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Modelling magmatic gas scrubbing in hydrothermal systems

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In volcano-hosted hydrothermal systems, the chemistry of deeply rising magmatic gases is extensively modified by gas-water-rock interactions taking place within the hydrothermal reservoir, and/or at shallow groundwaters conditions. These reactions can scrub reactive, water-soluble species (S, halogens) from the magmatic gas phase, so that their quantitative assessment is central to understanding the chemistry of surface gas manifestations, and brings profound implications to the interpretation of volcanic-hydrothermal unrests. Here, we present the results of numerical simulations of magmatic gas scrubbing, in which the reaction path modelling approach (Helgeson, 1968) is used to reproduce hydrothermal gas-water-rock interactions at both shallow (temperature up to 109°C; low-T model runs) and deep reservoir (temperature range: 150-250 °C; high-T model runs) conditions. The model was built based upon the EQ3/6 software package (Wolery and Daveler, 1992), and consisted into a step by step addition of a high-temperature magmatic gas to an initial meteoric water, in the presence of a dissolving aquifer rock. The model outputted, at each step of gas addition, the chemical composition of a new aqueous solution formed after gas-water-rock interactions; which, upon reaching gas over-pressuring (PgasTOT > Psat(H_2O) at run T), is degassed (by single-step degassing) to separate a scrubbed gas phase. As an application of the model results, the model compositions of the separated gases are finally compared with compositions of natural gas emissions from Hekla volcano (T< 100°C) and from Krisuvik geothermal system (T> 100°C), resulting into an excellent agreement. The compositions of the model solutions are also in fair agreement with compositions of natural thermal water samples. We conclude that our EQ3/6-based reaction path simulations offer a realistic representation of gas-water-rock interaction processes occurring underneath active magmatic-hydrothermal systems.

Helgeson, H.C. (1968), “Evaluation of irreversible reactions in geochemical processes involving minerals and aqueous solutions-I. Thermodynamic relations”. Geochem. Comochem. Acta, vol. 39, 853-877.

Wolery T. J. and Daveler S. A. (1992), “EQ6, a computer program for reaction path modeling of aqueous geochemical systems: theoretical manual, user’s guide and related documentation (version 7.0)”. Report UCRl-MA-110662 PT IV. Lawrence Livermore National Laboratory, Livermore, California.