Widespread synchronous volcanism on the Snake River Plain

B. ELLIS[1]*, J.A. WOLFF[1], D. MARK[2] AND I. BINDEMAN[3]

[1]SEES, Washington State Uni., Pullman, WA, 99164, USA
(*correspondance: ben.ellis@wsu.edu)
[2]SUERC, East Kilbride, G75 0QF, Scotland, UK
[3]Geological Sciences, Uni. of Oregon, Eugene, OR, USA

Rhyolitic volcanism in the central Snake River Plain (SRP) represents the early history of the Yellowstone hotspot. An ignimbrite flare-up has been recognised in the SRP between 11.7 and 10.2 Ma [1] during which >75% of the total volume of ~20,000 km^3 of high temperature rhyolitic magma was erupted. Ignimbrites of the central SRP are almost identical in field appearance being intensely welded with an anhydrous mineral assemblage, so geochemical methods are required to distinguish between magma batches. Here, we combine field constraints, mineral and glass compositions, stable isotopes, and new high precision ^{40}Ar/^{39}Ar geochronology to fingerprint magma batches and investigate the timing and distribution of volcanism during the flare-up. Our results indicate that five similar but subtly different magmas were erupted and deposited to both the north and south of the plain beginning with Brown's Bench 4 (11.59 ± 0.081 Ma, n=31, 2σ) and ending with the Tuff of Fir Grove (11.14 ± 0.13 Ma, n=19, 2σ). Magma batches may be distinguished by the presence of multiple compositional populations of both pigeonite (Mg# 9-17) and augite (Mg# 8-22) and variation in ilmenite compositions. All five ignimbrites exhibit the characteristic depletion in δ^{18}O observed in the central SRP with feldspar values between 1.96 and 2.97‰.

The widely dispersed (>100 km E-W) and geographically limited nature of some of the ignimbrites suggests they were erupted from different sources currently buried beneath younger basalts within the SRP. These results suggest that the currently accepted model of discrete 'eruptive centres' requires reconsideration. The high precision geochronology shows that during the flare-up ignimbrite-forming eruptions were occurring in the central SRP at a frequency more than 7 times that of the present Yellowstone volcanic field and 5 times that of the Heise eruptive centre. We propose that the opening of the western Snake River Plain graben, itself exploiting a pre-existing crustal weakness illustrated by the Vale fault zone directly to the NW, caused lithospheric thinning and resulted in the increased eruptive frequency.

[1] Bonnichsen *et al.* (2008) *Bull. Volc.* **70**,315-342.

Geochemical alteration of fracture geometry during leakage of CO$_2$

B.R. ELLIS[1], C.A. PETERS[1]*, J.P. FITTS[2], G.S. BROMHAL[3], D.L. MCINTYRE[3] AND R.P. WARZINSKI[3]

[1]Dept. of Civil & Environmental Engineering, Princeton University, Princeton, NJ 08544
(*correspondance: cap@princeton.edu)
[2]Environmental Sciences Department, Brookhaven National Laboratory, Upton, NY 11973
[3]U.S. DOE National Energy Technology Laboratory, Morgantown, WV 26507 and Pittsburgh, PA 15236

A series of three flow-through experiments were performed on artificially fractured caprock samples to investigate fracture evolution during simulated leakage of CO$_2$-acidified brine. The core samples are from the Amherstburg limestone, which is the caprock for a CO$_2$ storage demonstration project in northern Michigan, USA.

The evolution of fracture aperture was monitored in real time using X-ray computed tomography (CT). Before and after the experiment, 3-D reconstructions of the fracture structure, aperture and surface roughness were examined at higher resolution via micro X-ray CT. The cores were then sectioned and examined with scanning electron microscopy, X-ray flourescence and micro X-ray diffraction.

Although all three samples were of nearly identical mineralogical composition, the brine flow rates, initial brine compositions, and initial fracture permeabilities differed across the three samples. These differences in flow conditions and fluid composition generated different degrees of fracture deterioration. The first run resulted in substantial erosion of the fracture surface, while the second run had a decrease in fracture permeability that may be attributed to mineral precipitaion along the fracture.

Spectroscopic analysis of the samples after CO$_2$-brine flow demonstrated preferential calcite dissolution. Mineral spatial heterogeneity coupled with the preferential dissolution of calcite led to non-uniform degradation along the fracture and an increase in surface roughness. In areas where calcite is intermixed with dolomite and other silicate minerals the dissolution of calcite leads to the formation of a degraded zone along the fracture boundary, resulting in a smaller increase in fracture aperture.

The potential mineral precipitation found in the second run is in stark contrast to the rapid mineral dissolution found in the first and suggests a complex interplay of mineral spatial heterogeneity, brine composition, and flow conditions controlling caprock fracture evolution. Results from this study will be we used to frame a discussion on how flow through caprock fractures may be influenced by geochemical alteration of fracture geometry.