

Temperature dependent grain boundary complexions in olivine aggregates

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As the most abundant mineral in the upper mantle—and the only fully interconnected phase—olivine plays a key role in understanding mantle rheology, melt distribution, and electrical and seismic properties. Rocks are polycrystalline aggregates composed of crystals separated by grain boundaries or interfaces. While the effect of grain size has been extensively studied, grain boundaries also influence strength, conductivity, and creep behaviour. A grain boundary can be defined by five macroscopic parameters: three describing the crystal orientation and two describing the planes in contact at an interface. Studies on other ceramic systems show that the frequency of an interface is inversely proportional to its energy[1]. The lowest-energy interfaces occupy the greatest area within an equilibrated polycrystal, with the distribution of interfaces varying under different temperature and pressure conditions[2]. This change reflects a transition in the interface with the lowest energy, indicating a new, most stable chemistry or atomic configuration. As different interfaces exhibit different properties, changes in their distribution can directly affect bulk properties.

In this study, synthetic forsterite aggregates were produced between 1150 °C and 1390 °C, yielding grain sizes from 600 nm to 6.6 µm. EBSD was used to analyse the grain boundary plane distribution (GBPD) via a stereological method[3]. Results show that the most common grain boundary planes shift from those perpendicular to the [001] axis at temperatures below 1300 °C to those perpendicular to the [010] axis above 1300 °C. Annealing either side of this temperature threshold confirmed that the interfacial distribution is reversible and that the GBPD change is related to a complexion transition—a temperature-dependent change in grain boundary energy. We will discuss how understanding complexion changes helps to reconcile discrepancies related to grain boundary properties between different research groups.

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[3] Rohrer, G. S., Saylor, D. M., El-Dasher, B. S., Adams, B. L., Rollet, A. D. & Wynblatt, P. (2004), *Z. Metallkd.* 95, 197–214