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Deformation history in the southern Alberta foreland basin and petroleum system implications

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Summary

The foreland basin of southern Alberta, east of the mapped Rocky Mountain Foothills thrust front, has experienced a complex Cretaceous-Tertiary deformational history of flexural extensional faulting, thin-skinned thrusting and later thick-skinned compression, including inversion of earlier extensional faults. Deformation styles and sequence are revealed by integrating outcrop, seismic and well data.

Numerous NNW-SSE trending extensional faults have been documented previously on seismic data, and many extend from Precambrian basement upward through the entire Cretaceous section. At least one of these faults is exposed at surface within U. Cretaceous strata near Lethbridge. Many of these faults were intermittently active throughout Cretaceous-Tertiary deposition in the foreland basin. They locally control isopach/isochron variations and facies changes including fluvial channel locations and orientations.

A seemingly anomalous zone of thin-skinned thrusting and significant shortening within U. Cretaceous strata is exposed in the Oldman River near Monarch, more than 50 km east of the surface limit of the Foothills. The approximately 1 km long outcrop exposes structural geometry that is very similar to the “Triangle Zone” structural trend well documented at the eastern limit of the Foothills. The inferred detachment level beneath the observed deformation at Monarch is at or only slightly stratigraphically higher than the inferred “blind” detachment east of the Foothills “Triangle Zone” and deformation front, and we infer that thin-skinned slip is transferred from the Foothills into the foreland on this detachment.

The stratigraphy and zone of thin-skinned deformation at Monarch, however, have been subsequently structurally elevated about 150 m above a “regional” datum. Seismic data show the outcrop coincides with a steep NNW-SSE reverse fault rooted in the basement, possibly an inverted extensional fault. In the outcrop, low-angle thrust faults are cut by younger steep thrusts. Several hydrocarbon fields are associated with this broad structural culmination.

Extensional faulting has influenced reservoir and seal facies distribution, and late thick-skinned uplift has influenced hydrocarbon migration and trapping. This deformational history also has influenced development and distribution of fractrues critical for enhanced permeability.