

DIC concentration and $\delta^{13}\text{C}$ in thermal springs of La Soufrière volcano (Guadeloupe, FWI): Implications for volcanic surveillance

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La Soufrière volcano (Guadeloupe, FWI) is an arc volcano representing high risks of future eruptions. It is among the best surveyed volcano in the world, thermal springs and fumaroles being sampled and analyzed since 1979, providing a continuous data record over 28 yr [1]. The increase in seismic and fumarolic activity since 1992 and HCl degassing since 1998 prompted the observatory to intensify the surveillance of the volcano. Since CO₂ is the least soluble volatile species in magmas, it is the first to be degassed from a rising magma. As a consequence, carbon and its stable isotopes in fumaroles and thermal springs are potentially the most powerful magmatic tracers of new intrusions and of future eruptions.

Ten thermal springs of La Soufrière volcano were analyzed on a monthly basis for their dissolved inorganic carbon (DIC) concentration and $\delta^{13}\text{C}$ -value in the period Aug. 2006-Jan. 2007. The results show that: (1) the waters show a wide range of DIC concentrations from 0.5 to 9 mmol/l, each spring being relatively constant in DIC, (2) the DIC decreases systematically with increasing distance from the dome, (3) most of the thermal springs show a $\delta^{13}\text{C}$ of magmatic origin close to -3.5‰ similar to that emitted at the fumaroles at the summit of the dome, (4) three springs located NW of the dome show low $\delta^{13}\text{C}$ from -8.5 to -17‰ indicating interaction with soil organic carbon, and (5) some of these springs show evidence of CO₂ degassing occurring at their outlet or in the superficial aquifer where the water last circulated. These observations represent a reference baseline for interpreting future CO₂ degassing from a magmatic body. It can be expected that future intrusions would result in an increase in DIC with a magmatic $\delta^{13}\text{C}$ -value in the springs. Therefore, DIC and $\delta^{13}\text{C}$ may represent valuable tools for volcanic surveillance.

References

[1] Villemant *et al.* (2005), *EPSL* **237** 710-728.

The role of fluid immiscibility in the formation of magmatic-hydrothermal ore deposits

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Experimental studies suggest that large immiscibility gaps exist in H₂O-salt ($\pm\text{CO}_2$, CH₄) fluids at the P/T-conditions prevailing in subvolcanic to plutonic environments. Not surprisingly, therefore, samples recording the former coexistence of two types of fluids are rather common in the magmatic-hydrothermal systems. One major consequence of fluid immiscibility is chemical fractionation. PIXE, SXRF and LA-ICP-MS analyses of individual fluid inclusions have shown that Cu, Au, B, As, Sb and Li are often systematically enriched in vapor inclusions relative to coexisting brine inclusions (e.g., Williams-Jones and Heinrich, 2005). In the case of Cu and Au it is believed that this behavior is caused by the formation of stable sulfur complexes in the vapor phase, although definitive experimental proof is lacking so far. Another major consequence of fluid immiscibility is that differences in density and/or wetting properties lead to physical separation of the two fluid phases. This, together with chemical fractionation, can result in chemical zonations at various scales, e.g., the formation of epithermal gold deposits above porphyry-Cu deposits.

Fluid inclusion studies and experimental data suggest that intermediate to felsic magmas crystallizing at depths relevant for magmatic-hydrothermal ore deposits first exsolve a single-phase fluid of intermediate density and low salinity (2-10 wt% NaCl_{equiv.}) upon cooling (e.g., Audétat and Pettke, 2003). Fluid immiscibility commonly does not occur until the magma has approached its solidus, where pressure starts to change from lithostatic to hydrostatic. Due to the pressure decrease and the low salinity of the bulk fluid, the mass of vapor generated may often exceed that of the coexisting brine, such that the bulk fluid can be thought of a vapor plume at that stage. However, in view of the high metal content and relatively low mobility of brines it is nevertheless feasible that some deposits formed predominantly from brines rather than from vapors, and that the condensation of brine out of a low-density bulk fluid helped to concentrate the metals in a small rock volume. Element partitioning between coexisting fluid phases combined with quantitative fluid flow models will advance our understanding on how elements are separated, distributed and concentrated up to ore grade in magmatic-hydrothermal environments.

References

Audétat A. and Pettke T., (2003): *Geochim. Cosmochim. Acta* **67**, 97-121.

Williams-Jones A.E., and Heinrich C.A., (2005): *Econ. Geol.* **100**, 1287-1312.