



Temperatures in the Archean Mantle

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Knowledge of temperatures in the Archean mantle is essential for the construction of credible models for the thermal and geodynamic evolution of the Earth but this information is difficult to obtain. Attempts using compositions of common Archean tholeiites are unsuccessful because all such rocks formed from evolved magmas and do not represent primary melts. The compositions of these basalts depend mainly on the extent of crystallization and provide few constraints on the compositions of primary magmas and little information about the temperatures in their source.

Although some komatiites, such as those from Boston Creek in Canada, contained minor water contents, most komatiites were essentially anhydrous. Using whole-rock and olivine analyses, the MgO contents of the parental magmas can be calculated and the temperatures in their sources can be inferred. The highest MgO is calculated for flows of the Weltevreden Formation of the Barberton Belt in South Africa. These komatiites contain olivine with the composition Fo₉₆ and crystallized from liquids containing 32-34% MgO (Kareem & Byerly 2003, *Lunar Planet. Sci XXXIV*). They would have erupted at about 1650°C. Mantle source temperatures are normally estimated by extrapolating the liquid adiabat to the solidus of mantle peridotite. Because of the steepening of the solidus with pressure, the liquid adiabat of Weltevreden komatiite becomes parallel to the solidus in the lower part of the upper mantle, indicating that the komatiite source was already molten at the transition zone. Other Archean komatiitic liquids contain 20-30% MgO. They erupted at 1500-1600°C and were derived from sources with temperatures >1800°C at depths >200km. The most magnesian Proterozoic komatiites, from Thompson in Canada, contained 25% MgO, a little higher than Cretaceous Gorgona komatiites (20-23% MgO). Source temperatures of Gorgona komatiites were about 1700°C.

Komatiites formed in mantle plumes whose temperatures were far higher than ambient mantle. The temperature difference between the Gorgona plume and modern ambient mantle is about 300°C. If a similar difference applies in the past, ambient Archean mantle was 200-300° hotter than modern mantle.