Evidence for Large-Scale Hydrostatic and Thermal Inversion Across the Foothills of Central Alberta, and its Impact on HC Prospectivity

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Summary

Three types of inversion characterize major overthrusts of the central Alberta Foothills: (1) stratigraphic inversion featuring Cambrian and younger Paleozoic rocks which have been transported over Cretaceous units; (2) hydrostatic inversion defined by mountain-fed high pressure drive within allochthons residing over the plains-fed lower pressure aquifers of the footwall autochthon, and; (3) thermal inversion characterized by high temperature hangingwall units emplaced above cooler footwall rocks.

The most dramatic manifestation of major thrust sheets in the central Alberta Foothills and Front Range is the bedding-parallel juxtaposition of Cambrian and younger Paleozoic carbonate rocks over Cretaceous clastic units, with transport on individual sheets estimated at up to 30 km or more. Mountain-front occurrences comprise classic outcrop examples, whereas deep drilling in the last 20-30 years has delineated similar thrusts in the sub-surface of the foothills. However, two other important aspects of inversion characterize these thrust sheets as well. In the Central Foothills west of Calgary, Paleozoic reservoirs within major thrust sheets, such as the Moose-Panther overthrust, house distinct hydrostatic regimes relative to footwall units. Structurally, the Moose-Panther sheet is a far-travelled Paleozoic allochthon which locally breaches the surface, and has been thrust over para-authochtonous structures in its footwall including Jumping Pound and West Jumping Pound gas pools. Hydrostatic head gained from higher altitude (1400-1500 m) recharge has established an elevated pressure environment for the allochthon, which is open to the surface in the mountains. In contrast, footwall reservoirs are in apparent lateral hydrostatic communication with up-dip plains aquifers. In the later, hydrostatic head is significantly reduced due to lower altitude (800-900 m) recharge from the east. Consequently hydrostatic gradients and pressures are inverted; the shallower hangingwall allochthons contain higher gradients and reservoir pressures than the deeper footwall units and gas pools. Influx for one is local and from above, whereas the other is fed laterally by the regional Alberta homocline tucked under the first mega-thrust. The two regimes are largely disconnected, and high altitude re-charge from the mountains does not apparently drive fluids updip into the plains. Major thrust sheets effectively compartmentalize fluid regimes.

Thermal inversion is another characteristic of the major overthusts. Anomalous vitrinite reflection values characterize the disturbed belt, with high temperature characteristics preserved in allochthonous sheets above cooler footwall units. Heating of the footwall from the hot allochthons is also apparent in some profiles. Although structures formed late after peak burial and hydrocarbon generation, charge timing has not been an issue with significant gas accumulations developing in closures of the allochthonous sheets.