Understanding the genesis of Charnockites from an Early Archean Mafic Crust: a case study from Coorg massif, S. India

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Charnockites, sensu lato, referring to orthopyroxene (and rarely fayalitic olivine) bearing granitoid rocks are restricted in their occurrence to mainly the Archean and Proterozoic eons. Their genesis has been enigmatic, pointing to some process that was prevalent only in the early history of the Earth. We have studied exposures of enderbitic rocks (calcic, plagioclase-rich orthopyroxene-bearing granitoid) from the Coorg massif in S. India. We have combined field observations (association of the enderbites with mafic and pelitic rocks, inclusion of mafics in the enderbite) and geochemical data (bulk chemistry, mineral chemistry and modal abundance of minerals) with thermodynamic phase equilibria modelling to infer possible modes of origin of enderbitic rocks. We used the Perple_X software in combination with thermodynamic data from [1,2]. We find that it is possible to derive the observed enderbitic rocks from mafic rocks. While different pathways may lead to the formation of enderbites, two processes are critical and common to all pathways: (1) Melting of the mafic composition at high pressures in the presence of water, so that melting point depression may occur, and (2) Ascent of the melt to shallower depths and crystallization, with or without fractionation, after dehydration to yield the opx-bearing granitoid. The modelled results match well with the observed compositions and modal abundances of minerals in the rocks.

This sequence of processes requires tectonic settings that allow (a) deep burial, along with water, of mafic rocks and (b) presence of shallow, hot settings where melts may exist without freezing. This combination is found in the recently proposed form of early plate tectonics involving peeling-off and recycling of continental crust [3]. The proposed mechanism of formation of opx-bearing granitoids helps to explain the temporal restriction of these rocks in the Earth history and also provides a means of silicification of the continental crust from an early mafic crust.

[1] Holland and Powell (2011) J. Metamorph. Geol. 29, 333-383 [2] Green et al. (2016) J. Metamorph. Geol. 34, 845-869 [3] Chowdhury et al. (2017) Nat. Geosci. 10, p. 698