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Maturation of Organic Matter in Paleocene-Eocene Wilcox Group, South Texas: Relationship to Clay Diagenesis and Sandstone Cementation

Thirty-three mudstone core and cuttings samples ranging in depth of 1.6–4.7 km (5,200–15,400 ft) and in temperature from 80° to 210°C (175–410°F) were obtained from wells in south Texas. The results of closed-system pyrolyses and bitumen and kerogen analyses are related to available data on clay mineralogy and sandstone cement. This study examines the diagenesis of Wilcox organic matter, the migration of hydrocarbons, and the importance of organically derived CO₂ in sandstone cementation.

The samples average 1% TOC, contain type III kerogen, and generally show bitumen contents less than or equal to about 150 mg/gC. Modeling indicates that primary migration of methane and light hydrocarbons in aqueous solution is capable of producing giant (≥ 1 tcf) gas and condensate fields. Because hydrocarbon generation does not occur until after the main stage of illitization, smectite accounts for less than 25% of the total water involved.

Pyrolysis experiments indicate that as much as 150 mg/gC CO₂ may be liberated by Wilcox organic matter during diagenesis to present-day temperatures of 100°C (212°F). The main zone of oil generation occurs at subsurface temperatures of 95°–125°C (203°–257°F). The timing of these processes suggests that CO₂ could play an important role in creating secondary sandstone porosity for hydrocarbon migration. The $\delta^{13}\text{C}$ values indicate that 25% of the carbonate cement present in Wilcox sandstones may originate from decomposition and diagenesis of organic matter.

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Depositional Environments, Reservoir Trends, and Diagenesis of Red Fork Sandstones in Parts of Blaine, Caddo, and Custer Counties, Oklahoma

The Red Fork sandstone was divided into the upper and lower Red Fork which are separated by a consistent marker bed. The Red Fork interval thickens markedly across the study area from 250 ft (75 m) in the northeast to over 1,300 ft (400 m) in the southwest. Most of the thickening is within the lower Red Fork. The lower Red Fork is believed to have been deposited in shelf-to-basin transitional terrain. Sands were located in delta-front, submarine-channel-fill, and possible submarine-fan terrain. The upper Red Fork is believed to represent the maximum progradation of a deltaic complex.

Sandstones of the lower Red Fork are sublithic to lithic arenites; the upper Red Fork is sublithic arenite. The dominant lithic fraction is mudstone fragments. The main diagenetic alterations of both the upper and lower Red Fork sandstones were destruction of primary porosity by compaction and cementation. Dissolution chiefly of mud fragments has produced well-developed secondary porosity. Clays of the lower Red Fork mainly are authigenic chlorite; clays of the upper Red Fork primarily are authigenic kaolinite.

Present oil and gas production from Red Fork sandstones is most abundant from localities on the paleoshelf.

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East Painter Reservoir 3-D Survey, Overthrust Belt, Wyoming—Case History

The discovery of the East Painter Reservoir field in mid-1979 led to the initiation of the first major 3-D survey in the Wyoming Overthrust belt. A 3-D survey was necessary because interpretation of conventional 2-D seismic data over the East Painter area did not provide a sufficiently reliable picture of the structure on the objective Triassic Nuggett zone to permit an aggressive development program to be carried out. Field data for the 17 mi² (44 km²) East Painter 3-D survey were collected during the winter of 1979–1980, and the final migrated sections were in hand by July 1980.

Interpretation of the final 3-D products resolved the previous structural ambiguities and showed the East Painter structure to be continuous and almost as large as the main Painter Reservoir feature. Information

from the 3-D mapping allowed up to 6 development wells to be drilled at one time and helped to guide the locations of the last 13 development wells; all of them were successful. The average cost per well was \$4 to \$5 million. The cost of the 3-D survey was \$1.6 million, which turned out to be a good value.

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Origin of Chiwaukum Graben, Chelan County, Washington

The Chiwaukum graben in central Washington is bounded by the Entiat fault on the east and the Leavenworth fault on the west. The graben is largely underlain by the middle Eocene Chumstick formation, an unusually thick (> 5,800 m? or 19,000 ft?) sequence of sandstone, shale, conglomerate, and minor tuff. Five lithofacies are recognized in the Chumstick formation. They are interpreted as debris-flow and stream-generated alluvial fan deposits, braided and meandering stream deposits, and lacustrine deposits. Stratigraphic relationships within the basin are highly variable and include lateral facies changes, pinchouts, and interfingering of units. Basaltic dikes and sills intrude Chumstick sediments throughout the graben.

Structural data from the Leavenworth fault zone show highly variable orientations of minor fault planes, and dominance of subhorizontal slickensides. The fault zone has an irregular trace, and contains braided and en echelon fault segments which separate lenses of conglomerate. The Entiat fault has a highly linear trace. Fault surfaces with slickensides of variable orientation, fractured and folded mylonites, and pods of fractured conglomerates within the Entiat fault zone indicate a complex history of faulting. Within the graben, folds, normal faults, and fracture zones trend northwest, parallel to the graben-bounding faults; strike-slip faults in the graben trend northeast.

It is proposed that the Chiwaukum graben formed as a rhombochasm or possibly as a composite pull-apart basin. Consistent with this interpretation are the rhomb-shape of the graben; the thickness of basin fill; sedimentation patterns, including cyclic upward-coarsening sequences adjacent to uplifted fault blocks, and rapid facies changes; the presence of extension-generated(?) volcanism synchronous with sedimentation; and evidence for syndepositional deformation in the graben and on the basin margins. Orientations of structures in the graben are not consistent with a transverse model; however, they may be the result of strike-slip and normal faulting in an asymmetrical shear zone.

Strike-slip models for the origin of the Chiwaukum graben are consistent with Ewing's tectonic synthesis of the Pacific Northwest during the Eocene.

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Thermal Maturity of Organic Matter in Green River Formation, Piceance Creek Basin, Colorado

The thermal maturity of organic matter in the Green River Formation in the Piceance Creek basin was determined by vitrinite reflectance on coalified logs in the otherwise alginite-rich oil shale, marlstone, and sandstone. Only vitrinite from logs in sandstone and marlstone was used to determine thermal maturity because reflectance of vitrinite from alginite-rich oil shale generally is lower than that in associated other rock types. Mean random vitrinite reflectance (R_o) at the top of the Green River Formation ranges from about 0.30% around the perimeter of the basin, where maximum burial depth of the rocks was less than 1,000 m (3,300 ft), to 0.55% in the structurally lowest part of the basin, where maximum burial depth of the upper part of the Green River was more than 1,500 m (4,900 ft). The Green River Formation is almost 1,200 m (3,900 ft) thick in the structurally lowest part of the basin, suggesting that the lower part of the formation in this area may have reached an R_o of 0.7%, generally accepted as the threshold for oil generation in alginitic rocks. Bitumin-filled fractures observed in core from this area of the basin support this conclusion. A lithologically similar lacustrine section of the Green River Formation in the adjacent Uinta basin, where maximum burial was as great as 5,600 m (18,400 ft), is producing large quantities of oil from over-pressured, fracture-controlled reservoirs. Present-day maximum temperatures in the Green River Formation in the Piceance Creek basin are between 55 and 70°C (131 and 158°F). This temperature seems too low