Thermal structure and chemical composition of the Archean mantle and origin of mantle "plumes": Insights from ca. 2.73 Ga komatiite and basalt, Nunavut, Canada

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Geochemical studies of komatiite- and basalt-dominated volcanic successions within late Archean supracrustal belts have the potential to yield important insights into the thermal structure and chemical composition of the early Earth's mantle, as well as the dynamics of mantle melting. The high eruption temperatures and degrees of melting that are required to explain the first-order geochemical features displayed by the vast majority of late Archean komatiite, namely their high-MgO contents and pronounced depletion in incompatible elements, have been used to argue that these magmas must have an origin related to mantle plumes. Unfortunately, the near universal acceptance of a mantle plume origin for komatiite is used as an argument (circular) for the existence of plumes, and geochemical observations are routinely interpreted in terms

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of the modern plume paradigm. The underlying assumptions of the paradigm are seldom questioned or why, if they exist, potential plumes in the modern mantle might be similar to those in the Archean. Currently, no consensus exists on the nature or very existence of modern or ancient mantle plumes and their relationship with respect to the ambient mantle, a situation that requires remediation. This study presents geochemical data from a unique and exceptionally well-preserved ca. 2.73 Ga volcanic succession, dominated by large volumes of chemically diverse komatiite and basalt recently discovered in the Canadian Arctic. This succession constitutes the basal sequence to a vast network of co-genetic clastic-dominated supracrustal belts (~1400 km long and ~400 km wide) formed between ca. 2.73–2.69 Ga. Modeling the geochemical data with constraints from high- and low-pressure peridotite melting experiments has yielded the following conclusions: (1) high-MgO komatiite magmas were derived from thermally anomalous mantle, which was ~150°C hotter than the ambient mantle; (2) the ambient ca. 2.7 Ga mantle was ~200°C hotter than the modern mantle; (3) ambient and thermally anomalous mantle are the same composition and both are similar to the modern depleted upper mantle; (4) Archean mantle plumes are discrete "parcels" of thermally anomalous mantle; (5) primary magmas within the late Archean were komatiitic not basaltic; (6) plumes have an origin within the upper mantle; and (7) the source of thermal energy required to heat the upper mantle may ultimately have originated from the core.

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