

## Storage conditions of the silicic magmas preceding major plinian eruptions of Santorini volcano

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Magma storage conditions can dramatically change over time at a single volcano and might be in close relationships with stress variations imposed on the crustal plumbing system by the overlying edifice as well as changes in eruptive dynamism. The Santorini volcano (Greece) is an ideal target to unravel these potential relationships. We focused on the silicic products of the four major plinian eruptions of Santorini which occurred since the last 200 ka: the Lower Pumice 1 and 2 rhyodacites, the Cape Riva dacite and the Minoan rhyodacite. In order to precisely define the P, T,  $fO_2$  and volatiles pre-eruptive storage conditions of these silicic magmas, we combined a micro-petrological and geochemical study on natural and experimental products. This study is of particular interest in the context of caldera unrest ongoing at Santorini since July 2011.

Our results indicate pre-eruptive temperatures ranging from ca. 850 to 900°C, and a  $fO_2$  along the FMQ buffer curve ( $\log fO_2 = -12.9$  to  $-13.5$ ) except for the Minoan rhyodacite which displays more oxidizing conditions near the NNO buffer ( $fO_2 = 10^{-12.8}$ ). The rhyolitic melt inclusions (MI) of plagioclase and pyroxene phenocrysts are mostly H<sub>2</sub>O-rich (~3 to > 6 wt.%). The MI and the matrix glasses are both Cl-rich (~3000-4000 ppm) while F (< 1000 ppm) and S (< 100 ppm) represent minor species. Phase equilibria from crystallization experiments for the four eruptions were established at T = 850-900°C, P = 2-4 kbar,  $fO_2 \sim$  FMQ, and XH<sub>2</sub>O [= moles of H<sub>2</sub>O/ (H<sub>2</sub>O+CO<sub>2</sub>)] between 1 (i.e., H<sub>2</sub>O saturated) and 0.6. Significantly, phase relationships show marked differences between eruptions, outlining the need to establish phase equilibria specific to each composition. While the petrological attributes are broadly reproduced at 2 kbar in the temperature range explored, additional experiments are in progress to explore more oxidizing (~NNO +1) and shallower storage conditions (1 kbar).

## Hydro-geochemical impact of CO<sub>2</sub> leakage from CCS on shallow potable aquifers: batch, tank and field scale experiments.

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Investigations regarding the environmental implications resulting from leakage of CO<sub>2</sub> from a geological sequestration site into overlying shallow potable aquifers include; simple laboratory batch experiments [1], reactive transport models [2] and field based studies [3]. However, the value of the methods has not been evaluated in detail and the application of several methods to a single field site has not been made. A 6 month field release experiment will commence in spring 2012 at Vrøgum plantation, Western Denmark and preliminary work has been conducted to aid design. First batch experiments exposing field site sediment to CO<sub>2</sub>, followed by a sediment flow tank experiment injecting CO<sub>2</sub> continuously were conducted. Finally, in a pilot field injection 45 kg of food grade CO<sub>2</sub> was injected at 10 m depth over 48 hours and the effects on water chemistry observed. The results from each method are compared to assess suitability and relevance to geochemical process understanding and risk assessment.

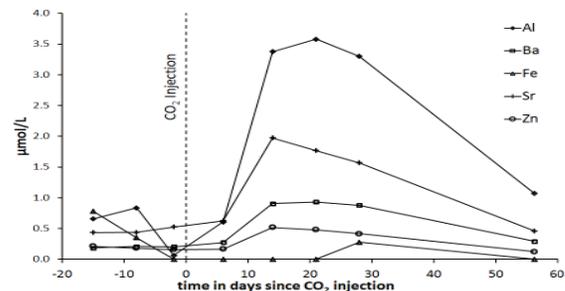


Figure 1: Trace metal concentrations measured 1.0 m down flow of injection point in field pilot experiment.

### Results and Conclusion

Batch, tank and pilot injection results all indicate a release of sorbed major and trace elements as well as a release from dissolving silicate minerals. Results also indicate that the risks to water resources from a short term leak from CCS into shallow, overlying, silicate based aquifers (such as the Vrøgum site) are minimal. Some elements approach or exceed guideline values but none of these are particularly toxic or beyond the scope of normal water treatment. Sorption of released elements and accumulation of other elements was observed in the tank and field injections, inferring that a large scale, long lasting leak may develop a CO<sub>2</sub> charged plume or front carrying elements exceeding guideline values for major and trace elements. Differences in the results from batch and flow based experiments were observed (both for element concentrations and physico chemical parameters) indicating that batch experiments do not accurately indicate the risks to water resources from CCS leakage.

[1] Lu et al. (2010) *Enviro Earth Sci* 60, 335–348. [2] Apps et al. (2010) *Transp Porous Med* 82, 215–246. [3] Kharaka et al. (2010) *Enviro Earth Sci* 60, 273–284.