

Volatile budget of the 2011 Cordon Caulle eruption (Chile) from various and integrated approaches.

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Estimates of volatile budgets for volcanic eruptions are often based on volatile concentrations measured in melt inclusions (MIs) versus groundmass glass and on measurements made by direct sampling and remote sensing techniques. Here, we present new measurements and estimates of volatile budget of the 2011 Cordon Caulle eruption in Chile. The eruption from the Cordón Caulle rift zone, part of the basaltic-to-rhyolitic Puyehue-Cordón Caulle volcanic complex, began on 4 June 2011. The first phase of the eruption was characterized by an explosion from Cordón Caulle that produced a 5-km-wide ash-and-gas plume that rose to an altitude of 12.2 km a.s.l. We used three different approaches to assess the volatile budget and how the volatile content of the magma controls the explosivity of such an eruption.

1- Pumice samples were collected on June 18th, a few hours after their eruption. Volatile (S, Cl, F) and major element concentrations were measured in MIs trapped in plagioclase (An₅₄₋₅₆) and pyroxene (Mg_{#39-44}) phenocrysts and also in groundmass. Homogeneous dacitic to rhyolitic compositions were observed in the MIs with maximum concentrations up to 160ppm S, 2600ppm Cl and 800ppm F. The difference between the maximum volatile concentrations in the MIs and those measured in the groundmass indicates that ~0.2Mt SO₂, 0.5Mt HCl and 0.3Mt HF were released into the atmosphere during the Cordon Caulle eruption.

2- Satellite remote sensing data from instruments in NASA's A-Train spacecraft constellation, including the Ozone Monitoring Instrument (OMI) on Aura and the Atmospheric Infrared Sounder (AIRS) on Aqua, indicate a total SO₂ emission of ~0.2 Mt from the initial explosive phase of the 2011 Cordon Caulle eruption. The Microwave Limb Sounder (MLS) also detected HCl in the volcanic plume, providing some constraints on the SO₂/HCl ratio.

3- These two previous preliminary results will be discussed and compared with ash-leachate analyses. Leachates from pristine ash collected on June 21st will also provide a plume-gas proxy.

Experimental simulation of brine re-injection under subcritical and supercritical conditions

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The re-injection of flashed brine at geothermal power plants is used to avoid adverse impacts of surface disposal. These fluids contain solutes that can precipitate and thus are detrimental to re-injection aquifer permeability. The deposition of silica is a particular issue that must be managed through brine aging and/or acid/base dosing. These treatments modify brine properties such that it is highly out of equilibrium with the aquifer mineralogy. The re-injection of fluids into deep (>4 km) drillholes, that may encounter supercritical conditions, also poses interesting questions in terms of fluid-rock interactions influencing reservoir permeability. Existing thermodynamic data used in modelling programmes are insufficient to provide adequate information on the effects of fluid-rock interactions in these situations. A viable alternative is direct simulation using experimental apparatus.

Re-injection scenarios have been simulated using a continuous flow apparatus. The experiments replicate the interaction between waste brine with fractured greywacke, a typical re-injection aquifer lithology at power plants in the Taupo Volcanic Zone. Deoxygenated brine from Kawerau power station (SiO₂ 950 mg/kg, Na 799 mg/kg, K 131 mg/kg, Cl 1027 mg/kg, SO₄ 423 mg/kg) was reacted with crushed, sieved and cleaned greywacke at T/P conditions of 157°C/27 bar, 204°C/35 bar and 400°C/279 bar. At the lowest temperature both polymerized and depolymerized brine were used to assess the effect of fluid aging. SEM/EDS examination showed that polymerized brine produced a continuous coating of amorphous silica composed of variable size silica spherules (<500 nm) cemented by dissolved monomeric silica. Using depolymerized brine, amorphous silica was also produced, the spherule size was uniform (80 nm) and the coating was more discontinuous. At 204°C, precipitated minerals include chlorite, potassium feldspar, a clay mineral phase and a Ca-Na aluminosilicate, most likely a zeolite, based on its morphology. SiO₂ concentration dropped below amorphous silica saturation but no SiO₂ polymorph was identified indicating that the decrease in SiO₂ concentration was the result of precipitation of the minerals listed above. At 400°C, the surfaces of the greywacke fragments were covered with continuous coating of acicular secondary minerals. These include a fibrous Na-Ca-Fe-Mg aluminosilicate (pargasite?), a Na-Fe silicate with a distinct amphibole morphology (riebeckite?) and an unidentified Ca-aluminosilicate. Titanite was also present, likely derived from the sample chamber. These experiments show that laboratory simulations can be successfully used to reproduce fluid-mineral interactions that correlate with temperature conditions found in re-injection aquifers. They also provide information on changes in surface roughness and permeability of fractures during re-injection of geothermal brines.