

Intracrystalline deformation of magmatic olivine: A microXRD, EBSD, and EPMA study of lavas from the southern Chilean Andes

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Can plastic deformation occur at crustal levels and form strained olivine in volcanic rocks? This is matter of debate and currently poorly constrained, although deformed olivine is abundant in volcanic rocks from various geodynamic settings. Magmatic deformation of olivine has been mostly ignored in favour of an upper mantle origin, but the petrological, chemical, and microstructural evidence keep driving the discussion towards the magmatic origin.

To approach the topic, we present coupled geochemical, microXRD, and EBSD results for olivines in lavas from various localities of the Chilean Southern Volcanic Zone: Copahue, Callaqui, and Villarica volcanoes; and the Caburgua-Huelmolle eruptive centers. These volcanic edifices lie above the Liquiñe-Ofqui Fault Zone, a major intra-arc dextral strike-slip fault system that controls most volcanic activity in southern Chile.

The studied lava samples contain up to 20 vol% olivine, 5-20% of which are deformed crystals presenting undulose extinction, deformation bands, or rectangular subgrains. They have XRD patterns showing streaks or asterism (both attributed to strain), which give $FWHM_{Chi}$ values up to 6° ($<1^\circ$ for undeformed grains). The core Fo content of all olivines varies strongly (Fo46-85), but no grains with Fo>85 have been found. This, coupled with their relative high CaO (>0.10 wt%) and low NiO (<0.20 wt%) content, supports the hypothesis of a magmatic origin (as opposed to mantle origin). This is further supported by the EBSD data: misorientations of 1-10° between subgrains imply significant rotation of sub-domains as a result of plastic deformation, but too low to be related to mantle flow.

We propose two models: (1) Olivine was *de facto* deformed in the magma plumbing system; (2) Some, if not all deformed crystals derived from the upper mantle where they experienced plastic deformation, followed by extensive chemical reequilibration during storage in the crust but slower dislocation recovery at magmatic temperatures. Modeling of timing of chemical reequilibration versus timing of dislocation recovery will aid in discriminating between the two models.