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PPS02-08 会場:203 時間:5 月 20 日 11:30-12:00

ユレイライト隕石中のダイヤモンド：生成メカニズムと惑星過程での役割
Diamond in ureilites: Formation mechanisms and roles in planetary proceses

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Diamond was found in the Novo Urei meteorite, one of typical ureilites, first in meteorites in 1888. Lonsdaleite, hexagonal polymorph of diamond, was found in the Canyon Diablo iron and the Goalpara ureilite first in nature. So far, mineralogical properties of carbon minerals in ureilites have been only roughly determined by using acid-treatment residues because they exist in small quantities in ureilites. Then, the origin of diamonds in ureilites has been controversial.

We observed carbon minerals under an optical microscope under a reflected light and obtained micro Raman spectra of them in polished thin sections. X-ray powder diffraction patterns were obtained from the carbon grains directly taken out of polished thin sections and picked up from disaggregated ureilite samples. Carbon minerals in these carbon grains were also directly observed by TEM and SEM.

In weakly shocked ureilites, diamond occurs with a granular shape of up to a few micron meters in size and shows sharp x-ray diffraction lines and sharp Raman bands at 1332 cm^{-1}, suggesting well-crystallinity of them. Lonsdaleite was not found in weakly shocked ureilites. In heavily shocked ureilites, diamond occurs together with lonsdaleite with a platy shape of up to a few tens micron meters in size and shows very broad x-ray diffraction lines and broad Raman spectra.

Selected area electron diffraction analyses and high resolution TEM observations of carbon grains from the heavily shocked Goalpara ureilite reveal the relative crystal-axes orientations between graphite (Gr), lonsdaleite (Lo) and diamond (Di) as $(001)_{Gr}$ // $(100)_{Lo}$ // $(111)_{Di}$, $[210]_{Gr}$ // $[001]_{Lo}$ // $[2\text{-}1\text{-}1]_{Di}$ and $(1\text{-}20)_{Gr}$ // $(\text{-}120)_{Lo}$ // $(0\text{-}22)_{Di}$. The shapes of diffraction spots in the SAED patterns reveal that the transformation of graphite to lonsdaleite and diamond is initiated by sliding of hexagonal carbon planes of graphite along the [210] of graphite structure. These results suggest that lonsdaleite and diamond in heavily shocked ureilites formed directly from graphite through boat-type buckling and chair-type puckering of hexagonal carbon planes of graphite, respectively[1].

A SEM image of the surface parallel to the basal plane of original graphite from the weakly shocked Y-8448 ureilite is shown in Figure 1. In the figure, triangular crystal faces were observed. BSED patterns reveal that the triangular faces are correspond to (1 1 1) crystal planes of diamond. Such forms of diamond clearly reveal that the diamond crystals have grown on the melt and strongly suggest that diamond in the weakly shocked ureilites was formed through catalytic processes.

In the planetary processes of the ureilite parent body, smelting is thought to be an important process by which the chemical structure of the body was controlled. Ferrous silicates are vulnerable to smelting in the presence of graphite at magmatic temperatures by generic reactions of the sort:

FeO(silicate) + C(graphite) = Fe(metal) + CO. (1)

On as much as gas of large molar volume appears only on the right-hand side of this reaction, the reaction is expected to be strongly pressure sensitive. Smelting is suppressed at elevated pressure and promoted as pressure falls[2]. Then, mg# of olivine is controlled by the depth at which it has been crystallized. In order to confirm the reaction (1) and the smelting process in the ureilite parent body, it is important to know the relation between mg# of silicate and the modal abundance of carbon. The modal abundance of original graphite in ureilites was obtained under an optical microscope (Figure 2). Figure 2 shows that the modal abundance of carbon decreases with the increase of mg# and directly confirms the reaction (1) and the smelting process in the ureilite parent body.

[1] Nakamuta and Toh (2013) Amer. Mineral., in press; [2] Walker and Grove (1993) Meteoritics 28, 629.

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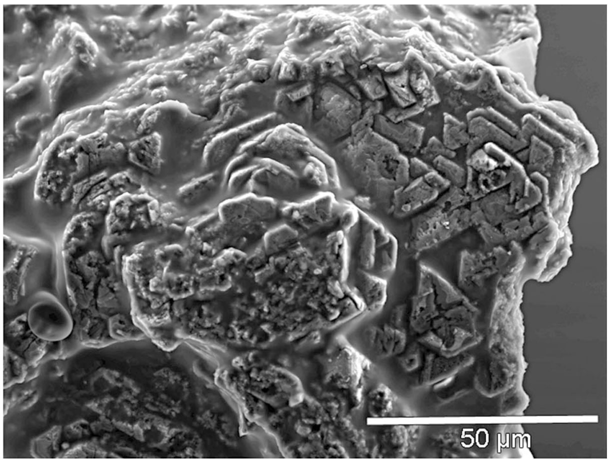
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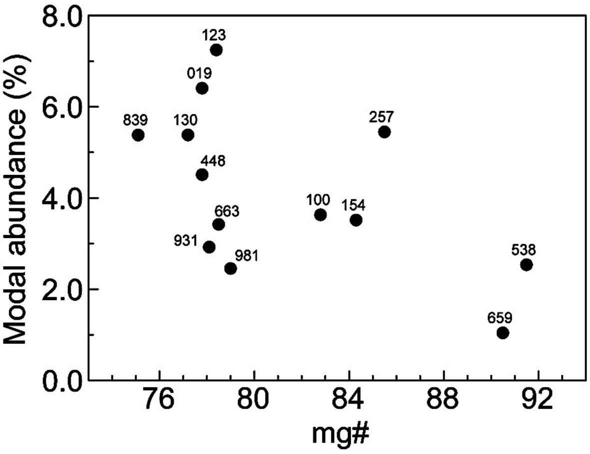
Modal abundance (%)
8.0
6.0
4.0
2.0
0.0
76
80
84
88
92
mg#
123
019
839
130
257
448
100
154
663
931
981
538
659