

Garnet fractionation drives sulfur oxidation in magmatic orogens

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Magma redox conditions can profoundly influence volatile transfer from Earth's interior to the surface, but what controls the redox conditions of magmas remains unclear. The Fe-depleted magmas that are abundant in magmatic orogens and formed much of the continental crust are thought to be oxidized. The high oxygen fugacity of the Fe-depleted magmas was recently attributed to garnet fractionation at the base of thickened crust because garnet prefers ferrous Fe over ferric Fe [1].

To test this hypothesis, we examined a range of felsic plutonic rocks from southern Tibet. These plutons are of Cenozoic ages and formed by melting of the juvenile Gangdese arc crust. They show a large variation in La/Yb ratio which reflects the increasing melting depth as the crust continuously thickened after the India-Asia collision. We find that Ce-in-zircon oxybarometer [2] consistently give higher oxygen fugacities for samples with high La/Yb ratios, suggesting that magma oxygen fugacity increases with the extent of garnet fractionation. Coupled with the increase in oxygen fugacity is an increase in apatite sulfur contents of the high La/Yb samples. In samples with low La/Yb ratio (<20), sulfur contents in apatite are generally lower than 1000 ppm whereas in samples with high La/Yb (>20), sulfur contents in apatite, though variable, can go up to ~4000 ppm. In apatite, sulfur only becomes compatible when it is oxidized to sulfate [3]. The high sulfur contents in the apatite from high La/Yb samples suggest high sulfate contents in the magmas. We thus conclude that garnet fractionation in magmatic orogens can cause significant magma oxidation, which in turn may oxidize sulfide to sulfate in the magmas. Our findings have implications for (1) sulfur cycle in subduction zones and (2) formation processes of porphyritic ore deposits which are usually associated oxidized Fe-depleted magmatic systems.

[1] Tang et al. (2018) *Sci. Adv.* 4, eaar444; [2] Smythe and Brenan (2016) *Earth Planet. Sci. Lett.* 4, 453, 260-266; [3] Parat et al. (2011) *Rev. Mineral. Geochem.* 73, 285-314.