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Crystal fractionation in the friction melts of seismic faults (Alpine Fault, New Zealand)

Laurence N. Warr[a,*], Ben A. van der Pluijm[b]

[a]Centre de Géochimie de la Surface (CNRS-ULP), 1 rue Blessig, 67084-Strasbourg, France
[b]Department of Geological Sciences, The University of Michigan, Ann Arbor, MI 48109, USA

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Abstract

Compositional variations are documented in friction melts along the Hari Hari section of the Alpine Fault, New Zealand, with multiple stages of melt injection into quartzo-feldspathic schists. Intermediate to felsic melts were heterogeneous in composition, but all fractions show a common trend, with a tendency for the younger melt layers and glasses to be more alkali – (Na+K) and Si-enriched, while being depleted in mafic (Fe+Mg+Mn) components. These changes are attributed primarily to crystal fractionation of the melt during transport. Farther traveled molten layers were on the whole less viscous, mostly due to a higher melt-to-clast ratio; however, compositional change, together with a decrease in volatile content, produced a progressively more viscous liquid melt with time. The glass phase is interpreted as a remnant of this high viscosity felsic residual melt that was preserved during final quenching. Following initial failure, the formation of largely phyllosilicate-derived, volatile-rich, lower viscosity melt corresponds with a phase of fault weakening. Subsequent rapid crystal fractionation during melt transport, the loss of volatiles and freezing of residual melt contributed to the strengthening of the fault during seismic slip.

Keywords: Pseudotachylyte; Friction melting; Crystal fractionation; Glass; Alpine Fault; Lubrication

1. Introduction

There is increasing realization that liquid melt generated by friction in the Earth's crust plays an important role in influencing the seismic and mechanical behavior of fault planes (e.g., Sibson, 1975). Frictional experiments in the laboratory have demonstrated how molten material can accumulate along a displacement surface to produce low viscosity melts that may lubricate the planes of displacement (Spray, 1993; Hirose and Shimamoto, 2003). Despite early recognition of the potential importance of the melt layer (e.g., Jeffery, 1942), we still know little about how it influences the behavior of faults.

One promising approach to reconstructing the properties of the molten material is to study the chemical composition of pseudotachylyte veins

* Corresponding author.
E-mail address: warr@illite.u-strasbg.fr (L.N. Warr).

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