

Fe, Cu and Zn isotopic insights into metal behaviour during magma mingling

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The 482 ± 8 Ma post-tectonic Mannum granite located in South Australia hosts a swarm of variably hybridised mafic enclaves of basaltic composition. These were generated by the injection and mingling of coeval mafic and host granite magmas. The temperature difference between the two magmas was relatively small, (<200 °C) and unhybridized enclaves were quenched soon after mingling. We use this location as a natural laboratory to explore the utility of Fe-Cu-Zn stable isotopes in determining the potential mechanism(s) of metal exchange between these magmas, by analysing host granite, mafic enclaves and hybrid compositions. Fe, Cu and Zn isotopes were chosen as they represent a range of geochemical behaviours alongside distinct concentration contrasts between the host granite and mafic injections. The measured stable isotope values show variation in Cu and Zn, of $>2.5\%$ in $\delta^{65}\text{Cu}_{\text{NIST976}}$ and $>0.2\%$ in $\delta^{66}\text{Zn}_{\text{JMClyon}}$, and minimal variation in Fe of $>0.1\%$ in $\delta^{56}\text{Fe}_{\text{IRMM-014}}$. There is a slight increase in $\delta^{56}\text{Fe}$ with decreasing MgO. $\delta^{65}\text{Cu}$ values increase with decreasing S content, these trends are presumably driven by fractional crystallisation of oxides and sulphides. Conversely, $\delta^{66}\text{Zn}$ diverge into distinct heavy and light groups in the more felsic compositions produced by magma mingling (MgO < 2 wt.%) and in the host granite. This divergence may be controlled by fractionation between Zn-bearing magnetite and biotite. The observed Fe-Cu-Zn isotopic variation is probably a result of mineralogical control over elemental distribution. The mineralogical variation in itself is a product of magma composition and magma mingling.