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The dual origin of granites from fluid-absent and fluid-fluxed melting of the juvenile lower crust: New constraints from Mo isotopes and phase equilibrium modeling

YOUSHAN XIA, PENG GAO, GUOCHAO SUN, ZI-FU ZHAO, YAO ZHOU, LEI QIN, GANG WEN AND ZHENXIN LI

University of Science and Technology of China, Hefei

Water plays a pivotal role in the differentiation of continental crust and the formation of granitic magmas. However, it is still hotly debated how to distinguish between fluid-absent and fluid-fluxed melting regimes for the origin of granites. Mo isotopes have shown a potential in tracing the nature of fluid activity during magmatic and metamorphic processes. This study presents whole-rock geochemical and Sr–Nd–Mo isotopic compositions of early Paleozoic potassic granites (K_2O/Na_2O = 0.81 to 1.13) from the northern part of the Dabie orogen, east-central China. The Sr–Nd isotope results indicate that the potassic granites would originate from the juvenile lower crust, consistent with the spatiotemporally correlated sodic granites. However, the potassic granites show similar δ^{98}Mo values (–0.41 to 0.23‰, median = 0.02‰) to the adjacently coeval mafic rocks (–0.17 to 0.21‰, median = 0.02‰), whereas the sodic granites have higher δ^{98}Mo values (–0.13 to 0.74‰, median = 0.22‰). Simulation calculations indicate that neither fractional crystallization nor crustal contamination can account for the observed differences in K_2O/Na_2O ratios and Mo isotope compositions between the potassic and sodic granites. Such differences can be well explained by partial melting of the same source rocks at different fluid regimes. Further phase equilibrium modeling indicates that the addition of fluids can lead to the preferential decomposition of plagioclase, resulting in a decrease of K_2O/Na_2O ratios but an increase of δ^{98}Mo values for the resultant melt. The fluid-fluxed melting could be caused by fluids exsolved from crystallization of the underplated hydrous mafic arc magmas, but such fluids cannot be distinguished from those produced by the breakdown of hydrous minerals in the juvenile lower crust. On the other hand, the fluid-absent melting of the mafic crust would primarily occur via the breakdown of hydrous minerals, including biotite and amphibole, generating hydrous melts with relatively higher K_2O/Na_2O ratios and lower δ^{98}Mo values. Therefore, the fluid-absent melting gave rise to the lower δ^{98}Mo granites than the fluid-fluxed. This study provides compelling evidence for the control of fluids on the Mo isotope composition of granitic magmas and thus offers a new means to trace the fluid-absent and fluid-fluxed melting processes.