reflect control by lineaments trending north-south, northwest, and northeast. In central South Dakota, erosion and deposition of chalk and calcareous shale on a west-sloping carbonate ramp were controlled by lineaments that generally trend northeast and northwest.

Paleotectonism on lineament-bound blocks characterized four tectonic zones located in the Late Cretaceous seaway: the western foredeep, the west-median trough, the east-median hinge, and the eastern platform. The regional geometry of all four tectonic zones appears to be related to the geometry of the convergent plate margin on the west. Paleotectonic activity on lineament-bound blocks may have been the result of horizontal forces related to the convergent margin and to vertical forces related to the movement of the North American plate.

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Geologic Setting and Natural Gas Potential of Niobrara Formation, Williston Basin

Chalk units in the Niobrara Formation (Upper Cretaceous) have potential for generation and accumulation of shallow, biogenic gas in the central and eastern Williston basin. Similar to areas of Niobrara gas production in the eastern Denver basin, Niobrara chalks in South and North Dakota were deposited on carbonate ramps sloping westward off the stable eastern platform of the Western Interior seaway. Within the Williston basin, the Niobrara of the western Dakotas, eastern North Dakota, and central South Dakota has different stratigraphic relationships. These three areas can be further subdivided and ranked into six areas that have different exploration potential. The south margin of the Williston basin in central South Dakota is the most attractive exploration area.

Niobrara chalk reservoirs, source rocks, and structural traps in the southern Williston basin are similar to those in the eastern Denver basin. Chalk porosities are probably adequate for gas production, although porosity is controlled by burial depth. Organic carbon content of the chalk is high and shows of biogenic gas are reported. Large, low-relief structural features, which could serve as traps, are present.

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Stratigraphy and Petroleum Potential of Trout Creek and Twentymile Sandstones (Upper Cretaceous), Sand Wash Basin, Colorado

The Trout Creek and Twentymile Sandstones (Mesaverde Group) in Moffat and Routt Counties, Colorado, are thick, upward-coarsening sequences that were deposited along the western margin of the Western Interior basin during Campanian time. These units trend northeast-southwest and undergo a facies change to coal-bearing strata on the northwest. Surface data collected along the southeastern rim of the Sand Wash basin were combined with well-log data from approximately 100 drill holes that have penetrated the Trout Creek or Twentymile in the subsurface. The sandstones exhibit distinctive vertical profiles with regard to grain size, sedimentary structures, and biogenic structures. A depositional model that incorporates the key elements of the modern Nile River (northeast Africa) and Nayarit (west-central Mexico) coastal systems is proposed for the Trout Creek and Twentymile Sandstones and associated strata. The model depicts a wave-dominated deltaic, strand-plain, and barrier-island system. Depositional cycles are asymmetrical in cross section as they are largely progradational and lack significant transgressive deposits. Source rock–reservoir rock relationships are ideal as marine shales underlie, and coal-bearing strata overlie sheetlike reservoir sandstones. Humic coal, the dominant source of Mesaverde gas, generates major quantities of methane upon reaching thermal maturity. Existing Mesaverde gas fields are largely structural traps, but stratigraphic and combination traps may prove to be equally important. The sparsely drilled deeper part of the basin warrants testing as large, overpressured-gas accumulations in tight-sandstone reservoirs are likely to be found.

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Williston in the Family of Cratonic Basins

The Williston basin is one of a clan of subcircular to elliptical elements in the interiors of all cratons; such basins are distinguished by characteristics common to all. In each, the basement consists of continental crust and each basin is surrounded by areas of continental crust. Subsidence rates are typically low, so that conditions near depositional base level prevailed during much of the history of sediment accumulation. Episodic subsidence occurred over time spans of 10^7-10^8 years; major episodes of subsidence are broadly concurrent on all cratons. Tectonic tempo and mode of subsidence evolved synchronously on all cratons; therefore, similar isopach and facies patterns (and similar oil or gas maturation, migration, and trap potentials) occur on all cratons.

All members of the clan exhibit a range of individual variations imposed by latitude and climate. Intraplate tectonism and volcanism, approach to or distance from source areas, and distribution paths of detrital sediment. Nevertheless, facts and concepts developed by intensive study of basins with high-density documentation (outcrop and subsurface) are commonly applicable to basins such as the Williston, which is in a less mature stage of exploration.

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Hummingbird Structure in Southeastern Saskatchewan

Saskatchewan's first Devonian oil pool was discovered September 1966, at Hummingbird, 45 mi (72 km) southwest of Weyburn, Saskatchewan. The Hummingbird structure, located on the northwest flank of the Williston basin, is domal in nature and covers approximately 1 mi^2 (2.6 km^2). Oil production is from two zones. The Ratcliffe Member of the Mississippian Charles Formation produces from an algal and bioclastic limestone averaging 49 ft (15 m) thick. The Devonian Birdbear Formation produces from a finely crystalline vuggy dolomite averaging 56 ft (17 m) thick.

The Hummingbird structure is a sedimentary structure resulting from multiple-stage salt solution and collapse. Recurring local solution of Middle Devonian Prairie Evaporite during Late Devonian and Early Mississippian time resulted in collapse of overlying strata and deposition of compensating thicknesses of Souris River, Duperow, and Bakken sediments. Between Mississippian and Cretaceous time, solution of Prairie Evaporite in the surrounding area caused collapse of all super-Prairie Evaporite beds. The extra Souris River, Duperow, and Bakken strata at Hummingbird created the structure. Vertical migration of formation waters along a high-angle fault is suggested as the cause of the local salt solution at Hummingbird.

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Tectonic and Sedimentation Model for Morrow Sandstone Deposition, Sorrento Field Area, Denver Basin, Colorado

Pennsylvanian Morrow sandstones are oil and gas productive through a large area in southeastern Colorado. The Sorrento field is a recent Morrow discovery with reserves estimated at over 10 million bbl of oil over an area of 3,200 ac at depths of 5,400-5,600 ft (1,646-1,707 m). Minor production also occurs from the Mississippian Spergen and Saint Louis and the Pennsylvanian Marmaton.

Productive Morrow sandstones are interpreted on the basis of subsurface mapping to be fluvial valley-fill deposits, consisting mainly of channel sandstone. These deposits are encased in marine shale and range in thickness from 5 to 55 ft (1.5 to 16.7 m). Net pay ranges from 5 to 30 ft (1.5 to 9.1 m). Porosities average 19% and permeabilities range from 1 to 4,000 md.

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Paradox—Pull-Apart Basin of Pennsylvanian Age

The Paradox basin (Colorado Plateau province) is an intracratonic depression developed on continental crust. The elongate northwest-trending rhombic-shaped basin of Middle Pennsylvanian age is bounded on the northeast by the Uncompahgre-San Luis segments of the Ancestral Rocky Mountains and on the southwest by the less prominent Four Corners lineament. The basin sagged along intersecting basement fractures by strong east-west extension during Middle Pennsylvanian time. The master fracture system was the northwest-trending Olympic-Wichita structural lane.

Oblique divergent strike-slip faulting along the Uncompahgre-San Luis segment created a tension-releasing bend where the Paradox pull-