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Measurements of elastic constants of single-crystal chromian spinel by fequency resonant ultrasound spectroscopy

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Chromian spinel grains in mantle xenoliths usually contain fluid inclusions whose residual pressure (fluid density) can provide us the origin depth of the xenoliths. Elastic properties of chromian spinel are essential for precise estimation of the origin depth. Although elastic constants of spinel ($MgAl_2O_4$) and chromite ($FeCr_2O_4$) have been already reported, few studies have been done on chromian spinel. We thus have studied elastic constants of a chromian spinel single-crystal via a resonance method.

Chromian spinel grains were collected from mantle xenoliths from Sveyagin, Russia (Yamamoto et al., 2009, Island Arc). One grain was selected in terms of the uniformity of crystallographic orientation examined by SEM-EBSD. The selected grain was shaped into a rectangular parallelepiped (0.517x0.417x0.412mm^3). Each face was polished flat ($<$ 1 micrometer) in an orientation perpendicular to $\{100\}$ or $\{110\}$. The crystallographic orientation of the specimen was determined by the X-ray precession method. The density is 3.83(1) x 10^3 kg/m^3, which is calculated from the chemical composition analyzed with EPMA and the lattice parameter (a= 0.8115(1) nm) determined by XRD.

Lower 16 oscillation modes were observed in the frequency range from 4 to 9 MHz. The oscillation of a specimen is not free oscillation, because the specimen is held between two transducers. A specimen-holding force F affects resonance frequencies. In order to infer the resonance frequencies of free oscillation, resonance frequencies were measured as a function of the specimen-holding force F and then extrapolated to F=0.

Elastic constants are determined by comparing calculated and measured resonance frequencies. FEM was employed to calculate resonance frequencies. C_{11}, C_{12} and C_{44} are 264(3), 154(3), and 142.6(2) (GPa), respectively. Compared with elastic constants of end members, spinel (Yoneda, 1990) and chromite (Hearmon, 1990), chromian spinel has the lowest C_{11} and intermediate C_{12} and C_{44}.

Keywords: elastic constants, chromian spinel, resonance method, mantle xenoliths