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Whole-rock Mg isotopes distinguishing high- and low-temperature S-type granites

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Determining the temperature of crustal anatexis for granitic magmatism is crucial to understand the petrogenesis of granites and process of crustal anatexis. During partial melting of metasedimentary rocks, biotite breakdown at relatively high temperature can lead to the formation of peritectic garnet, which is rare or absent at low temperature when the melting is governed by muscovite breakdown[1]. Such a difference makes magnesian (Mg) isotopes a potential mean to trace the relative variation of crustal melting temperatures because garnet has the lowest δ^{26}Mg values relative to other Mg-bearing phases at equilibrium fractionation[2, 3]. However, it is poorly known to what extent the temperature variation may affect melt Mg isotope compositions.

This study revisits the Miocene high-temperature leucogranites from Yalaxiangbo and the low-temperature leucogranites from Cuona and Dingga in the Himalayas. By utilizing the Ti-in-zircon thermometer, whole-rock geochemistry —including Mg isotopes—and phase equilibrium modeling, we suggest the granites formed at high temperatures exhibit heavier Mg isotope compositions (δ^{26}Mg values of 0.46 to 0.53‰) due to the significant presence of peritectic garnet in the melting residue, contrasting with the granites produced under low-temperature conditions, which display lower δ^{26}Mg values (-0.70 to -0.14‰). Phase equilibrium modeling results demonstrate that partial melting can induce a maximum Mg isotope fractionation of over 0.50‰ between melt and source. There is the casual relationship between Mg isotope composition and anatectic temperature. As such, this study highlights that whole-rock Mg isotope can serve as a reliable indicator to distinguish high- and low-temperature S-type granites.

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