Sulfur and Oxygen Fugacity in Basaltic Arc Magmas

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Subduction zones are important in the formation of continental crust and ore deposits. There is a debate as to whether the more oxidized nature of arc magmas compared to MORB is caused by slab recycling processes or is related to differentiation and chemical interaction with the crust [1,2]. Additional insight into this debate comes from the S contents of primitive arc magmas as recorded by melt inclusions in Mg-rich olivine because S solubility is strongly dependent on fO2. A database of primitive arc magma compositions, including volatiles, representing 100 volcanoes from 18 subduction segments spanning the global range in slab thermal structure was compiled by Ruscitto *et al*. [3] using published melt inclusion data. The melt inclusions are mostly in Fo80-90 olivines, and primitive melt compositions were calculated by correcting for fractionation. The data for volatiles are based on the least degassed melt inclusions from each volcano, so effects due to degassing should be minimized. The S contents of primitive melts from individual arcs can be quite variable, with the low end of the range coinciding with the S contents of MORB. For the global dataset, S correlates with Cl and Ba, both of which are fluid mobile during slab dehydration.

The higher S contents of many primitive arc melts relative to MORB require higher oxygen fugacities. In some cases the high S occurs in melt inclusions in Fo88-90 olivines, so the high S and therefore high oxygen fugacity must either be a characteristic of mantle-derived magmas or be acquired during the very earliest stages of crustal differentiation. If the latter is correct, then crustal interaction must cause an increase in magma S content as well as oxygen fugacity. Using models for S solubility [4,5] it is possible to estimate a minimum fO2 for each volcano based on the S content of melt inclusions. The results indicate fO2 values of about FMQ to FMQ+1.4. Interestingly, the S contents and estimated fO2 values do not show a relationship to slab thermal structure, as the most MORB-like values occur in the Cascades, Tonga and the Marianas, which are at opposite ends of the global range for likely slab temperatures. Many of the inferred fO2 values are within the range for arc magmas deduced from Cu systematics [1], but many are also at or above the upper limit suggested in that study.

[1] Lee *et al Science*, 2012 [2] Kelley & Cottrell, 2012, *EPSL* [3] Ruscitto *et al G-cubed*, 2012 [4] Jugo *et al GCA*, 2010 [5] Moretti & Baker, *RIMG* vol. **73**, 2011.