Depositional Model for Submarine Fans

Sand deposition on the Dume submarine fan off southern California is localized in the prominent leveed channels on the upper fan and on suprafans. The sand-laden turbidity currents, confined to channels by high levees in the upper reaches of the fan, overtop the low levees in the suprafan area and deposit their loads in fan-shaped sheets across the middle and lower fan segments. Thus suprafans normally are formed on middle to lower fan areas and are characterized by sand sheets and numerous small distributary channels with no levees, or very low-relief levees. These channel-suprafan units form the basic building blocks of submarine fans and are the key to understanding their sedimentary facies distributions.

On high resolution sparker sections, the fan is internally characterized by discontinuous reflections and abundant diffractions resulting from the depositional relief produced by buried leveed channels. In detailed interpretations of the sparker sections, the fan complex can be divided into lobes and stratigraphic intervals related to different depositional processes. A three-dimensional fan model has been developed and applied in the interpretation of ancient fans recognized in outcrops and the subsurface.

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Sedimentology of Brent Formation (Middle Jurassic), Statfjord Field, Norway-United Kingdom

The Brent Formation of Middle Jurassic (Bajocian-Bathonian) age is the primary reservoir in the 3-billion bbl Statfjord field which is located in the northern North Sea on the boundary between Norway and the United Kingdom. Averaging approximately 180 m in thickness, the Brent can be conveniently divided into three major units that are easily identifiable on electric logs. The lower unit is a coarsening-upward sequence that commences with shale and terminates with coarse-grained sandstone. Sandstones in this unit, with porosities as high as 33%, comprise the best part of the reservoir. Interbedded shales, sandstones, siltstones, and coals characterize the middle unit, and the upper unit consists of sandstones with minor thin shales and occasional coals.

Analysis of cores from 10 wells in the field and several wells in nearby areas indicates that the Brent Formation represents a lobate, river-dominated deltaic complex morphologically similar to the Lafource delta of the Mississippi River. The lower unit, in ascending order, consists of prodelta, distal bar, distributary mouth bar, and distributary channel deposits; the heterogeneous middle unit comprises a delta plain association of distributary channel, interdistributary bay, splay, and marsh deposits. The upper unit was also deposited in a delta plain setting, but in places exhibits evidence of marine reworking. Facies patterns and trends demonstrate that the deltaic sediments of the Brent Formation in the Statfjord area were derived from a source area to the south-southeast rather than from the East Shetlands Platform to the west.

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Glacial-Marine Sedimentation: A Model

Glacially eroded sediments are introduced into the marine depositional environment by rivers, ice rafting, ice-contact deposit, or rarely by eolian transport. Glacial-marine facies range from well-sorted unimodal stratified deposits to bimodal or multimodal chaotic or massive deposits.

Position of the glacier terminus relative to the shoreline is the most important facies-determining factor in glacial-marine sedimentation. If the terminus is landward of the shoreline, as in the Gulf of Alaska, glacial-marine sediment is fluvially transported, in places rafted, and infrequently blown into the marine depositional environment. Deposits are generally unimodal, well sorted, stratified, and lack a coarse fraction. These deposits form in proximal environments, including beach, delta, and nearshore, and in a medial rock-flour-rich environment on the open shelf. If a glacier has an icebeig calving terminus in a fiord, or is grounded on the continental shelf, ice-contact deposition, ice rafting, and fluvial or current transport are the dominant processes. Ice-contact and ice-rafted deposits are poorly sorted, whereas fluvial and current deposits are well sorted and stratified. Ice-contact deposits accumulate where glacier ice contacts the continental shelf and slope. If the glacier terminus is floating, as is the Ross Ice Shelf of Antarctica, then all proximal glacial-marine facies and most medial facies on the open shelf are absent. The resulting deposit is a distal facies, typically ice-rafted in origin, which is almost everywhere bimodal or multimodal. The distal ice-rafted component has commonly been incorrectly identified as the only glacial-marine facies. Variations in ice-terminus position can cause rapid, radical changes in the resulting deposits. Depositional rates in proximal or medial deposits may range from 1 to 30 mm/year; short-term accumulation rates may exceed 4 m/year. Accumulation rates in distal ice-rafted deposits average less than 0.1 mm/year.

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Shelf-Slope Boundary at Active Subduction Zones

About 30 subduction-zone segments are identified worldwide by intermediate-focus earthquakes, calc-alkalic volcanic arcs, and lines of rapid mountain uplift. The total length of these active convergent plate boundaries is approximately 58,000 km. Of this length, 46% is of the Japan type, where the upper plate is relatively stable horizontally, 30% is of the Andes type, where the upper plate actively overrides the trench, and 24% is of the Himalaya type, where continental plates or microplates collide with continents.

Subduction zones of both the Japan and Andes types are marked by basement highs at the shelf break. Uplift of the crust and upper mantle at the edge of the upper plate causes these highs when a relatively low-density prism of accreted trench sediment is emplaced below. The accretionary prism usually forms within 5 m.y. after a new subduction zone is established, during the time that the megathrust at its sea-floor outcrop is evolving from an initial dip of 30 to 45° to a steady-state dip of about 10°. Except during this relatively brief initial period of accretion, trench sediment at subduction zones normally is carried deeply into the lithosphere.

Elongate sedimentary basins form on both sides of the shelf-break uplift, but compression generally removes the fluids from sediment on the lower trench slope before thermal maturation of oil precursors can occur. Elsewhere at the active margin, although the low geothermal gradient caused by subduction of cold oceanic crust delays hydrocarbon maturation, it can resume after continental collision or after subduction-zone realignment.

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Characteristics of Sunda Subduction Zone

The Sunda Arc is continuous from east of Java northwest to Burma and has a wide lower trench slope, an outer-arc ridge, and a fore-arc basin with a thick sediment fill. South of Java, a thin cover of hemipelagic sediment is carried into the trench on the subducting plate, whereas northwest of Sumatra up to 6 km of Bengal Fan sediments enter the trench. This change in sediment thickness produces a corresponding change in trench slope structure. Off Java, trench and hemipelagic sediments are accreted in thrust packets with no discernible internal structure. In the north, the fan sediments are deformed into large coherent folds. The outer-arc ridge, which is 1 to 3 km below sea level off Java, becomes emergent to the northwest as Nias, Mentawai, Nicobar, and Andaman Islands. Subduction is oblique west of Sumatra, and the fore-arc region is cut by strike-slip faults. The fore-arc basin is segmented into smaller basins along its strike by transverse structural highs. Fore-arc basin sediments are derived from the old crystalline terranes of Sumatra and the volcanic terrane of Java. Sedimentary sequences in the fore-arc basin reflect several periods of uplift and deformation of the outer-arc ridge and the magmatic arc.

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Contrasts in Paleogene Tectonic Style, Kodiak Accretionary Complex: Ridge-Trench Interaction and Reduced Convergence Rate

The Paleogene Sitkalidak and Ghost Rocks Formations, along the southeastern side of the Kodiak Islands, respectively comprise the youngest and second youngest deep-sea deposits exposed adjacent to the eastern Aleutian Trench. The Paleocene Ghost Rocks Formation consists of a trench and/or trench slope turbidite sequence with interstratified oceanic basalts and andesites which were deformed and intruded by tonolitic plutons by 60 Ma. The Eocene Sitkalidak Formation comprises a trench slope and trench-filling fan sequence, lacking lavas and plutons, but petrographically correlative to the Aleutian abyssal fan. Regional metamorphism to prehnite-pumpellite and zeolite facies with maximum temperatures of 200 to 240°C and 100 to 125°C, respectively, characterize the Ghost Rocks and Sitkalidak Formations. Offscraped parts of the Ghost Rocks Formation exhibit more intense deformation than the comparable obductively offscraped unit of the Sitkalidak Formation.

The near-trench volcanism and plutonism, and regional metamorphism of the Ghost Rocks Formation is most simply explained by interaction with the Kula-Farallon Ridge, which plate reconstructions place near Kodiak 60 Ma. The Eocene progradation of sediment from the Kodiak area to the Aleutian abyssal fan requires a filled trench and probably reflects a reduction in convergence rate. Both the Paleocene demise of the Kula-Farallon Ridge and any Eocene northward motion of the Alaska Peninsula would have reduced the convergence rate beneath the Kodiak region during progradation of the Aleutian abyssal fan. Obductive offscraping of the Sitkalidak Formation is consistent with slow convergence beneath a prograding fan sequence. Cessation of siliciclastic turbidite accumulation on the Aleutian abyssal fan about 30 Ma suggests an increase in the convergence rate and/or decrease in sediment influx at this time.

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Genetic Lithostratigraphy of Dunkard Group, Southwestern Pennsylvania and Northern West Virginia

The Dunkard Group (Late Pennsylvanian–Early Permian) consists of 400 m of clastic sedimentary rocks with thin limestones and coals that were deposited in deltaic and alluvial-plain environments during the final stages of late Paleozoic sedimentation in the Appalachian basin. Lithofacies indicative of deposition in prograding, tidally influenced, high-constructive deltas dominate the lower Dunkard; these lithofacies are superseded up-section by alluvial-plain lithofacies. The distribution of lithofacies and paleocurrent data indicates that the fluival-deltaic systems prograded northward during deposition of the Dunkard. Sandstones of the Dunkard Group are typically multistory belt sands which were deposited by meandering rivers and highly sinuous delta distributaries.

Petrographic analysis indicates that Dunkard sandstones are immature to submature litharenites derived from a mixed sedimentary, metasedimentary, and volcanic terrane, suggesting a collision orogene provenance related to Alleghenian suturing. Composition of the sandstones is strongly grain-size controlled and depositional environments influenced composition by controlling grain size. Constant composition through the section suggests no major change in source lithology or tectonic regime of the source area during Dunkard deposition.

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Landsat Imagery as Tool for Determining Potential Oil and Gas Resources

Several hydrocarbon-bearing areas in the world have been examined using custom processed Landsat imagery along with geologic interpretations to determine potential hydrocarbon resources. Project areas are located along the Texas Gulf Coast, the western Overthrust Belt, the Athabasca Canadian region, and the South China Sea area.

Digital Landsat data were processed to produce 1:250,000 scale edge-enhanced, false-color, and high pass filter images. All the images were geometrically corrected with topographic controls and nonlinear deconvolution techniques (coverage = 13,000 sq mi or 33,800 sq km). These specially processed images have been used to map surface geology, lineament systems, and geomorphic anomalies in relation to subsurface geologic and geophysical data. Project areas are defined in terms of their tectonic genesis, structural trends, and hydrocarbon potential. Numerous exploration targets and several modes of hydrocarbon entrapment are identified by image interpretation.

The pressing need for more energy resource demands an accelerated large-scale exploration program. Landsat imagery has been utilized as a tool in the four project areas for structural, stratigraphic, and geomorphic analysis to locate geologic anomalies. Image analysis provides a better understanding of the regional stress-strain relations for tectonic correlation. This information can be used to identify a suite of exploration targets to be integrated into industry seismic programs.

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Subtle Porosity and Traps Within Frisco Formation (Devonian, Hunton Group): Geologic-Seismic Waveform Ap-