Structural Study of Western Anticosti Island, St-Lawrence Platform, Quebec: Fracture Analysis and Integration of Surface and Subsurface Structural Data

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A structural analysis has been conducted on western Anticosti Island, Québec, to characterize joint sets, folds and faults affecting the globally flat lying Upper Ordovician to Lower Silurian rocks outcropping on the island. Field data are integrated to subsurface data, so as to determine a possible relationship between the different structures observed in the Lower Ordovician to Lower Silurian sedimentary sequence on the island and in the estuary of the St-Lawrence River. The aim of this study is to estimate the role of the following events in the development of such structures: 1) the Taconian and Acadian orogenies, even though Anticosti Island lies 70 km northwest of the Appalachian structural front, the Logan's Line; 2) the opening of the Atlantic Ocean in the Jurassic, as two dikes linked with this event outcrop on the island (Bédard, 1992); 3) local stress field linked with pre-existing structures.

Anticosti Island is part of the St. Lawrence Lowlands platform. The sedimentary sequence is made up Lower Ordovician to Lower Silurian carbonate ramp deposits (Long and Copper, 1994) and rests unconformably on Precambrian basement. Younger rocks outcropping at surface on the island are globally flat lying and dip approximately 3° to the south (SOQUIP, 1987).

Results of the Joint Survey

A statistical fracture analysis is combined to a geometric analysis of the joint pattern, so as to identify the joint sets and systems as well as their relative chronology. The stations are spread through the different formations to represent the behaviour of fractures both in time and in space. Five joint sets are identified: a NS and EW orthogonal joint system, a N140-160 set, a N50-70 set and some irregular, randomly oriented joints. The geometric analysis of the orthogonal system (Rives et al., 1994) shows that the EW set was developed prior to the NS set, but both sets were probably formed during a same late uplift event associated to the release of the orogenic elastic strain after the Middle Ordovician Taconic Orogeny. The N140-160 and N50-70 sets may have developed later, in a local extensive setting during the Acadian Orogeny. The irregular joints could

represent the final steps of fractures development (Rives et al., 1994) triggered by erosion followed by an uplift of the Early Silurian sequence, or linked with the isostatic uplift after the ice age.

Integration of other Surface and Subsurface Data

Repeated sets of WSW-trending largely open folds occur in the Chicotte Formation (uppermost Llandoverian), in the southern part of the island. Their trend is similar to fold axis in the St. Lawrence estuary, in the top of the Jupiter Formation, just below the Chicotte Formation (SOQUIP, 1987). Other open folds are identified on offshore seismic lines shot across the St Lawrence estuary, between Anticosti Island and the Gaspé Peninsula. They probably affect sedimentary rocks younger than the Chicotte Formation outcropping on Anticosti Island. All these folds may have formed during a compressive regional setting during the Middle Devonian Acadian Orogeny.

In subsurface, major Taconian faults are identified. One of them, the Jupiter fault (Shell, 2000), affects mostly the Early to Middle Ordovician Romaine, Mingan and Vauréal Formations and belongs to a set of SW-dipping normal faults (SOQUIP, 1983) probably linked with an extensional stress field in front of the Taconian structural front during late Ordovician times. Deeper in subsurface, major fracture zones are interpreted in the basement from an aeromagnetic survey (LGS, 1971). They are oriented WSW-ENE, NW-SE or N-S. They could be related to the opening of the Iapetus Ocean in the Cambrian and might control the orientation of later developed structures.

A lineament analysis realized from a Digital Elevation Model shows that some Taconian faults like the Jupiter fault may have been reactivated during later tectonic events linked with the fracture development. In fact, the DEM shows major fracture or fault zones that affect the Lower Silurian sedimentary sequence. Their average strikes are N-S, E-W to WNW-ESE, NW-SE or SW-NE, so they are consistent with the orientation of joint sets identified on the field. Some of these fracture zones may also have been reactivated during the opening of the Atlantic Ocean in the Jurassic, as two dikes associated with this major tectonic event are observed in the northern part of the island (Bédard, 1992).

References

Bédard, J. H. 1992. Jurassic quartz-normative tholeiite dikes from Anticosti Island, Quebec. *In* Puffer, J. H., and Ragland, P. C., eds. Eastern North American Mesozoic magmatism. Geol. Soc. Am. Spec. Pap. 268: 161-167.

Lockwood Geophysical Services (LGS), 1971. Report on interpretation of aeromagnetic data – Anticosti Island – Québec. Lockwood Survey Corporation Limited, Toronto, Canada.

Long, D.G.F. and Copper, P. 1994. *The late Ordovician - early Silurian carbonate tract of Anticosti Island, Gulf of St. Lawrence, Eastern Canada.* Geological Association of Canada Mineralogical Association of Canada, Joint Annual Meeting, Waterloo, Ontario. 20 - 25 May, 1994. *Field Trip Guidebook B4*: 67p.

Rives, T., Rawnsley, K. D., Petit, J.-P. 1994. Analogue simulation of natural orthogonal joint set formation in brittle varnish. Journal of Structural Geology, Vol. 16, No. 3, 419-429.

SHELL Canada – ENCAL Energy. 2000. Anticosti Island Exploration, 1997-2000.

SOQUIP. 1983. Rapport technique statutaire. Ile d'Anticosti, n° 13129.

SOQUIP. 1987. Estuary and Gulf of St-Lawrence – Geological, Geophysical, Geochemical Data integration, n°14092. Geological Survey of Canada, Open file N°1721.