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Pressure-temperature-time constraints on the metamorphism of mafic granulites and meta-ironstones of the Pikwitonei Granulite Domain, Manitoba

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The Pikwitonei Granulite Domain (PGD) located in Manitoba, Canada is unique in that it is a relatively unretrogressed exposure of the north-western Superior craton that records Neoarchaean ultra-high temperature (UHT) metamorphism. Understanding the tectono-metamorphic processes that shaped this granulite domain is critical towards constraining potential tectonic mechanisms operating in the Archean. The tectonic origin of the PGD, specifically the prograde metamorphic path that led to the formation of the UHT rocks here and the causal tectonic mechanism behind it, remains debated. Possible factors include higher mean mantle temperature, smaller crustal thicknesses, and/or high radiogenic heat production in the crust. This study aims to shed light on this debate through the petrochronology of two mafic granulites and two meta-ironstones from locations spanning western to north-western PGD. We utilize phase equilibria modeling complemented by mineral thermometry (Ti-in-amphibole and Al-in-orthopyroxene) to establish peak temperatures and pressures of metamorphism in the PGD. The mafic granulites preserve evidence of recrystallized melt, indicating that partial melt loss modified their bulk compositions during metamorphism. To account for this, we employed a stepwise down-temperature melt-reintegration approach at constant pressure, recovering the original bulk compositions that existed prior to melt loss. These bulk compositions were then used to reconstruct the pressure–temperature path of the metamorphic event. The modeling results imply a peak temperature of ~950°C-1000 °C at a pressure of ~0.7-0.8 GPa. To anchor these petrological constraints in deep time, we apply Lu-Hf geochronology on bulk garnets sampled from each rock. Results, consistent with previous studies, show that garnet growth, which is interpreted to be coeval with prograde metamorphism, started at least 2.6-2.7 Ga. To further constrain the timescale of prograde metamorphism, ongoing work focusses on metamorphic zircon growth. Zircon geochronology combined with REE partitioning between zircon and garnet will help determine whether both minerals grew coevally or record distinct metamorphic events. The integration of phase-equilibria modeling, geochronology, and trace element partitioning can provide a robust framework for resolving Neoarchean deep crustal processes in the PGD.