Seismic and outcrop investigation of fault development in the transtensional Moncton Sub-basin at the McCully gas field, southern New Brunswick, Canada

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Sedimentary basins in strike-slip settings contain complex structures due to concurrent extensional, contractional, and rotational deformation, making it challenging to understand early basin configurations and depositional patterns. The kinematic history of such basins can be unraveled by measuring the heaves and orientation of fault arrays to quantify deformation.

In the Moncton Sub-basin in southern New Brunswick, Canada, data from the McCully gas field reveal a complex structural geometry. Three-dimensional seismic reflection data tied to 46 wellbores show extensional faults, contractional faults, and folds within the unconformity bounded, Late Devonian to Early Mississippian Horton Group. A conjugate set of extensional faults is identified with typical east-west strike, along with contractional faults of various orientations. The strike-lengths of these faults range from less than 200 m to more than 4500 m, with dip-slip offsets up to 250 ms of two-way travel time (~500 m). Gentle folds trend NE. Analogous faults are found in highway outcrops, located approximately 15 km SW of the sub-surface data. Here, siltstone and sandstone of the Horton Group are offset by 136 observed extensional and contractional faults. Again, conjugate sets of extensional faults are observed, with average NNW-SSE strike orientations; the thrust faults mainly have NNE strike orientation.

The subsurface heave and orientation measurements indicate an apparent stretch of ~15% and an apparent, approximately perpendicular shortening of ~2.5%. The outcrop data yield an additional 2% of sub-seismic apparent stretch. These quantities indicate that during the Late Devonian to Early Mississippian, the Moncton Sub-basin was deformed in a transtensional setting with an angle of divergence (alpha) of ~43 degrees from the zone boundary, resulting in horizontal extension roughly 017 degrees clockwise from north. This extension produced faults which divide the reservoir into fault blocks. Understanding the kinematics of strike-slip and transtension is therefore important for resource exploration in such basins.

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