Evidence for thermal rejuvenation of the Masonic Park Tuff, San Juan Volcanic Field, CO

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It has been recently proposed that near solidus silicic magmas of various sizes may be reheated and rejuvenated by the underplating of hotter, more mafic magma, possibly triggering an eruption [1,2]. This hypothesis was tested on the >500 km^3 crystal-rich and compositionally homogeneous Masonic Park Tuff, an Oligocene dacitic unit from the San Juan Volcanic Field, CO, USA. Preliminary microprobe data reveal complex chemical zoning in all major phases present in rock samples (Plag, Bio, Pyx, and Hbl). Specifically, we observe rimward increases in Al and Ti (in Hbl) and Ca (in plag), as well as calcic microlites in the matrix glass. Such chemical indicators can be interpreted as changes in either melt composition, water content, or temperature prior to eruption.

As no textural evidence for important magma mingling is observed (homogeneous whole-rock composition and lack of mafic enclaves in this viscous, crystal-rich magma), the chemical variations are interpreted as records of reheating and/or addition of volatiles just prior to eruption. Applying different thermometers (2 feldspar, Hbl-plag, Ti-in-Hbl) [3,4,5] yields increases in temperature from core to rim that vary from 25-30°C (using Ti-in-Hbl) to 60-80°C [5] using 2-feldspar (avg k-spar compositions) [3] and hbl-plag thermometry [4]. Other evidence of a late reheating and/or volatile addition include rimward increase in F (independent of the Fe content) in the last 50 microns of biotite phenocrysts. These zoning patterns suggest a late reactivation of the very crystal-rich Masonic Park magma chamber by a new influx of heat shortly prior to eruption, most likely accompanied by the upward percolation of a buoyant fluid phase released by the hotter, more mafic and wet magma below. Such a gas sparging event may have accelerated heat transport into the erupted mush.

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The role of crystal-plastic deformation in the serpentinization of olivine

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Olivine replacement reactions in the presence of a fluid have wide-ranging consequences for large-scale geological processes. For example, the petrophysical properties and geochemistry of the oceanic lithosphere are strongly affected by the serpentinization and Ca-metasomatism (rodingitization) of ultramafic rocks. In addition, olivine is one of the most promising candidates as an *in situ* reactant to sequester CO_2 via mineral carbonation. It is therefore crucial to constrain the mechanism of how natural olivine replacement reactions proceed in the presence of a fluid phase. Natural olivine grains in peridotites commonly show microstructural evidence for crystal-plastic deformation such as kink bands. The development of perfect ‘cleavage’ parallel to the (010) and (100) planes is also observed in natural olivine grains from ophiolite complexes [1, 2].

We present observations of deformed olivine from the Leka ophiolite complex in Nord-Trøndelag, Norway. These indicate that the serpentinization was strongly dependent on the crystal-plastic deformation of olivine and the resulting intergranular microchemistry. Olivine grains from Leka show banded zoning subparallel to the (100) plane. The zoning is caused by an increase in Mg and Mn concentration corresponding to areas of low Fe and Ni concentration. These chemical changes are parallel to kink bands and the optical undulose extinction that is caused by intergranular misorientation [3]. This is known to arise from the planar alignment of dislocations to form subgrain boundaries. Fluid infiltration was assisted by the subsequent development of ‘cleavages’ that are closely linked to the zoning, resulting in serpentinization and rodingitization [4].

Development of banded zoning caused by crystal-plastic deformation of olivine and its close relationship with a strong preferred orientated ‘cleavage’ has a critical influence on the mineral replacement of olivine in the presence of a fluid phase.

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