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Paradigms for the physico-chemical modeling and interpretation of C/S ratios measured at basaltic volcanoes: the case of Kilauea volcano

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By considering available melt inclusion (MI's) data and summit emissions of gases at Kilauea, it is shown that in order to model and interpret C/S molar ratios measured at basaltic volcanoes the following methodological steps must be iteratively applied:

1) Computation of redox conditions in the magmatic system (fO2 from sulfur and iron speciation in the melt phase or melt/olivine equilibria).

2) Determination of total budgets of H2O, CO2 and S from MI's and multicomponent gas-liquid equilibrium modeling.

3) Recognition and description of the degassing style (open vs. closed).

4) Thermodynamic modeling of the saturation paths of H2O, CO2, and S in melts.

The determination of the whole gas speciation in the C-H-O-S gas system (minor components such as CO, H2, COS, SO) may be included as an additional step on the basis of the redox conditions estimated at point 1. The case of Kilauea emissions is discussed in terms of quantification of depths of gas separation and recognition of magma ascent and injection. Based on the available CO2 fluxes, the excess gas phase (computed in agreement with Papale, JGR 2005 in press) allows estimating magma volumes that are required to sustain the degassing process. It is discussed how trends of C/S molar ratios due to magma injection may be mirrored by varying other conditions. For example, C/S increase measured at the crater may be due to either magma ascent and depressurization or changes of magma redox conditions.

The role of the oxidation state in the feeding magma is therefore emphasized as a critical parameter controlling the whole process, from deep to shallow degassing. The availability of comprehensive MI's sets allows constraints to be put on the total volatile contents in magmas including exsolved (or excess) gas, and a description of the basic processes leading to C/S changes in the crater gas as due to magma movement and evolution.