



## Phosphorus zoning in olivine of Kilauea Iki lava lake, Hawaii

Alessandro Fabbri, John R Beckett, Michael B Baker, and Edward M Stolper

California Institute of Technology, Division of Geological and Planetary Sciences, Pasadena, United States  
(ale75@caltech.edu)

Kilauea Iki lava lake was formed when the lavas of the 1959 summit eruption of Kilauea volcano ponded in Kilauea Iki pit crater, as described by [1]. The main chamber of this lake has been drilled repeatedly from 1960 to 1981 as the lake has cooled and crystallized and partial descriptions of core can be found in [2-7]. The bulk of the core consists of a gray, olivine-phyric basalt matrix [3]. Rapid diffusion of divalent cations through olivine at magmatic temperatures can delete information on early-formed zoning and thus information on early magmatic history, recorded in olivine during its growth, is often largely lost [8-11]. In the last years many studies [8-11] have shown that natural olivine, terrestrial and extraterrestrial, from several localities and rock types can preserve a complex zoning in P (sometimes associated with Cr and Al). Simple crystallization experiments conducted by [10] and [11] were able to replicate these features (i.e., sector and oscillatory zoning). Here, we describe P, Cr and Al zoning in olivine from the 1981 drilling of Kilauea Iki lava lake hole #1 (KI81-1) [6].  $K_{\alpha}$  X-ray intensity maps and major and minor element quantitative analyses were obtained using the Caltech JEOL JXA-8200 electron microprobe. We acquired P, Cr, Al, Fe and Ti X-ray maps simultaneously at 15 kV and 400 nA, a beam diameter of 1  $\mu\text{m}$ , pixel spacing of 1-2  $\mu\text{m}$ , and count times of 420-1500 msec/step were used depending on the dimension of the crystal. 15 kV and 40 nA with a beam diameter of 1  $\mu\text{m}$  were used to collect quantitative analyses.  $\text{P}_2\text{O}_5$  contents of the Iki olivines range from below detection limit to 0.30 wt%. Zoning in phosphorus, based on X-ray intensity maps, was observed in all olivines we examined. The P zoning patterns of the olivines display several styles. P shows oscillatory zoning comparable to that seen in terrestrial and extraterrestrial igneous olivines and in experimentally grown olivine [8-11]; high P regions, inside the crystals, outline low P chambers and P enriched zones were also observed; near the margins of the crystals is possible to find the presence of discontinuous sets of P-enriched bands that generally outline euhedral crystal forms; some crystals are characterized by P-enriched ghosts of relict crystals in their interior that are associated with probable undercooling and/or with an initial pulse of rapid crystal growth [8, 10]. Phenocrysts and microphenocrysts are frequently unzoned in major and minor divalent cations (Fe, Mg, Mn, Ca, Ni), but all are zoned in P. Variations in Cr and Al correlate spatially with P but are much fainter or absent, in some crystal the P-enriched bands are superimposed with small crystals of chromite ( $\leq 1 \mu\text{m}$ ) aligned along the P zoning. Probably these chromites were formed by precipitation from the original Cr and Al bands. In no case was observed Ti zoning.

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