The redox state of volcanic gases: a reflection of magma depth.

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The combination of "Multi-gas" electrochemical sensors and open-path Fourier transform infrared spectroscopy has made it possible to record continuous measurements of redox couples such as H_2O/H_2, SO_2/H_2S and CO_2/CO in volcanic plumes. While variations through time in these ratios have been observed at volcanoes such as Erebus (Antarctica), the cause of these variations has remained uncertain. We applied Fe and S K-edge x-ray absorption near-edge structure spectroscopy (XANES) to investigate a suite of melt inclusions in lavas belonging to the Erebus lineage (basanite through phonolite) with entrapment depth spanning the entire lithosphere. We found that a strong reduction of both Fe and S is associated with magma ascent and that the fO_2 of the magma reduces by more that two log units with decreasing pressure. Although the driving force behind this process cannot be unambiguously identified, we propose that sulfur degassing is a likely explanation. This redox-depth relationship allows us to examine the redox state of volcanic gas emissions at Erebus in terms of their last equilibration depth. In this way, we can explain oscillatory variations in CO_2/CO and H_2O/H_2 observed for the plume emitted from the Erebus lava lake as a reflection of episodic input of magma into the lake from the underlying conduit.