

Kinetics of oxygen isotope exchange between water and minerals from Mesozoic A-type granites in China

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Post-magmatic water-rock interaction is a common phenomenon for intrusives, but its timescale is variable from pluton to pluton depending on temperature and water origin. By means of the conventional BrF_5 method and the laser fluorination technique, O isotope analyses were carried out for whole-rocks and mineral separates from three A-type plutons at Nianzishan, Shanhaiguan and Suzhou in eastern China. The results show that, despite a relatively limited $\delta^{18}\text{O}$ range of 3.10 to 5.39‰ for zircon, the granites exhibit variable $\delta^{18}\text{O}$ values of -2.4 to 9.2‰ for whole-rock, 0.0 to 9.2‰ for quartz, -3.8 to 7.3‰ for alkali feldspar, -14.1 to 4.5‰ for magnetite, and -5.8 to 6.8‰ for biotite. Most of the samples exhibit apparent equilibrium fractionations between quartz and zircon, yielding temperatures of 800 to 1000°C that are unreasonably higher than the closure temperatures of O diffusion in quartz during granite cooling. In contrast, fractionations between alkali feldspar, biotite and quartz are significantly deviated from equilibrium values, indicating post-magmatic water-rock interaction at medium to low temperatures.

Quantitative simulation was carried out by using the kinetic model of O isotope exchange between multi-minerals and water. The initial $\delta^{18}\text{O}$ values of whole-rock and exotic fluid are estimated according to the O isotope compositions of zircon and modern meteoric water. The results obtain that the flow rate of fluid is about 10^{-15} to 3×10^{-14} mol/s, the timescale of water-rock interaction is about 0.3 to 3 Ma, and ratio of water to rock is about 0.11 to 1.02. Significant decrease in quartz $\delta^{18}\text{O}$ is ascribed to water-rock interaction of higher temperatures (~400°C) and longer duration (>1 Ma). The present study demonstrates that the A-type granites were not only crystallized from low- ^{18}O magma but also overprinted by meteoric-hydrothermal alteration. Because of significant differences in the rate of O isotope exchange by diffusion and surface reaction between granitic minerals and water, subsolidus alteration is readily distinguishable from such supersolidus reactions as crustal contamination, water-rock interaction and partial melting in the pattern of mineral-pair O isotope distributions.