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Redox change during magma ascent; Observation from three volcanoes and implication for gas monitoring

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The oxidation state of volcanic gases dictates their speciation and hence their reactivity in the atmosphere. It has become increasingly recognized that the oxidation state of a magma can be strongly affected by degassing. The oxidation state of gases will equally be impacted and the composition of gases emitted by volcanoes will therefore be function of the magma degassing history. This presentation will show results from three volcanoes where the oxidation state of the magma has been tracked during degassing. At Erebus and Laki we used Fe X-ray absorption near-edge structure spectroscopy (XANES) on extensive suites of melt inclusions and glasses, while at Surtsey we used S-Kα peak shifts measurements by electron microprobe (EPMA) on melt inclusions, embayment and glasses. At all three locations we found that a strong reduction of both Fe and S is associated with magma ascent. At Erebus this reduction is greatest, corresponding to a fall in magmatic fO_2 of more than two log units. We propose that sulfur degassing can explain the observed evolution of the redox state with ascent and show that forward modeling using initial melt composition can successfully predict the composition of the gas phase measured at the surface. We suggest that the redox state of volcanic gases (expressed in term of redox couples: H_2O/H2, SO_2/H2S and CO_2/CO) can be used to monitor the depth of gas-melt segregation at active volcanoes.