オリビンの硬さと破壊靭性におけるサイズ効果
Size effects on hardness and fracture toughness of olivine

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We conducted Vickers indentation tests on Fe-free (Mg_2SiO_4) and Fe-bearing ($Mg_{1.8}Fe_{0.2}SiO_4$) olivine. Their single crystals and highly-dense polycrystalline materials with various average grain sizes (d) from 170 to 890 nm were tested. The largest Vickers microhardness (H_v) of 18 GPa at the lowest load of 0.1 N, which corresponds an indentation depth (h) of 0.6 μm was measured from the polycrystalline material with the finest grain size. The H_v decreases with increasing d and h, both of which are represented by $H_v \propto l^x$ where l corresponds to both sizes with a common x value of ~0.09. The relationship no longer holds at of > 4 μm and of > 1 μm where H_v take constant values of ~9.5 and ~8 GPa for Fe-free and Fe-bearing olivine, respectively. Fracture toughness (K_{IC}) measured from indentation diagonal size and length of cracks radiated outward from the indentation corners is ~0.8 MPa・$m^{1/2}$ for the polycrystalline materials, whose value does not change with the applied load, and olivine chemistry and grain size. The single crystals exhibit lower and orientation dependent toughness from 0.4 to 0.7 MPa・$m^{1/2}$.

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