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Fayalite oxidation processes in Obsidian Cliffs rhyolite flow, Oregon

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Abstract

This study investigates the oxidation of fayalite $Fe^{2+}_2SiO_4$ that is present in lithophysae from a rhyolite flow (Obsidian Cliffs, Oregon). Textural, chemical, and structural analyses of the successive oxidation zones are used to constrain: (1) the oxidation processes of olivine, and (2) the role of temperature, chemical diffusion, and meteoric infiltration. Petrologic analyses and thermodynamic modeling show that the rhyolite flow emplaced at 800–950 °C. Fayalite-bearing lithophysae formed only in the core of the lava flow. Variations in the gas composition inside the lithophysae induced the oxidation of fayalite to a laihunite-1*M* zone $Fe^{2+}_1Fe^{3+}_2\square_1(SiO_4)_2$. This zone is made of nano-lamellae of amorphous silica SiO_2 and laihunite-3*M* $Fe^{2+}_{1.6}Fe^{3+}_{1.6}\square_{0.8}(SiO_4)_2$ + hematite Fe_2O_3. It probably formed by a nucleation and growth process in the fayalite fractures and defects and at fayalite crystal edges. The laihunite-1*M* zone then oxidized into an "oxyfayalite" zone with the composition $Fe^{2+}_{0.52}Fe^{3+}_{2.32}\square_{1.16}(SiO_4)_2$. This second oxidation zone is made of lamellae of amorphous silica SiO_2 and hematite Fe_2O_3, with a possible small amount of ferrosilite $Fe^{2+}SiO_3$. A third and outer zone, composed exclusively of hematite, is also present. The successive oxidation zones suggest that there may be a mineral in the olivine group with higher Fe^{3+} content than laihunite-1*M*. The transformation of laihunite-1*M* to this "oxyfayalite" phase could occur by a reaction such as

$$0.24Fe^{2+\ \text{laihunite-1}M}_{M1} + 0.06O_2 = 0.16\ Fe^{3+\ \text{“oxyfayalite”}}_{M1} + 0.08\square^{\text{“oxyfayalite”}} + 0.04\ Fe^{3+}_2O_3^{\text{hematite}}$$

This would imply that Fe^{3+} can also be incorporated in the M1 site of olivine.

Keywords: Olivine, fayalite, laihunite, oxyfayalite, rhyolite, lithophysae, oxidation