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Eclogite melting and the destruction of early high-pressure rock records

GUIBIN ZHANG SR. AND SHUAIQI LIU

Peking University

Presenting Author: gbzhang@pku.edu.cn

The presence of eclogite marks the high-pressure metamorphism and deep subduction of the crust which is a key indicator for the onset of modern-style plate tectonics. However, the eclogite is rarely preserved in many intensely granulite-overprinted orogens, especially for the old (Archean & Paleoproterozoic) metamorphic terranes. Here, we found that the eclogite melting process is in great association with the preservation of high-pressure records. We demonstrate the eclogite melting process based on the results of detailed petrological, geochronological, and geochemical analyses on eclogites and separated centimetric leucosomes from the central Himalaya. The central Himalaya eclogites were overprinted by strong granulite metamorphism and the omphacite is hardly preserved. The eclogitization occurred at >2.3 GPa and 770–830 °C at ca.17 Ma, and subsequent high-temperature granulite metamorphism took place at 0.9–1.0 GPa and 840–890 °C at ca. 13 Ma. Our results indicate the eclogite witnessed two types of anatectic reactions: phengite dehydration melting together with omphacite in the high-pressure domain and later omphacite breakdown solely during exhumation. Diagnostic features for the above melting reactions include i) the occurrence of Kfs−Pl−Qz multiphase solid inclusions and Cpx–Pl–Qz polymineralic inclusions; ii) the high Na_2O/K_2O melts and Na-rich plagioclase in leucosomes; iii) the consistent trace elements patterns between omphacite and leucosome veins; and iv) obvious Na_2O zonation in clinopyroxene; v) thermodynamic modeling results indicate an early phase of anatexis triggered by phengite dehydration melting and formed K-rich melts, while later melt portion increases resulting from the consuming of clinopyroxene. The change of anatectic reaction was also recorded by the melt composition showing distinct K_2O, Al_2O_3, Rb, Ba contents due to phengite contributions. Integration of experimental studies, partial melting of omphacite is characterized by the breakdown of jadeite component that releases Na and Al into the partial melts. This melting mechanism subsequently forms a less solic clinopyroxene and high Na_2O/K_2O melts. Considering the similar high thermal gradients and intense granulite overprints, partial melting of eclogite dominant by omphacite breakdown could erase the high-pressure records on early earth which is related to the modern-style tectonics.