The Rift between Ontario and Quebec: Structural Analyses of the Ottawa-Bonnechere Graben Faults

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Abstract

The Ottawa-Bonnechere Graben is an aulacogen associated with the breakup of the supercontinent Rodinia and the formation of the Iapetus Ocean, initiating in the Neoproterozoic. However, field observations show that the faults that presently define the graben offset Late Cambrian and Middle Ordovician units. The Late Cambrian Nepean Sandstone exhibits pervasive brecciation, undulous extinction, bulging grain recrystallization and sub-grain development in quartz. These are obvious signatures of low temperature deformation (<300°C). Higher in the stratigraphy, vein style and fault breccia calcite within Middle Ordovician Ottawa Group limestones possess extensive lamellar twinning. Many calcite grains show post-twinning brittle deformation via fractures that offset lamellar twins. Differences exist between vein calcite precipitated within fractures and brecciated fault calcite, as the vein calcite preserves much thicker and less intensive twinning (~35 μm width, 7 twins/mm) than the fault breccia calcite (~8 μm width, 30 twins/mm). This indicates the brecciated calcite experienced lower-temperature deformation (150-250°C) than the vein calcite (>250°C). Based on the cross-cutting relationships, we have interpreted these observations as a continuum of deformation, in which the more recent deformation occurred under lower temperatures (i.e. fault breccia calcite post-dates vein calcite). Below the Paleozoic strata, fault gouge within the Mesoproterozoic Grenvillian gneiss exhibits brittlely fractured quartz and feldspar, and largely untwinned calcite veins. Anastomosing pseudotachylite bands (0.3-1.0 mm thick) are present within the fault gouge. $^{40}Ar/^{39}Ar$ geochronology conducted on the pseudotachylite has dated the formation of the pseudotachylite at ca. 495 Ma. Subsequent deformation is evidenced by calcite veins which cross-cut and off-set the pseudotachylite veins. It is plausible that reactivation along this fault continued into post-Ordovician times. We conclude that the Ottawa-Bonnechere Graben was tectonically active from its incipient rifting stage in the Neoproterozoic through at least the Ordovician, with multiple low-temperature deformation events being the dominant mechanism for accommodating regional strain.