

Anatomy of a 2nd-Order Unconformity: Stratigraphy and Facies of the Bakken Formation during Basin Realignment

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Historically we have all been guilty of viewing the Williston Basin as a “symmetrical soup bowl” — a time-averaged image common and appropriate to intracratonic sag basins worldwide. Because it is relatively devoid of classic Laramide compressional structures, the Williston tends to be viewed as a “structurally simple” basin. Yet the presence of numerous sub-basins complicates simplisitic lithofacies generalizations and requires detailed facies mapping with 1 or 2 ft contour intervals to unravel Middle Bakken paleogeography. The unconformity capping the Devonian Three Forks represents the infilling and destruction of the long-lived Devonian Elk Point Basin, sets the stage for the Bakken system, and marks the birth of a very differently configured Mississippian Williston Basin.

The tripartite lower, middle, and upper Bakken members form a distinct, early-basin-fill package overlying a megaregional 2nd-order angular unconformity. Even above the unconformity, short-lived Fammenian-Kinderhookian sub-basins formed and infilled, and structures such as the Nesson and Antelope were intermittently active, leading us to view the process of basin realignment as a dynamic process extending above the actual unconformity surface. Eventually, by Mission Canyon and Charles time (Osagean-Meramecian), the Williston Basin and Central Montana Trough assumed the form we commonly associate with the Williston.

Too commonly, “black” shales are thought of as exclusively deep water deposits— many view the Bakken as deeper than (or indeed tosets of) the Lodgepole limestone. Yet a review of stratigraphic geometry and facies successions leads to a very different conclusion. The lower, middle, and upper Bakken progressively overlap outwards from various subbasins. Each onlaps the underlying 2nd-order unconformity that caps the upper Devonian Three Forks and they are downlapped by the Kinderhookian lower Lodgepole, a depositional system with vastly greater aerial extent. During Bakken deposition the basin fluctuated from a stratified lagoon with euxinic bottom-waters caused by episodic connection to the open sea via a silled and only incipiently developed Central Montana Trough (in the process of inverting from a precursor Central Montana Uplift), to relatively open-marine conditions characterized by crinoid-rich sediments and extensive bioturbation. Thus the entire Bakken package represents a 2nd-order lowstand to transgressive systems tract lying below an interval of maximum flooding represented by the basal Lodgepole. This lowstand to transgressive stratigraphic context is a relatively new view for the Middle Bakken and explains the high aerial variability in sedimentary process and provenance. Detailed core and wireline analyses of upper and lower Bakken black shales, and the diverse facies associated with the intervening middle Bakken dolomitic to limey siltstones and sandstones are better understood in the context of a complex suite of sub-basins associated with this critical period of basin realignment.