glomerates commonly top the upper facies. In general, producing-zone porosity increases upward from subtidal to intertidal.

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Seismic Models of 15 Stratigraphically Controlled Oil and Gas Fields Containing Sandstone Reservoirs in Rocky Mountain Basins

Two-dimensional, normal-incidence, ray-theory seismic models were generated for 15 stratigraphic traps which have accumulated oil and gas in the Rocky Mountain province. The investigation is a feasibility study to determine the seismic character of moderate-sized (6-30 m thick), lenticular sandstone reservoirs in Rocky Mountain basins. The models are noise free and do not include all the complexities of the seismic phenomenon, but they do provide a reasonable indication of the anomaly to be expected for a specific problem and the quality of seismic data required to solve it. The fields chosen for the model studies represent different kinds of stratigraphic traps, and the reservoirs range in age from Late Pennsylvanian to Late Cretaceous. The fields include nine from the Powder River basin, three from the Denver basin, two from the Green River basin, and one from the San Juan basin.

Each seismic model was constructed from a detailed geologic cross section and typically consists of 30 layers and several hundred velocity and density values. Effects of inelastic attenuation, interbed multiples and diffractions, are not incorporated in these seismic models. Hydrocarbon effects should be partly represented through the response of acoustic and density logs from which the models were derived. Final synthetic seismic sections are displayed with symmetrical Ricker wavelets at three different frequencies.

Many of the 15 fields investigated appear to be detectable on conventional seismic sections, although several of the anomalies are very subtle. The seismic expression of the objectives modeled are manifested by amplitude changes due to acoustic contrasts at stratigraphic boundaries, or to constructive interference of waveforms.

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Middle Member of Minnelusa Formation (Middle and Upper Pennsylvanian)—Implications for Stratigraphic-Trap Oil Accumulations in Powder River Basin, Wyoming

The middle member of the Minnelusa Formation (Middle to Upper Pennsylvanian) thins northward across the Powder River basin from about 150 m thick in the Hartville uplift to less than 50 m near the Wyoming-Montana border. Much of the thinning occurs beneath a regional, pre-Permian unconformity, which is identified in the south half of the basin by a mudstone commonly identified as the red shale marker.

Cyclically arranged units up to 10 m thick, composed in ascending order of black organic-rich shale, mud-supported dolomite, anhydrite, and quartzose sandstone, characterize most of the middle Minnelusa. The majority of the sandstone units (informally designated in the subsurface as the Leo sandstones) are less than 3 m thick, tabular shaped, and commonly cemented with anhydrite and dolomite. Locally, however, the sandstones, particularly in the first Leo interval, are lenticular and linear, very porous, and attain thicknesses of more than 15 m. Several of these 10 to 15-m thick, linear first Leo sandstone bodies trend northwest across the southern Powder River basin. They probably represent wadi-type channels that have cut across sabkha and associated peritidal deposits during low stands of sea level. The source of the Leo sandstones is presently uncertain, but at least the lowermost ones appear to be distal equivalents of the Tensleep Sandstone (Desmoinesian) to the northwest.

Where the thicker sandstone units of the first Leo cross anticlinal noses such as at Red Bird, Pine Lodge, and Little Buck Creek, they commonly contain stratigraphically trapped oil. The oil in these fields was probably locally derived from the thin (0.5 to 2 m), widespread, black organic-rich shale units in the middle member. The lenticularity, proposed northwest trend, thickness, porosity, and associated probable source rocks make these sandstone units prime targets for oil and gas exploration in the sparsely tested, deep, southern Powder River basin.

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Physical Evidence for Cretaceous Tides, Western Interior Basin, North America

Shallow-marine and marginal-marine sandstone bodies constitute important reservoirs for oil and gas in the Western Interior. The geometries and physical characteristics of these bodies reflect the hydrographic regimes of their paleoenvironmental settings.

Tidal range is a primary determinant of hydrographic regime and is, therefore, an important factor in paleoenvironmental reconstruction and in delineation of exploration targets. Two opposed models exist for tidal patterns in epeiric seas: (1) tidal ranges were small, with the amplitude of the tidal wave generally decreasing away from apertures with the oceans; and (2) tidal ranges were large, the tidal wave being amplified with increasing distance from the apertures and attaining maximum amplitudes in the interior parts of the seas. A variety of evidence indicates that the second model is more applicable to the interior Cretaceous seaway. In the Western Interior Cretaceous, features that indicate tides include tidal inlets, tidally influenced reaches of river systems, tidal flats, linear sand bars, and thick foreshore sequences. These paleoenvironments are characterized by suites of physical and biogenic structures. The distribution of these features indicates that tides were present throughout the interior Cretaceous seaway. Microtidal conditions prevailed in the area of its connection with the proto-Caribbean. Tidal range increased northward along the western shoreline, attaining mesotidal amplitudes in Wyoming, in Montana, and probably in southern Alberta. Tidal patterns farther to the north cannot be discerned on the basis of physical evidence. The eastern shoreline was probably everywhere microtidal as a result of dissipation of tidal energy across the very shallow eastern shelf of the basin.

The Arafura Sea displays a tidal pattern that may be similar to that of many ancient epeiric seas. Though smaller and shallower, it is thought to be a good modern analog for the interior Cretaceous seaway.

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Organic Matter in Sediments Underlying Ross Ice Shelf

Eleven gravity cores (maximum penetration 102 cm) were obtained in December 1977 below the Ross Ice Shelf at Site J9. The sediments proved to be middle Miocene glaciomarine mud. The sediments may reflect a recent grounding of the Ross Ice Shelf which probably resulted in the erosion of the Pliocene-Pleistocene section. The sediment cores contained two lithologic units: an upper, light olive-gray unit from 5 to 20 cm thick, and a lower darker unit.

Concentrations and stable isotope compositions of the total organic carbon were determined for 13 samples in two of the cores. Three samples from the upper unit contained 0.17, 0.18, an 0.19% organic carbon with $\delta^{13}C_{PDB}$ compositions of -25.5, -25.3, and -24.3‰, respectively. Ten samples from the lower unit contained more than twice as much organic carbon, ranging from 0.35 to 0.46%, and slightly lower $\delta^{13}C_{PDB}$ values, ranging from -25.1 to -26.1 ‰. The amounts and isotopic compositions of the organic carbon in these sediments are probably controlled by the relative amounts of kerogen derived by erosion of rocks from the Transantarctic Mountains and organic carbon fixed by photosynthetic organisms in the Miocene ocean.

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Generation, Migration, and Entrapment of Petroleum in Extensional Basins

The interplay of tectonics, thermal regime, and depositional history generally determines the petroleum potential of individual basins. The application of these factors to a review of several extensional basin systems (Rhine graben, North Sea basin, Reconcavo basin, Gulf of Suez basin, Red Sea basin, Bass basin, and Gippsland basin) provides the basis for this analysis.

Extensional tectonic systems provide a mechanism for thinning the crust and upper mantle (the lithosphere). The result is a progressive rift-basin evolution starting with graben formation and ending in the development of continental margins. However, if tensional stress stops at any stage, a post-rift phase of subsidence, regulated by thermal decay, begins.

Sedimentary rocks deposited prior to extension (pre-rift sediments) are preserved in the graben areas but eroded from the horsts. Rift sediments (usually clastics) deposited during extension are eroded from the uplifted areas, but carbonate rocks and evaporites may be deposited if the climatic environment is favorable. Sediment deposition is continued after extension stops (post-rift sediments).

Source beds can be in the pre-rift, rift, or post-rift sediments but generation does not occur until they are buried to the depth of the generative window. Generation is aided by the high heat flow caused by the thinned crust. The kind of petroleum generated is dependent on the type of organic material present and the deepest zone of generation reached.

Extensive normal faults contribute to trap geometry but inhibit long distance migration. Consequently, except in the post-rift section, entrapment of petroleum requires that the source and reservoir rocks are in close proximity, which can be accomplished by faulting, interfingering, or the superposition of source rocks on reservoir rocks at unconformities. The most favorable conditions for generating and trapping large oil fields are commonly in or near the deepest part of the basin.

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Sedimentation, Biostratigraphy, and Source-Rock Potential of Deseret Starved Basin (Mississippian), Western United States

Dark, organic-rich starved-basin sediments of the basal, phosphatic member of the Deseret Limestone and equivalents were deposited west of a westward-prograding carbonate platform in Osagean to early Meramecian time. These sediments comprise mainly pelletal, peloidal, oolitic, and conglomeratic phosphorite; phosphatic shale enclosing large calcareous concretions; bedded spiculitic and radiolarian chert; cherty micritic limestone; siltstone; and mudstone. The starved basin extends for more than 700 km from southeastern Nevada to southeastern Idaho. Rate of sedimentation of starved-basin sediments is calculated from the conodont zonation to be about 10 m/m.y. Slope sediments that intertongue westward with basinal sediments and eastward with carbonate-platform sediments consist mainly of thin-bedded clinoform micrite interbedded with some debris-flow encrinite. These sediments were deposited on a gentle foreslope of 5° or less at a rate of 16 to 18.5 m/m.y. Time-equivalent carbonate-platform sediments were deposited at a rate of about 113 to 130 m/m.y.

The biota of the basinal sediments is mainly planktonic radiolarians, nektonic goniatites and conodonts, benthonic agglutinate foraminifera and sponges, and infaunal traces of burrowing organisms. The sparse shelly fauna consists mainly of small solitary corals and a few brachiopods. The bathymetry of the foreslope and shelf, considered together with the character and biota of the basin sediments, suggests that the floor of the central basin lay in the dysaerobic zone at a depth of about 300 m.

Organic-carbon and hydrocarbon content of outcropping phosphatic shales that have been deeply weathered, leached, and biodegraded are difficult to evaluate. Analyses generally produce values that are much lower than values that can be expected in the subsurface, where the same rocks have generated or are generating petroleum. Nevertheless, the following organic-carbon yields have been obtained from carefully selected out-