The Sage Breaks Scour Event and its Influence on Layer-Bound Normal Faulting Within the Niobrara and Turner Formations, Southern Powder River Basin, Wyoming

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Abstract

The Sage Breaks Shale (Carlile Shale) in the southern Powder River Basin ranges in thickness from 0 to over 300 feet due to a significant scouring event that occurred during the Late Turonian Age of the Cretaceous Period. Stratigraphic analysis reveals a complimentary depositional relationship between the Sage Breaks Shale and the unconformably overlain Niobrara Formation, where accommodation space created by the scoured Sage Breaks Shale is filled with a thickened section of Niobrara Marl. This variable stratigraphic package of shale and marl hosts a system of layer-bound (polygonal) normal faults similar in origin and distribution to those found in the Niobrara Formation of the Denver Basin, Colorado. Detailed interpretation of 3-D seismic and horizontal well log data reveals a selective pattern in fault development in relation to the scoured areas, where fault density, displacement, throw gradient, and fault length vary with the thickness of the Sage Breaks Shale. Faults within the scour zone are larger and commonly extend beyond the Niobrara and Sage Breaks formations to offset the underlying Turner Sandstone and overlying Steele Shale. These “scour-zone-faults” are characterized by broad throw distribution profiles and shallow throw gradient. Faults outside of the scour-zones are smaller, less frequent, and mostly restricted to the Niobrara and Sage Breaks formations. Fault analysis from horizontal wells drilled in the Niobrara and Turner formations provides additional evidence that vertical fault growth from the Niobrara Formation to the Turner Formation is controlled by the thickness of the Sage Breaks Shale. Fault initiation point, relative timing, and mechanical stratigraphy provide possible explanations for the observed relationship and are all considered to play an important role in the development of this fault system.

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