New evidence of diffusion-controlled garnet growth during deformation

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Extraordinary Ca zoning in synkinematic garnets from a pelitic schist near the base of the Lucomagno nappe at Passo del Sole, Switzerland, reveals a previously undocumented crystallization process in which porphyroblasts grow at rates proportional to their size (Fig. 1).

Individual Ca zones are known to have grown contemporaneously in all crystals, because they bear a uniform relationship to the onset of deformation, as recorded by the curvature of sigmoidal inclusion trails; correlated zones also all have the same chemical composition. The width of each zone therefore reflects the radial growth rate integrated over a specific time interval. Zone widths, measured on central sections through 20 crystals and corrected for non-normal intersections with the plane of section, are linearly proportional to the average radius of the zone. Smoothly varying Mn concentrations also yield a linear relationship between radius and radial growth rate.

The data are best interpreted as reflecting a growth mechanism in which sluggish intergranular diffusion dictates that the local concentration of nutrients determines the rate of crystal growth: crystals growing in nutrient-rich regions grow faster and achieve larger final sizes than others. Because the present results are for synkinematic growth, they negate the hypothesis that deformation during growth accelerates nutrient transport and eliminates diffusional controls on crystallization. Thus partial chemical disequilibrium, inherent in diffusion-controlled growth, extends to crystals growing during deformation.

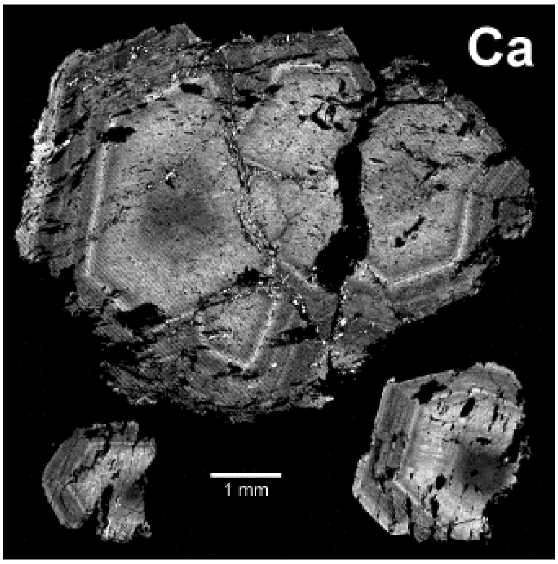

Figure 1. Identical patterns of Ca zoning on central sections through garnet crystals (X-ray maps). Widths of dark and bright zones vary in direct proportion to crystal size.

Presence of Sulphite (S^{IV}) in Basaltic Magmas: Implications for Volcanic Sulphur Emissions

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It is commonly accepted that sulphur is transported exclusively as sulphide (S^{II-}) or/and sulphate (S^{VI}) by mantle-derived melts, before being released as SO_2 and/or H_2S in volcanic emissions.

This work provides the first direct and quantitative determination of the oxidation state of sulphur in a selection of minute glass inclusions trapped in olivine crystals, using X-ray fluorescence microspectroscopy. The inclusions are representative of a variety of basaltic magmas that have supplied the activity of different volcanoes [Stromboli, Vesuvius in Italy; Piton de la Fournaise (PdF) in Reunion island; Mid-Atlantic-Ridge (MAR)]. The micro-X-ray Absorption Near Edge Structure (µXANES) experiments at the sulphur K-edge were carried out at ESRF (Grenoble, France). The µXANES spectra of glass inclusions indicate a clear predominance of sulphur dissolved as sulphide (S^{II-}) in PdF and MAR basalts. In contrast, they reveal the ubiquitous presence of sulphite (S^{IV}) species in addition to sulphate (S^{VI}) in inclusions representative of oxidised and water-rich basaltic magmas from subduction environment (Stromboli, Vesuvius). Independent determinations of the [$Fe^{3+}/\Sigma Fe$] redox ratio in two of these inclusions confirm much higher oxidising conditions in subduction-related basalts (e.g., Stromboli) relative to MAR- basalts. Hence, these results demonstrate that sulphur is not only dissolved in oxidised basalts as sulphate, but it also coexists with significant amounts of sulphite (S^{IV}).

Therefore, considering the equilibrium $SO_3{}^{2-}{}_{melt} = SO_{2gas} + O^{2-}{}_{melt}$ the decomposition of sulphite is a suitable candidate reaction to promote the release of sulphur as SO_2 into the gas phase. We propose a new model involving sulphite (S^{IV}) as the intermediate species yielding to highly efficient partitioning of sulphur into gas phase at the origin of excess volcanic SO_2 release in subduction zones.