JENDEN, PETER D., and I. R. KAPLAN, Univ. California at Los Angeles, Los Angeles, CA

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 CO_2 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 CO_2 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 CO_2 could play an important role in creating secondary sandstone porosity for hydrocarbon migration. The $\delta^{13}C$ values indicate that 25% of the carbonate cement present in Wilcox sandstones may originate from decomposition and diagenesis of organic matter.

JOHNSON, CHRISTOPHER L., Oklahoma State Univ., Stillwater, OK

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.

JOHNSON, DONALD G., Chevron USA, Inc., Denver, CO

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 mi^2 (44 km^2) 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.

JOHNSON, PETER ERIC, Mobil Oil Corp., Dallas, TX

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 transtensile 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.

JOHNSON, RONALD, and V. F. NUCCIO, U.S. Geological Survey, Denver, CO

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_0) 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_0 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 overpressured, 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 for hydrocarbon generation. However, temperatures in the past probably were high enough for hydrocarbon generation. Oil generated during this earlier, hotter period could have migrated into conventional stratigraphic and structural traps.

JOHNSON, SAMUEL Y., GREGORY T. FRASER, JAMES W. ROBERTS, and STEPHEN B. TAYLOR, Washington State Univ., Pullman, WA

Eocene Strike-Slip Faulting and Basin Formation in Washington

Eocene right-lateral displacements occurred on several fault zones in western and central Washington, including the Straight Creek fault (90-190 km or 56-118 mi of offset), the Entiat-Leavenworth fault system (amount of offset unknown), and possibly a major unnamed north-south trending fault through the Puget lowland. Within this framework, nonmarine sediments accumulated in several rapidly subsiding basins to form some of the thickest (more than 5,800 m or 19,000 ft) nonmarine sequences in North America. Two types of sedimentary basins are recognized. The Chiwaukum and Foss River grabens are small pull-apart basins that formed along the major faults. The Chuckanut, Swauk, and Puget(?) basins are much larger (up to 100 km or 62 mi wide) and formed between the major faults. To varying degree, these larger basins display the characteristics of idealized smaller pull-apart basins: (1) high sediment accumulation rates; (2) rapid facies changes; (3) abrupt stratigraphic thickening and thinning; (4) partly internal drainage patterns; (5) irregular basin margins characterized by dip-slip faults and unconformities; (6) predicted deformational patterns; (7) rapid changes between extensional and compressional tectonics; and (8) interbedded and intrusive relationships with extension-generated(?) volcanic rocks. The difference in size and mode of occurrence between these basin types emphasizes the regional as well as local control that strike-slip faulting has on basin formation.

This extensional-basin province formed in a forearc setting between an obliquely subducting oceanic plate to the west, and the broad, diffuse Challis volcanic arc to the east. Eocene nonmarine basins in Washington should therefore be considered as end-member types of forearc basins.

JONES, C. M., and S. J. TEWALT*, Bur. Econ. Geology, Austin, TX

Petrologic and Chemical Characteristics of Deep-Subsurface Wilcox (Eocene) Lignites from East and East-Central Texas

A recent drilling program has provided new petrographic and chemical data on deep-subsurface Wilcox Group lignites in east and east-central Texas. The seams occur in major lignite-bearing horizons of the Wilcox Group at depths of 240-1,040 ft (70-315 m).

The petrologic examination has been performed using white and blue light reflectance microscopy. The seams contain limited well-preserved plant material. Humodetrinite is the dominant maceral, and many of the huminites have undergone partial or complete gelification. The liptinite content is high and may exceed 30%, much of it occurring as a fine-grained matrix. Seams with less liptinite tend to contain more inertinite. Some of the huminites contain granular material which has a low reflectance and weak orange fluorescence. It is believed to represent an early stage in the formation of micrinite, with which it may be found in close association.

Chemical characterization includes proximate and ultimate analyses, forms of sulfur, ash oxides, plus minor and trace element concentrations. Most seams are low in sulfur, except for a seam underlying a marine unit at the top of the Wilcox, in which the dry sulfur content exceeds 5%. Ash contents are variable and largely determine calorific value. Sodium content increases from shallow to deeper seams, coincident with the evolution of ground-water chemistry from Ca-HCO_3 to Na-HCO_3 with increased depth. Comparison between petrographic and chemical data show that lignites with larger amounts of liptinite have higher hydrogen contents and calorific values.

JONES, JON R., JR., Univ. Texas, Austin, TX

Reservoir Characterization of Mesaverde (Campanian) Bedload Fluvial Meanderbelt Sandstones, Northwestern Colorado

Reservoir characterization of Mesaverde meanderbelt sandstones is used to determine directional continuity of permeable zones. A 500-m (1,600-ft) wide fluvial meanderbelt in the Mesaverde Group is exposed as laterally continuous 3-10-m (10-33-ft) high sandstone cliffs north of Rangely, Colorado.

Forty-eight detailed measured sections through 3 point bar complexes oriented at right angles to the long axis of deposition and 1 complex oriented parallel to deposition were prepared. Sections were tied together by detailed sketches delineating and tracing major bounding surfaces such as scours and clay drapes. These complexes contain 3 to 8 multilateral sandstone packages separated by 5-20 cm (2-8 in.) interbedded siltstone and shale beds. Component facies are point bars, crevasse splays, chute bars, and floodplain/overbank deposits.

Two types of lateral accretion surfaces are recognized in the point bar facies. (1) Gently dipping lateral accretions containing fining-upward sandstone packages. Large scale trough cross-bedding at the base grades upward into ripples and plane beds. (2) Steeply dipping lateral accretion surfaces enclose beds characterized by climbing ripple cross laminations. Bounding surfaces draped by shale lags can seal vertically stacked point bars from reservoir communication. Scoured boundaries allow communication in some stacked point bars. Crevasse splays showing climbing ripples form tongues of very fine-grained sandstone which flank point bars.

Chute channels commonly cut upper point bar surfaces at their downstream end. Chute facies are upward-fining with small scale troughs and common dewatering structures. Siltstones and shales underlie the point bar complexes and completely encase the meanderbelt system. Bounding surfaces at the base of the complexes are erosional and contain large shale rip-up clasts.

JONES, PETER B., International Tectonic Consultants, Ltd., Calgary, Alberta, Canada

Hydrocarbons, Blind Thrusts, and Upper Detachments

Oil and gas occur in the foreland margins of deformed belts around the world, concealed beneath the mountain-facing flank of a foreland syncline. Such a syncline is formed by wedging of blind, foreland-directed thrusts against an upper detachment zone that extends out to the synclinal axis. Examples include mature exploration areas such as the Carpathian foothills of Rumania and the foothills of the Canadian Cordillera, and the foreland margins of the Appalachians, Ouachitas, and Brooks Range. Other examples have been reported from several sectors of the Alpine-Himalayan and Andean orogens. The upper detachment was originally horizontal, uplifted by the blind thrusts beneath it. While there is no way of measuring how far into a thrust belt an upper detachment extended before it was removed by erosion, computer modeling can reconstruct thrust belts within the constraints imposed by inclusion of an upper detachment. An example from Canada shows that the entire southern Alberta foothills belt can be modeled this way. This is consistent with the observed plunge of the Alberta thrust belt along strike beneath the fold belt of northeastern British Columbia, where wells spudded in folds penetrate blind subsurface thrusts. These data suggest that, like folded faults, blind thrusts and upper detachments are common features of deformed belts. Failure to recognize them can result in severely underestimating the extent of thrusting, and consequently downgrading the hydrocarbon potential of a deformed belt.

JONES, PETER J., Univ. Oklahoma, Norman, OK

Maturity Parameters of Woodford Shale, Anadarko Basin, Oklahoma

The Upper Devonian-Lower Mississippian Woodford Shale is an important source rock in the Anadarko basin. Because of its stratigraphic relationship to the Hunton Group and other productive reservoirs, it has been the subject of several recent studies attempting to evaluate hydrocarbon potential. Standard geochemical analyses were performed on a 5-well cross-section beginning in the northeastern shelf of the Anadarko basin at a depth of 5,700 ft (1,737 m) and ending in the southeastern part