Noble gas in volcanic thermal springs: A window on hydrothermal system

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Magma-derived gas studies have been used for volcano monitoring and especially for detecting degassing of shallow magma intrusion. However, interactions between those gases and hydrothermal system lead to strong modifications of the magma initial gas composition. To better understand this effect we propose to study noble gases in hot spring water from active volcano.

Noble gases are of particular interest since they are chemically inert and show a wide range of solubilities in water. Their study in hot spring water may then provide insights on interactions between magmatic gases and hydrothermal water.

We focused our study on the Lesser Antilles Arc and more precisely on the Guadeloupe and Dominica islands. Those two volcanic islands show well-developed hydrothermal systems which played a key role in the last phreatic eruptions (1976-1977 in Guadeloupe and 1997 in Dominica).

Samples were collected from thermal spring water and sealed in copper tubes. A new method has been developped to extract He and Ne from the samples. He and Ne analysis (concentration and isotopic ratio) were performed with a QMS200 spectrometer and a Noblesse (Nu Instrument) mass-spectrometer.

Preliminary results show that, on the first hand, most of the hot springs have a mantellic signature with a $^{3}He/^{4}He$ similar to the MORB mean value (R/Ra=8). However some springs are slightly more radiogenic and then show a dilution of the magmatic signal in water in equilibrium with air. On the other hand, for neon, the results fall on the mass fractionation line.

Further He and Ne measurements, and other noble gas measurements (Ar, Kr, Xe) will allow to provide informations such as kinetic processes, equilibrium temperature or residence time.

Volatiles in plume-related magmas (Siberian traps)

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Magmatism in the Siberian CFB province is mainly represented by the voluminous lava flows of tholeiitic plateau basalts and subordinate amounts of highly magnesian volcanics and dyke rocks. These highly magnesian rocks are strongly enriched in incompatible trace elements and are characterized by high LREE/HREE ratios. It suggests that their primary magmas were near solidus melts formed at high pressures. P-T conditions of the generation of these hi-Mg melts must be nearly identical with the P-T parameters characterizing magma-generating mantle plume.

To assess the formation conditions of hi-Mg Siberian magmas we investigated melt and fluid inclusions in the phenocrysts of these rocks, which were analyzed for major and trace elements (EMPA and SIMS methods). High Ti/Na ratios and high normative olivine contents in the melt compositions recalculated to the condition of equilibrium with mantle peridotites imply, that initial pressure of magma-generation is in the range of 7–9 GPa.

Ion microprobe data for reheated melt inclusions in phenocrysts from Siberian rocks show relatively low concentrations of volatile and fluid-mobile components. The assessment of the contents of volatiles in the mantle source of these magmas is based on the ratio of volatiles to nonvolatile elements with similar bulk partition coefficients. F/Sr ratios for meimechites (1.18) are close to MORB (0.84) and BSE (1.23). Cl/Ba (1.50) values are similar to MORB (1.09), whereas B/Ce ratios are lower than MORB and they are similar to OIB. Estimate average H_2O content in melt inclusions is 1.2 wt%, whereas for modeled primary magmas after correction for olivine fractionation it is below 1%. Concentrations of volatiles in the mantle source of Siberian magmas are similar to estimates for the sources of OIB magmas.

Low levels of volatile contents imply that the estimates of near-solidus temperature based on comparison with volatile-free systems would not be changed significantly. Comparison of the estimated from melt inclusion data pressures with experimental data shows that the temperature of rising plume material was ca 400°C higher by comparison with convecting upper mantle at the same depth. This proves that plume material arrived from deep levels in the mantle below certain thermal boundary layer.