

Redox change driven by sulphur degassing: A review of empirical evidences

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The capacity of sulphur degassing to oxidise or reduce a magma has long been recognised. Sulphate (S^{6+}) or sulphide (S^{2-}) in the melt exsolves to sulphur dioxide (SO_2 ; S^{4+}) and hydrogen sulphide (H_2S ; S^{2-}) in the gas phase resulting in a reduction (e.g., six electrons are liberated with $S^{2-} \rightarrow S^{4+}$) or oxidation (two electrons are captured with $S^{6+} \rightarrow S^{4+}$) of dissolved iron, which is the only other major multiple valence state element in the melt. Empirical evidences of this process however have remained scarce. This presentation will review results from a series of recent studies where the oxidation state of a magma has been tracked during degassing using Fe X-ray absorption near-edge structure spectroscopy (XANES) or S-K α peak shifts measurements by electron microprobe (EPMA) on suites of melt inclusions, embayments and glasses. At Erebus, Laki and Surtsey, 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 sulphur degassing can explain the observed evolution of the redox state with ascent and show that forward modelling using initial melt composition can successfully reproduce the observations. We suggest that redox changes induced by sulphur degassing is a common phenomenon taking place at many magmatic systems on Earth and other planets. While the oxidation state of a volcanic rock does not reflect that of its source, in-depth melt inclusion studies can help track back original redox conditions.