What is the source of sulfur in arc magmas? Ion microprobe sulfur isotopic data on anhydrite from Yanacocha and Pinatubo

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In a variety of hydrous, oxidized arc magmas, sulfur species are strongly dominated by oxidized sulfate ($S^{6+}O_4^{2-}$) that is incorporated into apatite and sometimes preserved as igneous anhydrite. *In situ* sulfur isotopic data were obtained using the WiscSIMS Cameca 1280 instrument on anhydrite inclusions in mafic silicates and phenocrysts from andesite and dacite. Using a 8 micron diameter ion beam, our Balmat anhydrite standard (BT4) demonstrates a spot-to-spot precision of better than ±0.3‰ (2SD). Accuracy on unknowns is degraded by polishing relief of soft anhydrite inclusions but is better than ±1‰.

Phenocrystic and inclusion anhydrite from the 12 June 1991 Pinatubo eruption has a $\delta^{34}S$ value of 7.7 ± 1.3‰ (CDT, 2SD, n=18) compared to older SHRIMP data with a larger range (6 to 16‰, [1]). Anhydrite inclusions in amphibole and pyroxene from the sulfur-rich 13 to 11 Ma andesite and dacite at Yanacocha, Peru [2], span a narrow range of $\delta^{34}S$ (5 to 7‰). Compositions are similar for inclusions trapped in both high- and low-pressure amphiboles (~6 kb & 2 kb). Pinatubo phenocrysts are unzoned in $\delta^{34}S$, consistent with the breakdown of magmatic anhydrite to produce SO_2 and H_2S gas species as a kinetic process without isotopic fractionation. Therefore, the anhydrite isotopic composition likely accurately reflects bulk sulfur isotopic composition of the magma and evolved magmatic gases.

The Yanacocha and Pinatubo data are consistent with a narrow but isotopically heavy range of sulfur isotopic compositions of arc magmas from ~5 to 10‰. Previous conventional analyses of anhydrite phenocrysts reported $\delta^{34}S$ of ~9‰ and 5‰ from El Chichon, Mexico [3] and Julcani, Peru [4], respectively. The isotopic composition of sulfur from porphyry copper deposits also suggests arc magmas have variable but isotopically heavy values (~5-10‰). Thus, arc magmatic sulfate could be partly derived from sea water sulfate (+15 to +20‰) via subduction zones, or mid- to deep-crustal sulfide or sulfate derived via crustal assimilation.

[1] McKibben *et al* (1996) *Fire & Mud*, 825-843 [2] Chambefort *et al* (2008), *Geology* **36,** 719-722 [3] Rye *et al* (1992) *J. Volc. Geoth. Res.* **23**, 109-123 [4] Deen *et al* (2006) *Econ. Geol.* **89**, 1924-1938