American Mineralogist, Volume 92, pages 1119–1129, 2007

Origin of atoll garnets in eclogites and implications for the redistribution of trace elements during slab exhumation in a continental subduction zone

Hao Cheng,[1,2,*] Eizo Nakamura,[1] Katsura Kobayashi,[1] and Zuyi Zhou[2]

[1]The Pheasant Memorial Laboratory for Geochemistry and Cosmochemistry, Institute for Study of the Earth's Interior, Okayama University at Misasa, Tottori 682-0193, Japan
[2]State Key Laboratory of Marine Geology, Tongji University, 200092, Shanghai, P.R. China

Abstract

Detailed electron- and ion-microprobe analyses were carried out on atoll-shaped and normal garnets in ultrahigh-pressure (UHP) metamorphic eclogite from Dabie, east-central China. Compositional profiles of both normal garnets and rings of atoll garnets show well-preserved growth zoning with a decrease in Mn, Ca, and heavy rare earth elements (HREEs), and an increase in Mg toward rims. Manganese and middle rare earth element (MREE) enrichments are observed near garnet rims. Island- and peninsula-shaped garnet inside atolls are homogeneous in major elements and show the same composition as garnet rims, whereas the HREE concentrations are similar to those of the normal garnet cores. Electron back-scatter diffraction (EBSD) analyses show that the island- and peninsula-shaped garnet fractions inside atolls have crystallographic orientations identical to that of the atoll rings. These observations suggest that the atoll garnets were formed by the consumption of earlier-formed cores by fluid released from both hydroxyl exsolution from the nominally anhydrous minerals (NAMs) and lawsonite decomposition at the onset of exhumation, (i.e., garnet breakdown was from the inside and re-growth from outside to inside). Though somewhat restricted, this study reveals that because garnet and zircon act as sinks for HREEs and Zr, respectively, the majority of released HREEs and Zr were likely re-incorporated into newly grown garnet and zircon during the Dabie UHP metamorphic slab exhumation.

Keywords: Atoll garnet, fluid, eclogite, Dabie