The effect of partial melting on geochemical diversity in granites

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A combined study of whole-rock major-trace elements and Sr-Nd isotopes, zircon U-Pb ages, Lu-Hf and O isotopes was carried out for Triassic granites from the Nanling Range in South China. The results provide insights into the effect of partial melting on the geochemical compositions of granites. These Triassic granites exhibit large variations in both major and trace element compositions with SiO_2 contents from 62.28 to 76.92 wt.%, A/CNK ratios from 1.05 to 1.43, and Zr+Nb+Ce+Y contents from 145 to 708 ppm, covering a geochemical spectrum of common granites from S-type to possible I-type and A-type. Although only part of them are peraluminous to strongly peraluminous, all of them exhibit high zircon $\delta^{18}O$ values of 8.4 to 10.6‰, indicating their derivation from partial melting of sedimentary rocks and thus unambiguously S-type affinity. Despite a large range in $(^{87}Sr/^{86}Sr)_i$ ratios from 0.7060 to 0.7246, these granites exhibit limited ranges in whole-rock $\varepsilon_{Nd}(t)$ values of -11.55 to -9.35 and zircon $\varepsilon_{Hf}(t)$ values of -12.2 to -5.4, indicating their origination from the ancient crust. While these O-Sr-Nd isotope compositions do not change with SiO_2 contents, such variables as $MgO+FeO_T$, A/CNK, CaO/Na_2O, P_2O_5, δEu, LREE, Zr and Th change regularly with Al_2O_3/TiO_2 ratios.

Based on experimental data from partial melting of crustal rocks that the Al_2O_3/TiO_2 ratios of granitic melts are negatively correlated with melting temperatures at common crustal pressures, the Al_2O_3/TiO_2 ratios are used as a proxy for the melting temperatures. As such, the variable element contents but the similar isotope compositions for the Nanling granites can be accounted for by partial melting of a common source composed of sedimentary rocks at different temperatures. Thus, partial melting of the sedimentary rocks at lower temperatures would firstly produce the peraluminous to strongly peraluminous S-type granites. With increasing the melting temperature, restites after extracting the S-type granitic melts would become partially melted. This gives rise to the metaluminous granites of I-type affinity on the one hand and the high Zr+Nb+Ce+Y granites of A-type affinity on the other hand, but the O-Nd-Hf isotope compositions of these granites are still similar to those of peraluminous S-type granites. Therefore, the progress of partial melting with temperature plays a key role in the variations of geochemical composition in these granites.