Iron isotope compositions of oceanic arc lavas

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Iron is a major element in arc lavas and occurs in two valence states in natural igneous systems (Fe^{3+} and Fe^{2+}, commonly expressed as $Fe^{3+}/\Sigma Fe$). It is clear that fractionation in mafic igneous system preferentially removes minerals with Fe^{2+}, i.e., in olivine and pyroxene, inevitably forcing a shift of residual liquids towards a higher $Fe^{3+}/\Sigma Fe$. This change in total Fe valence state is coupled to an increase in calculated oxygen fugacity, up to several Δlog(FMQ) units (fayalite-magnetite-quartz buffer). Studies of a closed magmatic system [1] has shown that removal of Fe^{2+} will shift liquids towards heavier Fe isotope compostions ($\delta^{57}Fe$), whereas Fe^{3+} scavenging has the opposite effect, e.g., upon magnetite saturation. In principle, a similar effect can be postulated for arc lavas. However, series of arc rocks usually represent open systems, with variable water content, source heteregeneity and possible A-F-C processes. To study these effects and assess their impact on $\delta^{57}Fe$ systematics in convergent margin rocks, we have measured stable Fe isotopes in series of arc rocks from different geo-tectonic settings. Eastern Manus Basin lavas, renowned for their magnetite crisis [2], exhibit a reversal in $\delta^{57}Fe$ from heavy towards light values at magnetite saturation, similar to what is expected from trace elements (V). The $\delta^{57}Fe$ in Banda arc rocks is unaffected by the up to 10% subducted sediment melt contribution in their sources [3]. Late-stage arc melts with MgO < 1 wt.% experience a strong increase in $\delta^{57}Fe$, possibly related to accumulation of magnetite. Lau back-arc basin basalts exhibit differences in $\delta^{57}Fe$ that correlate with indices of magmatic differentiation with a possible relation between $\delta^{57}Fe$ and precious element abundances, such as Au. In summary, we find that igneous differentiation is the controlling factor for differences in Fe isotopes in evolving arc lavas. Magma recharge, source heterogeneity and A-F-C processes, however, may cause $\delta^{57}Fe$ to deviate strongly from a theoretical fractionation trend. If these processes are closely monitored, Fe isotopes have the potential as a redox/fractionation proxy in arc lavas.

[1] Sossi *et al* CMP, 2012 [2] Jenner *et al* G^3, 2012 [3] Vroon *et al* GCA, 1995