An ultra-refractory nodule in an Allende fine-grained inclusion: Isotopic studies using SIMS

T. USHIKUBO[1], H. HIYAGON[1], M. KIMURA[2] AND A. HASHIMOTO[3]

[1]University of Tokyo, Tokyo 113-0033, Japan (ushi@space.eps.s.u-tokyo.ac.jp) (hiyagon@eps.s.u-tokyo.ac.jp)
[2]Ibaraki University, Mito 310-8512, Japan (makotoki@mx.ibaraki.ac.jp)
[3]Hokkaido University, Sapporo 060-0810, Japan (akihiko@ep.sci.hokudai.ac.jp)

Introduction

We discovered an ultra-refractory (UR) nodule, Hendrix, in a fine-grained inclusion, AFG-1, from the Allende CV3 meteorite. Hendrix shows high concentrations of ZrO_2, Y_2O_3, Sc_2O_3 and heavy rare earth elements (HREE) with abundances of up to ~8000 x CI. Texture, mineralogy, mineral chemistry, and REE abundance patterns of Hendrix have been reported by Hiyagon et al. (2003). In order to better understand the formation process of this unique inclusion, we further analyzed O, Mg, Ca and Ti isotopes in various phases in AFG-1 including Hendrix using an ion microprobe, CAMECA ims-6f, at the University of Tokyo.

Results

Spinel is abundant in AFG-1 and found in various lithologies: Fe-poor spinel region with UR signatures (Hendrix), Fe-poor spinel regions in other nodules (typically showing Group III REE patterns) and Fe-rich spinel regions both in Hendrix and in other nodules. All spinel grains in different lithologies show ^{16}O-rich compositions with $\delta^{17}O \sim \delta^{18}O$ from –42‰ to –54‰ and no systematic difference is found among them. A large perovskite grain in Nodule C shows less ^{16}O-rich composition with $\delta^{17}O$= -28‰ and $\delta^{18}O$= -22‰, suggesting some isotopic exchange with a ^{16}O-poor reservoir. Rim diopside shows rather ^{16}O-rich compositions with $\delta^{17}O \sim \delta^{18}O$ from -30‰ to -35‰. Hence, O-isotopic compositions of minerals in Hendrix are not different from those of other typical CAIs. For Mg isotopes, spinel shows unfractionated composition, which is consistent with condensation origin of AFG-1. Preliminary results for Ca isotopes show no significant isotopic anomalies for perovskite in Hendrix. This suggests that exotic components, if present, are minor in Hendrix (cf. El Goresy et al., 2002). Further isotopic analyses are going on for this unique inclusion.

References

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Fate of the subducted Farallon plate inferred from eclogite xenoliths in the Colorado Plateau

TOMOHIRO USUI[1], EIZO NAKAMURA[1], KATSURA KOBAYASHI[1], SHIGENORI MARUYAMA[2], HERWART HELMSTAEDT[3]

[1] The Pheasant Memorial Laboratory for Geochemistry and Cosmochemistry (PML), Institute for Study of the Earth's Interior, Okayama University at Misasa, Japa
[2] Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro, Tokyo, Japan
[3] Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, Ontario, K7L 3N6, Canada

Since plate tectonic theory became widely accepted, eclogite xenoliths brought to the Earth's surface in kimberlite pipes have been studied intensively as being potentially representative of material recycled deep into the mantle. However, as a result of their long residence in the mantle, most eclogite xenoliths have not preserved their initial petrographic and chemical features reflecting subduction processes. In this study, we focused on eclogite xenoliths from the Colorado Plateau with exceptionally well preserved minerals and textures similar to those from more expansive exposures of eclogites in metamorphic suites.

Eclogite xenoliths investigated in this study were collected from the Moses Rock and Garnet Ridge diatremes in the Four Corners region. The xenoliths consist mainly of almandine-rich garnet, omphacite, lawsonite, and zoisite and have minor amounts of phengite, rutile, pyrite, and zircon. Moreover, we found coesite as inclusions in eclogite garnets with weak radial fracturing, representing the first detection of this mineral in a xenolith suite from the Colorado Plateau. The presence of coesite inclusions in garnet crystals associated with lawsonite conclusively supports the hypothesis that the eclogite formed in a low-temperature–high-pressure environment such as envisaged inside subducted oceanic lithosphere.

We applied an ion-microprobe dating technique (Usui et al., 2002) by employing Cameca ims-1270 to micrometer-scale zircons found in the eclogite xenoliths. The U-Pb ages of the zircons ranges from 81 Ma to 33 Ma, with the two extremes in age likely indicating the age of crystallization during subduction-related metamorphism and the age of recrystallization by the host magmatic event, respectively. These observations conclusively demonstrate that certain eclogite xenoliths from the Colorado Plateau originated as fragments of the subducted Farallon plate, which had been residing in the upper mantle since the Late Cretaceous. This is the first conclusive evidence that any eclogite xenoliths can be directly linked to a known subducted plate.

References

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