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Using thermodynamic modelling, quartz-in-garnet geobarometry and monazite geochronology to understand Early Jurassic orogenesis in the Northern Canadian Cordillera

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Polydeformed mid-crustal rocks crop out throughout much of the Northern Canadian Cordillera in Yukon, Canada, yet the timing and conditions of deformation and metamorphism are not well constrained in many areas. Regional mapping, in-situ monazite U-Pb geochronology, quartz-in-garnet geobarometry and thermodynamic modelling indicate that parts of southwest Yukon experienced tectonic burial to 25-30 kilometres by 199 Ma. Decompression was accompanied by widespread high-Y monazite growth around 185 Ma. These results highlight the significance of thick-skinned Early Jurassic orogenesis in the Northern Canadian Cordillera.

Data obtained using garnet isopleth thermobarometry and pseudosection modelling indicate that garnet grew along a positive P-T gradient, with garnet nucleation at 0.3-0.4 GPa and 500-550°C. Modelling constrains peak metamorphic conditions to 0.6-0.8 GPa and 650°C. Pressure estimates obtained using Raman spectra of quartz inclusions in garnet cores (quartz-in-garnet geobarometry) also suggest that garnet nucleation occurred at pressures of 0.3-0.4 GPa. However, pressures obtained from inclusions outside of garnet cores vary between 0.3 and 0.7 GPa, with some intervals of garnet growth apparently accompanied by a decrease in pressure. Therefore, these data are not consistent with garnet growth along a simple positive P-T gradient, as suggested by thermodynamic modelling. Our results highlight discrepancies between metamorphic conditions obtained using thermodynamic modelling compared with those obtained using quartz-in-garnet geobarometry. This brings into question the accuracy of P-T paths obtained by using techniques, such as pseudosection modelling, which often cannot resolve such paths in detail. Nevertheless, the consistent garnet core pressures obtained in this study suggest that garnet growth initiated at near equilibrium P-T-X conditions. A subsequent departure from equilibrium conditions would explain the discrepancy between thermodynamic modelling and quartz-in-garnet geobarometry for later stages of garnet growth. This study highlights the potential for precise determination of complex P-T-D-t paths. Such paths could provide insight into the tectonic processes responsible for deformation and metamorphism in the mid-crust.