismic. Unmigrated lines do not show the dip between the salt mass and rim syncline; migrated lines contain migration artifacts, making a salt interface interpretation ambiguous and recognition of small faults impossible. To overcome the problems inherent to the 2-D seismic method, a dense grid of data (trace spacing of 110 ft, 33.5 m, in both *X* and *Y* directions) was collected over this field and migrated in three dimensions. This placed events in their proper spatial relationship, thus enhancing both fault delineation and salt face interpretation. In previous interpretations (based on 2-D data), only one fault was mapped—a large down-to-the-north fault extending eastward from the northeast quadrant of the dome. The 3-D data show a more complicated combination of fault systems including other large parallel faults, some with compensating faults; buried down-to-the-south faults; and an extensive system of small radial faults.

Salt-face maps based on 2-D data were very inaccurate. Due to sideswipe problems, only lines shot radially across the dome were interpretable. This created large areas of no control. Using a 3-D grid eliminated the sideswipe problem and increased the amount of control on which to base the interpretation. The salt face, as seen on the seismic was tied to existing well control to make an accurate salt-face interpretation.

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Fan-Delta and Lacustrine Margin Sedimentation, Chinle Formation (Upper Triassic), Canyonlands National Park, Utah

Cyclic fluvial, fan-delta, and lacustrine margin depositional systems dominate the lower part of the Chinle Formation, Canyonlands area, southeastern Utah. Detailed facies analysis of the Moss Back Member and related strata document two alternating fluvial-lacustrine sequences. (1) During high fluvial output, coarse-grained meander belts built fan-deltas into shallow lakes. (2) During low fluvial output, braided streams waned before reaching the lakes, and algal and evaporitic mud flats formed on broad lacustrine perimeters.

The high fluvial output phase comprises three depositional

systems. (1) The coarse-grained meander belt system consists of point-bar and channel deposits. Abundant carbonate grains were cannibalized from upland caliche soils and lowland oncolite-bearing carbonate mud flats. (2) The fan-delta system contains sandstone and mudstone delta foresets that coarsen upward into delta-distributary deposits. (3) Blue-green, bentonitic, limy mudstone was deposited in the shallow lacustrine system.

The low fluvial output phase comprises three depositional systems. (1) Braided stream deposits contain trough and planar cross-stratified calcarenite, calcirudite, and quartzarenite. (2) Micritic limestone, algal mats, and oncolites formed on swampy lake margins. (3) Shallow, warm, clear-water, lacustrine deposits are represented by continuous micritic limestone beds and bioturbated limy mudstone and sandstone.

Three external controls produced the cycles. Tectonics associated with the adjacent salt anticline region affected source terrane (intrabasinal carbonate output) and fluvial discharge. Regional humid-arid cycles affected fluvial discharge and lake levels. Volcanic eruptions to the southwest produced periodic influx of volcanic debris that caused increased turbidity and sedimentation rates and decreased carbonate production.

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Sedimentology and Provenance of Miocene Intraclastic Chalks, Blake-Bahama Basin

Leg 76 of the Deep Sea Drilling Project cored 165 m of a 500-m thick Miocene intraclastic chalk formation in the Blake-Bahama Basin. The carbonate material was derived mainly from the Blake Plateau and slopes of Little Bahama Bank with less amounts coming from the shallow platform of Little Bahama Bank. The sediment was transported 150 to 200 mi (240 to 320 km) into the Blake-Bahama Basin via Great Abaco Canyon and Eleuthera Ridge (a Miocene submarine canyon).

Deposition close to the sources was primarily by mass flow or debris flow mechanisms (medium to coarse grains of both shallow- and deeper-water origin float chaotically in a matrix of carbonate mud), whereas turbidite deposition (finely laminated to massive silt and clay-size carbonate) dominates throughout most of the basin. Turbidite sedimentary structures also dominate over debris flow structures in the various facies of this formation.

Upon entering the basin, these chalk turbidites descended below the carbonate compensation depth and eroded and incorporated clasts of partly consolidated siliceous mudstone (the background hemipelagic sedimentation). These clasts of mudstone, as well as clasts of limestone and previously cemented chalk, produce the distinctive appearance so characteristic of this formation.

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U.S. Geological Survey Activities in Oil Shale

Since the early 20th century, the U.S. Geological Survey has been concerned with oil shale; the extent of Survey activity has fluctuated widely during these decades as functions of changing national energy needs and economic outlook for competitive production. Recent international events, namely the rapid price escalation of crude oil imposed by OPEC and the ever-lingering concern over further import constraints, have again made oil shale a potentially attractive energy source. Although organic-rich shales occur in several formations in the United States, the rich deposits of the Green River Formation in Colorado, Utah,

and Wyoming have received the most attention by both the Survey and prospective developers. Widespread Survey optimism on oil shale's viable future was emphasized by increased funding in 1981 for Conservation Division's enlarged monitoring and regulatory office in Grand Junction, an expanded research and resource appraisal program for Geologic Division, and for Water Resources Division's hydrologic studies. Deep drilling, coring, and hydrologic testing in the east-central Uinta basin, supported by Geologic, Conservation, and Water Resources Divisions, is currently under way. Environmental investigations related to oil-shale development and production are concentrated in Water Resources and Conservation Divisions along with associated regulatory responsibilities and interagency coordination. In Geologic Division, we are (1) providing basic geologic data to support the government's prototype oil-shale and by-product saline mineral leasing program; (2) continuing stratigraphic, mineralogic, geochemical, and resource appraisal studies; and (3) expanding the computer data base for oil-shale resources and the associated software for more flexible and varied information retrieval and display. We are convinced the enormity of the resource, its occurrence in a relatively small geographic area, and its potential national and international impact require comprehensive basinwide planning and development to achieve maximum recovery of the resource with minimum loss and degradation.

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Deposition and Penecontemporaneous Deformation of Sediments on a Faulted Submarine Slope, Hunters Cove Formation (Campanian-?Maestrichtian), Southwest Oregon

The Hunters Cove Formation is a 300-m thick, fining-upward sequence deposited above and perhaps also contemporaneously with Cape Sebastian Sandstone, a transgressive shelf sequence. Overall, the formation is fine-grained (sand:shale < 1:3) and consists of thin, T(a)bc(de) turbidites, siltstone, and shale. Distinctive, thick sandstone beds exhibit varied sedimentary structures indicative of rapid sedimentation, soft-sediment deformation, and fluid-escape processes. These sandstones were probably deposited at a break-in-slope or canyon mouth, resulting in unstable-grain-framework sands susceptible to hydroplastic deformation, liquefaction, and fluidization.

The Hunters Cove Formation also contains small-scale slump zones and a thick slump breccia containing clasts of basal Cape Sebastian Sandstone, indicating that Hunters Cove deposition was contemporaneous with, and may have been initiated by, active faulting. This faulting is also suggested by small-scale penecontemporaneous faults and sheet and web structures. Hunters Cove deposition probably occurred on the edge of a small, fault-bounded, borderland-type basin. In particular, submarine-canyon and fan processes in the California Borderland, as described by Shepard, Dill, and others, may be modern analogies for it.

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Depositional Systems in Naknek Formation, Late Jurassic, Lower Cook Inlet, Alaska

The Naknek Formation is a thick wedge-shaped unit of Late Jurassic age. It accumulated along the western edge of a Jurassic fore-arc basin. The formation was examined by BP Alaska geologists along the western shore of Lower Cook Inlet between Chisik Island and Cape Douglas.

Correlation of stratigraphic sections has identified three sand-

stone/conglomerate sequences separated by two siltstone units. The conglomerate units are thick, lenticular, and occur as both organized and disorganized conglomerate facies. The sandstone units exhibit the following sedimentary structures and bedding types: (1) massive, graded, and amalgamated beds; (2) thickening and coarsening-upward sequences; (3) slump structures; (4) load and flute casts; (5) soft-sediment faulting; (6) rip-up clasts; (7) ripple lamination; and (8) minor cross-bedding. The siltstone units are parallel laminated and have thin sandstone beds with partial and complete density current sequences. Bioturbation is not common although some grazing burrows are present. Ammonites, belemnites, plant debris, and radiolarians are the most common fossils, although forams, gastropods, and pelecypods (dominantly *Buchia* sp.) are also present.

Previous workers have described the Naknek Formation as a shallow-marine deposit, but did not identify specific sedimentary facies. This study indicates that the Naknek Formation was deposited in moderate to deep water as a submarine fan complex.

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East Brentwood Gas Field: A Paleotopographic Trap

The East Brentwood gas field is located about 45 mi (72 km) east of San Francisco, California. The discovery well was drilled in 1978 by Depco, Inc. and completed in the Upper Cretaceous Third Massive sand at a depth of 8,050 ft (2,454 m). The Third Massive sand is a progradational sequence of sands with thin shale interbeds, interpreted to have been deposited in a near-shore, open-sea environment. The reservoir sand is dramatically truncated by the Meganos Gorge, a shale-filled fossil channel of Paleocene age. Faunal assemblages indicate that the cutting and filling of the gorge were submarine rather than subaerial.

The East Brentwood gas field is primarily controlled by the truncation of the basal part of the Third Massive sand by the Meganos Gorge shale fill with lateral closure afforded by several normal faults which divide the field into at least four separate producing blocks. Exploration mapping techniques, including seismic and well control, concentrate on the relation of the Massive sands to the basal Meganos Gorge configuration, the intersection of which essentially represents a buried paleotopographic surface. Exploration for updip sand termination against the shale-filled erosional gorge feature should result in the discovery of additional natural gas accumulations. Nine wells are presently completed in the gas field in which the better wells have over 250 ft (76 m) of net gas sand. The field has produced 19 bcf of 1,080 Btu gas and 50,000 bbl of 46° API gravity condensate since discovery. Field ultimates are expected to be in excess of 40 bcf and 100,000 bbls of condensate.

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Comparison of Wave-Dominated Deltaic Deposits and Associated Sand-Rich Strand Plains, Mesaverde Group, Northwest Colorado

The Mesaverde Group (Campanian) in northwestern Colorado is a thick (> 700 m) clastic wedge that prograded eastward into the Western Interior seaway. Models of the main depositional systems in this group were constructed through the study of rock textures and physical and biogenic structures. The geometry of lithofacies was determined from outcrops and