

Basement Structure in the Alberta Basin, Canada from Gravity and Magnetic Studies

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Abstract

New exploration methodologies can substantially extend the productive life of mature sedimentary basins and lead to new discoveries. Our techniques help address one understudied fundamental aspect of the Phanerozoic Alberta and Williston basins: control on the location of oil and gas deposits by the underlying Precambrian crystalline basement.

Predictive correlations between even minor structures in the basement and many geologic features in the sedimentary cover arise from geophysical detection of subtle faults and fractures with public-domain gravity and magnetic data.

Two types of basement structure are recognized: ancient, orogenic, ductile structures; and post-Mid-Proterozoic, high-angle, brittle faults. The former dominate the regional potential-field signatures – but, crucially for exploration, this main pattern is cut by younger brittle faults with various orientations and subtle potential-field signatures.

Using inexpensive data from the Geological Survey of Canada, lineament detection requires detailed data processing (Geosoft software was used): vertical, horizontal and total gradients; shadowgrams; trend removal; and amplitude gain control. Upward continuation reveals regional anomaly patterns. To prevent creating lineament-like artifacts, bandpass filtering is avoided. Subtle lineaments are picked manually: a lineament can be a gradient zone, straight alignment of small anomalies, aligned breaks in regional anomaly pattern, etc.

Comparing potential-field lineaments with geologic features in the sedimentary cover points to intermittent, sporadic, commonly indirect basement control. Even seismically invisible, zero-offset steep faults conducted salt-dissolving fluids, influencing Mesozoic depositional patterns. Some Paleozoic reef chains and other reservoir trends follow potential-field lineaments, and many Paleozoic sub-basins have polygonal shapes with straight sides.