Process and condition of granitic magma fractionation: Insights from thermodynamic modelling for peraluminous charnockite

KAI ZHAO [1], XISHENG XU* [1]

[1] State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing, 210023, China (*Correspondance: xsxu@nju.edu.cn)

Granitic magma fractionation is a crucial process for differentiation of continental crust and enrichment of elements of economic interest. It is still debatable whether or not granitic magma fractionation takes place at middle to upper crust. Here, we present a case study for the peraluminous Jiuzhou charnockite (orthopyroxene-bearing granite) from South China combining detailed petrography and thermodynamic modelling to shed new lights on this topic. Thermodynamic modelling for the charnockite suggests that orthopyroxene stabilizes at conditions of >750 °C and <5 wt% melt H_2O content, while magma completely solidifies at H_2O-saturated solidus, i.e. ~650 °C and ~5.8 wt% melt H_2O content at 0.2 GPa, indicative of the instability of orthopyroxene at late stage of magma crystallization. The preservation of orthopyroxene is attributed to melt extraction within orthopyroxene stability field, which is further supported by the microstructural and textural records in the charnockite. Melt extraction occurs at solidification fronts, resulting in the pluton-scale compositional zoning and the more mafic composition for the charnockite compared with metasediment-sourced experimental melt. The majority of exposed peraluminous granites in South China is orthopyroxene-free, which has comparable K_2O/Na_2O and Rb/Sr ratios and zircon saturation temperature with the Jiuzhou charnockite, indicating production by fluid-absent melting. Melting experiments suggest that fluid-absent melting produces high temperature (>800 °C) and moderately H_2O-poor (<4-5 wt%) melts. Such melts have the potential to crystallize orthopyroxene, but they cannot preserve orthopyroxene because the primary melts are high-silica (mostly >~70 wt%). When melt extraction occurs, the orthopyroxene has been totally reacted to be biotite. Examination of compositional data for the orthopyroxene-free granites suggests that many of them show compositional gradients and have more mafic compositions compared with experimental melts, indicating the potential importance of magma fractionation. Detailed petrography combining thermodynamic modelling for these granite plutons may provide insights into granitic magma fractionation.