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.

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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.

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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.

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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.

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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.

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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