Frictional Melting in Volcanoes.

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Introduction

Seismogenic faulting and rapid slip (>0.1 m/s) of rock may result in non-equilibrium frictional melting [1] at temperatures >1000 °C after few centimetres of slip [2]. Upon cooling (and recrystallization) this melt forms a pseudotachylyte [3].

In active volcanoes, the transition from endogenous to exogenous growth is generally attributed to a shift in magma rheology into the brittle regime. The ascent of this high-viscosity magma can form discrete shear zones via strain localisation along conduit margins [4]. Although comparable to tectonic faults, little information regarding the slip processes and generation of fault products in such shear zones are known. Pseudotachylytes have, until now, rarely been noted in volcanic materials [5, 6], and seldom in active volcanic environments [4, 7] despite laboratory experiments which support magma's propensity for frictional melting [8].

Here, we combine field evidence and experimental data to demonstrate that pseudotachylyte ought to be a common product of volcanic activity due to simultaneously high ambient temperatures and differential stresses, and propose a hypothesis for this conspicuous absence of pseudotachylytes in the volcanic record.

Results and Conclusion

Experimental results demonstrate that higher slip rate and/or axial load increases the rate of heat production by friction. At volcanoes, repeated slip events at a high ambient temperature during the ascent of a magma may thus promote melting (as well as subsequent cooling) in (near-)equilibrium, hence eradicating some of the key pseudotachylyte characteristics, including heterogeneous melt filaments formed by selective melting of crystals [9]. Our studies suggest that the indentification of volcanic pseudotachylytes relies upon combined investigations of structural characteristics, magnetic properties (Curie temperature, remanence, susceptibility and domain state) and calorimetric glass transition, which can identify different P-T equilibrium conditions between the wallrock and pseudotachylyte.

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Extremely high iodine and noble gas abundances in forearc serpentinites

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Combined Cl, Br, I and noble gas analyses have been undertaken on 16 'seafloor serpentites' obtianed from IODP drill cores (Atlantic and Hess Deep MOR; Marianas and Guatemala forearcs; Iberian and Newfoundland passive margins; see [1]). The serpentinite halogen data overlap those of sedimentary marine pore fluids, with forearc serpentinites being most enriched in iodine (Fig 1). The maximum iodine concentration of ~50 ppm, is similar to the iodine content of organic-rich marine sediment.

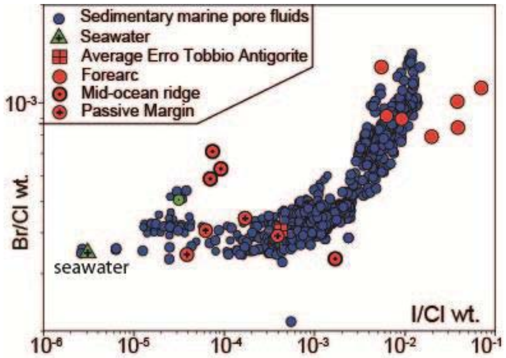

Figure 1: Br/Cl versus I/Cl three element plot showing the compositional range of sedimentary marine pore fluids (refs in ref [3]) and seafloor serpentinites.

The chrysotile-lizardite serpentinites all have atmospheric He, Ne, Ar, Kr and Xe isotope signatures. The maximum noble gas abundances of $\sim 2\times10^{-11}$ mol ^{36}Ar g^{-1} exceed those of antigorite serpentinites, by an order of magnitude[2]. Noble gas abundances are not simply correlated with serpentinites halogen signatures. However, the serpentinites preserving Br/Cl and I/Cl closest to the pore fluid trend have the highest ^{36}Ar concentrations. The data suggest that serpentinisation takes place at variable water-rock ratios. Serpentinites formed at low W/R, with pore fluids 'consumed' during serpentinisation, preserve halogen signatures close to the marine pore fluid trend, and the highest noble gas abundances. Serpentinites formed at higher W/R, do not preserve the halogen signature of the marine pore fluid, and trap an order of magnitude less noble gas.

The combined halogen and noble gas data show that the conditions of serpentinisation, as well as the involvement of sedimentary marine pore fluids in near subduction zone settings, exert critical controls on subduction zone volatile budgets.

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[3] Kendrick et al., (2011) *Applied Geochemistry* **26**, 2089-2100.