

tage of organic carbon extracted thereby doubling the yield of oil per ton. The process uses hydrogen at temperatures of 500 to 730°C and pressures of 20 to 50 atm. Experimental work in equipment capable of processing up to one ton of shale per hour has confirmed the technical and economic feasibility of above-ground hydroretorting of Devonian oil shales. Investigation of more than 550 samples from some 150 locations in 13 states indicates that IGT's HYTORT™ process can give organic carbon recoveries from 2 to 2.5 times those of conventional retorting, resulting in yields of 25 to 30 gal/ton at many localities, compared with 10 to 15 gal/ton using Fischer Assay.

Resource estimates are based on above-ground hydroretorting and four criteria: overburden less than 200 ft (59 m), stripping ratio less than 2.5 to 1, shale thickness of 10 ft (3 m) or more, and organic carbon at least 10% by weight. Resource estimates include: Kentucky 190 billion bbl, Ohio 140 billion bbl, Tennessee 44 billion bbl, Indiana 40 billion bbl, Michigan 5 billion bbl, and Alabama 4 billion bbl. Seven other states have been sampled but recoverable resources were not identified. The total recoverable resource exceeds 440 billion bbl of synthetic oil if all near-surface shales of more quality were mined for above-ground hydroretorting.

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Oxygen Isotope Record of Ice Volume History: 100 M.Y. of Glacio-Eustatic Sea Level Fluctuation

The $\delta^{18}O$ values for shallow-dwelling planktonic foraminifers vary as a function of global ice volume and local temperature. By using only sites which have been shown to have had a stable sea surface temperature during late Pleistocene, we propose to constrain paleotemperature to near-constant modern values. For such sites, variation in $\delta^{18}O$ of shallow-dwelling planktonic foraminifers is thus constrained to reflect variation in global ice volume.

With regard to average values, we suggest the earth has had a significant ice budget since the Cenomanian (approximately 100 m.y. ago). Thus, variation in the average state of the global ice budget is a likely cause for interregional unconformities.

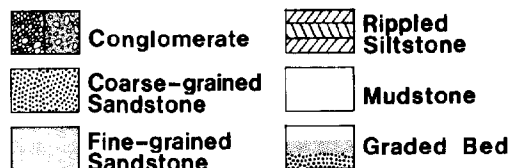
It is possible to evaluate the stability of continental ice caps by sampling short intervals of core in extreme detail. Our preliminary isotopic results show that high-frequency variation of ice volume persists throughout the last 40 m.y. at no less than 25% of the late Pleistocene amplitude. This implies that high-frequency sea level fluctuations of at least 30 m are superimposed upon longer term trends.

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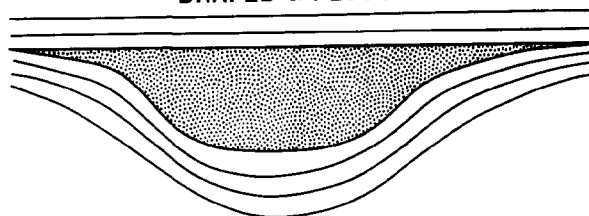
Shelf-Edge Conduit: Channelized Sediment Transport Across Eocene Fore-Arc Basin Margin, Southern California

A complete shallow-to-deep marine transition is exposed in Eocene rocks at San Diego, California. Well-exhibited facies relations, precise biostratigraphic control, and paleobathymetric indicators allow comparison of these continental margin outcrops with similar sequences most commonly observed only by seismic-stratigraphic methods. Even in this active tectonic setting, eustasy appears to be the dominant factor in cutting shelf-edge unconformities, forming and reactivating submarine canyons, and controlling the distribu-

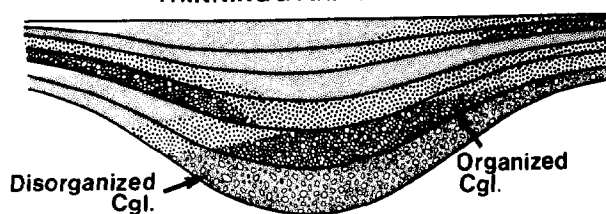
VARIEGATED CHANNEL FILLS



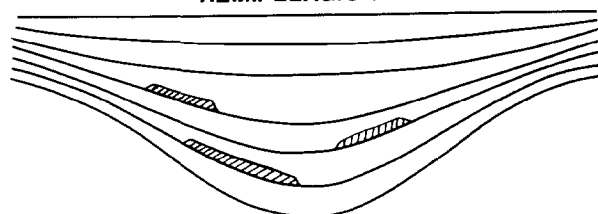
DRAPED & PLUGGED



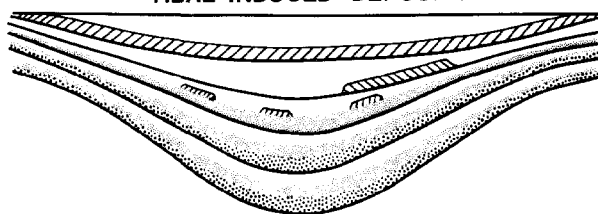
THINNING & FINING UPWARD



HEMPELAGIC FILL



TURBIDITES AND TIDAL-INDUCED DEPOSITS



tion of facies down the shoreline-to-basin conduit.

Broad, shallow outer-shelf channels funneled coarse-grained littoral sediments to the gullied upper slope and canyon head. These channels were filled with massive to laminated sandstone and shell lag, bioturbated mudstone, and rare slump-folded mudstone. An early Eocene canyon head was cut at the shelf edge during a eustatic lowstand, then eroded landward during subsequent sea level rise. The canyon is floored with a thick, massive sandstone that may be amalgamated or crudely graded, containing clasts of canyon-wall debris up to 6 m long in cross section, as well as conglomeratic to pebbly or gravelly sandstone. It exhibits convolutions, flame structures, and other evidence of rapid

deposition and dewatering. Deposits above the basal sand accumulated in broad, anastomosing channels 10 to 15 m deep with variegated fill; some still contain sand and conglomerate, but most were evacuated and filled with lower energy thin-bedded sands and muds or massive hemipelagic muds, indicating significant volumes of bypassed sand.

At the base of slope, a major 100-m deep leveed channel was floored with conglomerates and large canyon-wall clasts, and filled with massive to convoluted sandstone. The channel fed a system of shallow, crosscutting, conglomeratic channels, interpreted as inner fan that extended into the canyon mouth.

Paleobathymetric relief exhibited across this ancient shelf break is minimally 600 m (outer shelf to mid-bathyal or deeper) within a lateral outcrop distance of 3,000 m.

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Comparison of Eogenetic and Mesogenetic Porosity-Diagenetic Trends in Deeply-Buried Limestone Reservoir in West Texas

Stratigraphically trapped gaseous hydrocarbons occur in porous limestones of Atokan (Middle Pennsylvanian) age in the Chapman Deep field, along the northern shelf edge of the Delaware basin in Reeves County, Texas. These rocks were deposited as a shallow-water mosaic of cyclic algal bioherms, grainstone shoals, and low-energy interbank facies. A relatively uninterrupted sequence of porosity evolution related to early and burial diagenesis is recognized in these rocks. Syndepositional subaerial exposure resulted in the formation of a secondary pore system, including biomolds, non-fabric-selective vugs and channels, and solution-enlarged fractures. However, most of this porosity was occluded rapidly in the vadose and phreatic environments by calcite cementation, dolomitization, and internal sedimentation. Progressive burial to minimum depths of 13,000 ft (3,962 m) was accompanied by bulk-volume reduction via physical and chemical compaction. However, simultaneous fabric-selective dissolution rejuvenated a pore system of relatively low permeability which, enhanced by natural fractures and the presence of open stylolites, comprises the principal reservoirs in the field. Pore types include ooid and cement-solution molds; although not recognized in these rocks, burial-solution channels and vugs are reported to be relatively abundant in Smackover carbonates of the Gulf Coast region. Such tertiary porosity is easily misinterpreted as of meteoric origin, and its occurrence attests to a possible parallel evolution of eogenetic and burial-diagenetic processes and products.

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Tectonic Effects on Meandering River Deposits, Carboniferous, Nova Scotia, Canada

Sediments of the Boss Point, Port Hood, and Parrsboro Formations (Carboniferous) of Nova Scotia were deposited on alluvial plains in tectonically active basins bounded by strike-slip faults. Some basins contain over 1 km of strata of this age. Fining-upward fluvial channel sandstones are about 20 m thick and are composed of a vertical sequence of basal conglomerate, trough cross-beds, ripple lamination, and siltstone. Large-scale lateral accretion surfaces are present and the sandstones are interpreted as meandering river deposits. Flood-plain sediments include crevasse splay sandstones, rooted mudrocks, thin coals, and lacustrine deposits.

The channel sandstones are stacked vertically and many

form thick sandstone packages. One 1-km thick sequence, for example, consists of over 75% channel sandstone. There are similarly thick, laterally equivalent, sequences of flood-plain sediment with few or no channel sandstones. It appears, therefore, that meander belts were restricted in their positions for long periods, allowing the unusually thick sequences of channel and coeval overbank sediment to accumulate. The variation from the classic meander-belt model, in which avulsion randomly distributes the meander belts across the alluvial plain through time, was presumably due to differential subsidence rates which caused the meander belts to be restricted to the areas of higher subsidence, thus retarding avulsion frequency.

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Depositional Model of Sand-Dominated Mesotidal Estuary

Depositional environments were surveyed in a large sand-dominated estuary on the south-central South Carolina coast. The estuarine system is characterized by abrupt lateral variations in sediment texture, composition, and physical and biogenic sedimentary structures. Sand-dominated intertidal environments include point bars, ebb sand spits trailing seaward from marsh headlands, tidal sand ridges, and sandy tidal flats. Morphologically, point bars, trailing spits, and tidal ridges are in a continuum of linear to sinuous depositional forms 1 to 3 km long.

An idealized vertical section through these sand bodies is a fining upward sequence beginning with channel lags of coarse sand and gravel followed by interbedded and bioturbated sands and muds interpreted as channel-fill deposits. A gradation between high-angle, large-scale cross-bedding and low-angle, small-scale cross-beds is typical of bar platform and vertical accretion bar sands. Capping the sequence are muddy sands to laminated muds grading into salt-marsh deposits.

Sand flats that prograde from marsh islands typically display a fining-upward trend beginning with shell material concentrated in medium to coarse sand where high-angle cross-bedding is the dominant sedimentary structure. In the upper part of the tidal-flat sequence, biogenic structures increase and disrupt low-angle, small-scale cross-bedding. Wave-deposited laminated sands, capped by rooted, bioturbated marsh muds, top the idealized sequence. Delta-like deposits within the estuary are morphologically gradational between tidal-sand ridges and true flood-tidal deltas and include physical and biogenic structures common to both.

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Nonmarine Carbonates of Neogene Lake Idaho in Utah

Nonmarine carbonate sequences are not well known in Neogene rocks. Best known, perhaps, are two lacustrine sequences recently described in the Pliocene of western North America. One, in the Ridge Basin of southern California, contains numerous beds about one meter thick of stromatolitic and oolitic limestone interbedded with non-carbonate clastic rocks. The other, in southern Idaho, is the Glens Ferry oolite, a 10-m thick carbonate sand unit exposed for 45 km along the western margin of the Snake River Plain. The latter unit is a deposit of the extensive Miocene-Pliocene lake system called Lake Idaho, and is considered the largest freshwater lacustrine oolitic carbonate sequence known in the rock record. New