Use of EBSD to identify primary magmatic apatite inclusions in zircon

JACK GILLESPIE*, AARON CAVOSIE, ALEXANDER NEMCHIN, PETE KINNY

The Institute for Geoscience Research (TIGeR) and Space Science and Technology Centre, Curtin University, Bentley WA 6845, Australia
*correspondence: jack.gillespie@curtin.edu.au

We report the first electron backscatter diffraction (EBSD)-based quantification of systematic host-inclusion crystallographic relationships for magmatic zircon with apatite inclusions. Zircons ca. 3.6 Ga in age from the Narryer Gneiss Complex of the Yilgarn Craton, Western Australia, preserve simple primary magmatic oscillatory zoning. The zircons contain abundant apatite inclusions, up to sixty per grain, that are dominantly euhedral, elongate, hexagonal single domain crystals.

Orientation analysis demonstrates a systematic crystallographic relationship between all faces of host zircons and {100} faces of apatite inclusions. Regardless of host face, the c-axes of apatite inclusions are aligned in orientations parallel to the the zircon growth face, with some preferred orientions reflecting epitaxy. Preferential growth of apatite inclusions on zircon crystal faces is the result of zircon providing energetically favourable nucleation sites by decreasing the surface free energy of the apatite.

Growth of apatite inclusions at the surface of the zircon may be linked to oscillatory growth zoning of the substrate zircon via the 'xenotime' coupled substitution mechanism for incorporation of HREE and phosphorus. The oscillating crystal-melt interface chemistry due to competition between crystal growth and element diffusion in the melt may drive transient local supersaturation of apatite.

The systematic crystallographic relationship between inclusion and host as revealed by EBSD demonstrates the primary syngenetic nature of the inclusions, confirming their applicability for trace element and isotopic studies. The typical monzogranitic composition of the host gneiss and the apparent equilibrium crystallization of the zircon suggests that this should be a common mechanism for the growth and trapping of apatite in zircon in siliceous magmas. This phenomenon explains the very high abundance of apatite inclusions in magmatic zircon relative to other phases, and is potentially a widely applicable criterion for determining the origin of inclusions.