Abstracts

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Methodology for Determining Relative Favorability for Development of United States Tar Sand Deposits

As part of the Department of Energy's overall program to stimulate petroleum production from unconventional sources, the Los Alamos Scientific Laboratory is developing a methodology to compare and rank the U.S. tar sand deposits on the basis of favorability for production. Major categories were first defined and included resource characteristics, technologic parameters, extraction process costs, environmental impacts, and institutional constraints. Under each of these major headings are the factors identified as bearing on favorability for production. These factors are assessed by their interrelations and relative importance, and are prioritized by individual and combined impact. This ranking methodology is being verified by analyzing eight reasonably well characterized tar sand deposits, selected on the basis of available information and diversity of both location and character. Ultimately, it will be expanded to include all U.S. tar sand deposits that may have commercial potential.

A major goal of this work is to assist industry and government in the timely and systematic development of U.S. tar sands, potentially a very significant petroleum resource. If it is assumed that only 30 billion bbl of oil are contained in the U.S. tar sand deposits, and that only half that amount is recoverable, the tar sand resource could still reduce our current import needs by 50% for over a decade. Furthermore, world tar sand and heavy oil resources are estimated to be greater than all of the conventional oil produced or discovered to date.

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Structure and Seismic Stratigraphy of Yucatan Basin in Western Caribbean

The structure of acoustic basement and the seismic stratigraphy of the overlying sediments in the Yucatan basin were studied from approximately 4,700 km of UTMSI multichannel seismic reflection profiles (12 fold with air guns and explosive sources) and from available single-channel data. In the central part of the basin the basement lies beneath 1½ to 2 sec of sediments, at a total depth of 7 to 8 sec (2-way time). Several basement ridges, spaced 20 to 40 km apart with ½ sec of relief and trending east-west, were mapped. An east-west basement trend was also observed in the northeastern arm of the basin where the basement is at 6.5 to 7.0 sec with about 1 sec of sediments. Basement highs outcrop at two locations in the western part of the basin and are suitable for future dredging. West of the basin along the continental slope, several linear elongated sediment-filled troughs with parallel northeast-southwest ridges to the east were observed. Since published refraction and gravity data indicate a typical oceanic crust beneath the Yucatan basin, we propose that the east-west basement features originated as closely spaced fracture zones during the opening of the basin by sea-floor spreading during Jurassic and Cretaceous.

The previously described "pelagic" sediments, which appear transparent on single-channel monitors, showed several unconformities and other sedimentary and deformational features in our data. The basin sediments were divided into several major depositional sequences based on unconformities and seismic character. The time-structure and isochronal maps indicate that although deposition was uniform over the basin in the earlier time, major deposition shifted from one area to the other in later periods.

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Sediments and Sedimentary Environments in Guaymas Basin, Gulf of California, Northwest Mexico

The Guaymas Basin is an actively spreading oceanic basin in the Gulf of California, northwest Mexico, in which three major sedimentary environments can be established based on their structural position and types of sedimentary sequences. (1) The active rift-valley setting contains a sequence of fine to very fine, poorly sorted, silty sand, interbedded with mass-flow deposits. The latter includes a mixture of terrigenous sediment derived from the mainland and basinal redeposited(?) (diatom-rich) pelagic sediment. The two populations result from the downslope movement of granular solids dispersed in a clay-water fluid; the upper part is muddy and diatomaceous. (2) The basin floor setting is characterized by high sedimentation rates; consequently the frequency of turbidite deposition (mainly in the lower part of the stratigraphic column) is higher than in the other two settings. The upper part of the stratigraphic column is lithologically more uniform, and consists of disturbed diatomaceous mud with interbeds of turbidites. (3) The slope setting is a province within the oxygen minimum layer and the sediments consist of varved diatomaceous beds interbedded with graded and cross-laminated turbidites.

The transport and depositional mechanisms within Guaymas Basin are difficult to resolve owing to the diversity of sediments supplied from fluvial, beach, and dune sources bordering the basin and further, to the mixing of these sediments by subaqueous gravity transport into the basin. Turbidites deposited during the Holocene-late Pleistocene period are interbedded with varved diatomaceous ooze, and correlate with interglacial highstands of sea level. The terrigenous particles have surface textures produced by glaciofluvial action, and perhaps are derived from the Colorado River province.

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Early Cretaceous Sedimentation in Peruvian Andes

Continuous Early Cretaceous marine sedimentation is recorded in the Lima basin prior to the development of a Late Cretaceous volcanic arc. An abrupt change in source and tec-

*Denotes speaker other than senior author.

tonic style of sedimentation occurred in the middle Berriasian from arc-derived to basement-derived sediment. These changes are ascribed to a decrease in the angle of subduction, which caused a cessation of volcanism and widespread uplift of basement rocks. Sedimentation and subsidence continued only along the frontal-arc and rear-arc due to thermally induced subsidence. Away from the arc, sedimentation was initiated diachronously after regional unconformity, and subsidence was mainly controlled by the rate of sedimentation.

Two subparallel metamorphic belts were the main source terranes for the Morro Solar Group, which was deposited in a tectonically quiescent basin. The Brazilian shield furnished sediment only to the foreland basin. A complex distribution of source terranes gave rise to nonsystematic distribution of environments along and across the Andes. Fluviodeltaic and shallow-marine peritidal sedimentation characterizes most of the lowermost Cretaceous strata in the Peruvian Andes.

In the Lima basin, the Morro Solar Group consists of quartz-rich sandstone, shale, and minor micritic limestone beds. Sandstones are highly mature and exhibit cross-bedding that suggests paleosediment transport to the southeast. Shale units are thinly laminated and contain minor interbedded siltstone. Vertical facies variation suggests progradation of a braided system toward a broad intertidal zone prior to encroachment of the late Valanginian sea.

Lower Neocomian siliciclastic sedimentation in the Peruvian Andes is consistent with earlier facies developed in the initial stages of fore-arc evolution prior to the emplacement and localization of the volcanic arc. Continuous Mesozoic continental erosion not only accounts for the lack of an accretionary wedge, but also for the landward migration of the trench and uplifting of metamorphic cores. These processes resulted in a shortening of the fore-arc basin.

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Modern Mahakam Delta, Indonesia: Sand Distribution and Geometry in Mixed Tide and Fluvial Delta

A core study was made of a mixed, tide and fluvial, low-wave delta formed in the humid tropics. Little subsurface data were previously available for this type of delta, in which morphology and sediment distribution reflect both fluvial and tidal characteristics.

The delta plain is a tidal marsh, with bioturbated organic clays, incised by separate networks of distributary and tidal channels. In contrast to the mud-filled meandering tidal channels, distributaries are linear and filled with sand accumulating as lateral accretion bars. Distributaries form narrow ribbons of channel-fill sands of variable thickness (5 to 11 m), eroded or superimposed onto underlying delta front clays and sands. Facies and vertical sequences are fluvial, erosive based and fining-up in the upper delta plain, and tidal and coarsening-up in the lower delta plain. The lack of fluvial levees and splays reflects the tidal influence in the distributaries.

On the delta front, sand occurs as numerous bars, forming a spectrum of distinct types which reflect the local river-tide ratio. Major distributaries form thick (7 m) localized arcuate mouth bars, while off smaller distributaries, triangular middle ground bars occur, forming more sheet-like, thinner sand bodies. In areas of low river input, tidal ridges predominate. The bars are separated by organic clay, but lateral coalescence and stacking can locally increase sand continuity. Sequences are coarsening-up, and facies show tidal and marine characteristics. A general seaward bar thickening exists owing to the more distal position of the thicker arcuate bars; this results in a vertical bar thinning-up progradational sequence.

Seaward of the delta front bars, prodelta sediments composed of massive clays form the base of a 50-m thick regressive sequence composed of multiple bar deposits, followed and incised by sandy distributary fills. Sedimentation rates range between 0.2 and 1.3 cm per year^{-1}.

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Structural Control of Rocky Mountain Front: COCORP Profiles Across Laramie Mountains

The Rocky Mountain Front forms the eastern edge of the North American Cordillera and represents significant Laramide deformation of the continental basement 1,500 km from the nearest coeval plate margin. COCORP deep seismic profiles were recorded across the northern part of the front to investigate its structure and the influence of the Archean-Proterozoic crustal boundary, expressed in the nearby Medicine Bow Mountains as the Nash Fork–Mullen Creek (NFMC) shear zone.

Four COCORP profiles totaling 180 km transect the Denver basin, Laramie Mountains, and Laramie basin. West-dipping (20°) reflections beneath the mountains truncate basement events and project to key frontal faults, suggesting that the northern front has a structure of shallow, en echelon basement thrusts. A steep northwest dip for the NFMC shear zone is indicated by equivocal truncations and diffractions in basement beneath the east edge of the Laramie basin. Alternatively, a band of events with apparent southward dip under the mountains may be sideswiped from the shear zone, which, together with a predominant southeast-dipping seismic basement fabric, suggests a moderately steep southeast-dipping shear zone. The second interpretation is favored. Continuous reflections at 15.5 to 17.0 sec east of the mountains may indicate a Moho depth of 48 km, while the deepest events on other lines are shallower (11 to 13 sec).

Thus, COCORP profiling and nearby refraction surveys suggest crustal thinning to the northwest across the Archean-Proterozoic boundary which also controlled the segmentation of the northern Rocky Mountain front. On a regional scale, crustal thinning may be partly responsible for the greater diversity of the Laramide in Wyoming.

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Diagenesis and Secondary Porosity Evolution of Sarir Sandstone, Southeastern Sirte Basin, Libya

Virtually all porosity is of secondary origin in the productive Lower Cretaceous Sarir Sandstones of the Calanscio area in the southeastern Sirte basin, Libya, where production is obtained from depths of about 8,000 to 13,000 ft (2,438 to 3,962 m). Principal reservoirs are fluvial sandstones now composed predominantly of quartz, but originally composed of up to 25% mud intraclasts, rock fragments, feldspars, and mica. Even though most of the original porosity was destroyed by compaction and cementation, deep-burial leaching of the non-quartz constituents created considerable porosity. Average porosity is 13%; the maximum is 31%. Most secondary pores are oversized molds of dissolved non-quartz grains. Skeletal feldspars and ragged metamorphic rock fragments are preserved in some layers. Commonly, feldspar and rock fragments are