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Crystal structure, mosaicity, and strain analysis of Hawaiian olivines using in situ X-ray diffraction

Nicolas Vinet,[1,*] Roberta L. Flemming,[2] and Michael D. Higgins[1]

[1]Sciences de la Terre, Université du Québec à Chicoutimi, Chicoutimi, Québec G7H 2B1, Canada
[2]Department of Earth Sciences, The University of Western Ontario, London, Ontario N6A 5B7, Canada

Abstract

Deformation of olivine in a volcanic context is poorly constrained, although deformed olivine is abundant in some volcanic rocks, and its presence is important for the definition of the magmatic history of volcanic edifices such as Kilauea Volcano, Hawaii. Deformed olivines at Kilauea originate in the lower crust; therefore, the classic approaches and interpretations applied to mantle-derived olivine are not applicable. Deformed olivine crystals from Kilauea lava samples were examined using an in situ XRD technique. Our results validate and refine optical observations of olivine deformation. We also confirm the presence of deformation and quantify it for olivine crystals of any size, even for small crystals (0.15 mm). There are significant correlations between deformation intensity (strain-related mosaicity) and olivine composition and crystal size. Although this technique does not allow the simple estimation of the *P-T* conditions of deformation, crystal formation, or magmatic history, some constraints are provided herein. In particular we estimate the threshold degree of mosaicity, above which we consider that a crystal underwent deformation. In situ XRD is shown to be an easy-to-use, fast, low-cost, non-destructive technique and is less ambiguous than optical microscopy. For crystals optically exhibiting subgrain formation, analysis of asterism by in situ XRD has been used to reconstruct the mosaic spread of the original grain, and thus its original strain condition prior to subgrain formation.

Keywords: Olivine, deformation, crystal strain, microstructure, mosaicity, in situ XRD, Hawaii, Kilauea, Mauna Ulu, Kilauea Iki