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# Granulite facies metamorphism and melting: the message from metabasalts

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Metabasic lithologies make up a significant proportion of rocks in high-grade metamorphic terrains, and in the case of many Archean ones can be one of the dominant rock types. Such rocks undergo key prograde mineral assemblage changes that not only have the potential to inform high temperature processes but define the amphibolite–granulite facies boundary. Despite their common occurrence and importance, the lack of appropriate thermodynamic models for minerals and melt meant that the application of quantitative phase petrology to them to extract *P–T* information was extremely restricted. Thus, over the last 15 years phase-petrological constraints on high-temperature metamorphism have been derived primarily from metapelitic rocks. New thermodynamic models for hornblende, augitic clinopyroxene and tonalitic silicate melt now allow the calculation of suprasolidus equilibria in metabasic to intermediate compositions, and hence use them in a much wider range of studies. The models have been developed for the geologically realistic $Na_2O$–CaO–$K_2O$–FeO–MgO–$Al_2O_3$–$SiO_2$–$H_2O$–$TiO_2$–$Fe_2O_3$ (NCKFMASHTO) chemical system.

The common basalt types (tholeiite, MORB, calc-alkaline etc) show little variation in overall mineral assemblage stability and melt production. Melt production in such compositions is controlled largely by hornblende breakdown, coinciding with the appearance of orthopyroxene at the amphibolite–granulite boundary that occurs at 800–900°C for pressures of 1–10 kbar. At pressures above about 8–11 kbar, for most basalt compositions garnet may occur, coinciding with orthopyroxene stability becoming largely pressure dependent. This boundary marks the appearance of high-pressure granulite.

In quartz-absent assemblages, the breakdown of hornblende can occur over an interval of more than 100 °C, consistent with the common occurrence of hornblende-bearing granulites. By contrast, in more silica-rich rocks, complete hornblende breakdown may occur within 10s of degrees of the appearance of orthopyroxene, resulting in typical two-pyroxene granulite. Additional contributions to melt fertility may come from the consumption of sphene and or epidote just above the solidus and biotite close to the amphibolite–granuliite boundary.

An important application of the models is to high temperature processes in the Archean that produce TTG magmas. The models show that enriched Archean tholeiite compositions have substantial melt fertility for *P–T* paths that cross the solidus at pressures of 7–15 kbar and reach temperatures of 850–950°C, but that much higher pressure paths result in much lower melt production due to subsolidus deyhdration reactions reducing the bulk water content at the solidus. Thus, eclogite facies melting of metabasalt is unlikely to be a dominant source for TTG magmas.