Halite crystals derived from late-stage brines in an N–H–bearing Bennu grain

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Introduction:

The OSIRIS-REx mission successfully recovered regolith samples from the surface of the B-type carbonaceous asteroid Bennu [1]. Initial analyses revealed that the chemical and petrological characteristics of Bennu particles are similar to those of CI chondrites and samples returned from asteroid Ryugu [1–3]. The major mineral assemblages in Bennu samples indicate that the parent body experienced extensive aqueous alteration [3].

Infrared spectroscopic analyses of Bennu samples have suggested the presence of ammonium in phosphate minerals, based on the detection of N–H absorption bands [4]. Understanding the coexistence of ammonia and aqueous alteration minerals is critical for elucidating the unique chemistry of ammonia-rich fluids in the early Solar System.

In this study, we conducted a detailed mineralogical and petrological investigation of a Bennu grain that exhibits a strong N–H absorption band in infrared spectra [5]. This work is part of a coordinated analysis for organic chemistry and isotopic studies of the same grain, aiming to characterize nitrogen-bearing mineral phases and to the aqueous alteration histories of Bennu samples.

Sample and Methods:

Under optical microscopy, a half of the grain surface appears yellowish to bright, whereas the remaining area is darker. The grain ORX20007 locally exhibits a strong N–H absorption band at 3.1 μm in infrared spectra acquired by the MicrOmega at the JAXA curation facility [5]. After allocation from JAXA, the ORX20007 was stored in a nitrogen-filled glovebox to minimize terrestrial contamination and alteration. The grain was gently crushed using a tungsten needle, and the resulting fragments were examined by scanning electron microscopy (SEM) at Kyoto University. The fragments analyzed by SEM were derived from regions nearby the area showing the strongest N–H absorption. Other fragments from the same grain were distributed for complementary analyses, including organic and isotopic studies.

Results and Discussion:

SEM observations show that ORX20007 fragments contain pyrrhotite, magnetite, dolomite, and minor Ca-phosphate and Mg-phosphate embedded within a phyllosilicate matrix. This mineral assemblage is consistent with that reported for aqueously altered lithologies of Bennu [1, 3] and closely resembles typical CI chondrites and Ryugu samples [2]. Therefore, ORX20007 can be classified as a CI-like, extensively aqueously altered lithology.

In contrast, the grain surface includes abundant sub-micrometer to micrometer-sized sodium chloride (NaCl) grains with irregular or cubic morphologies. Stereo SEM images reveal that these NaCl crystals protrude from the surrounding phyllosilicate matrix. NaCl has been identified in both Bennu and Ryugu samples and is interpreted to have formed during the late stages of aqueous alteration [6, 7]. Soluble Na^+ and Cl^- ions likely precipitated from highly saline brines as liquid water volume decreased during progressive fluid evolution.

The occurrence of NaCl on the grain surface suggests that late-stage fluid activity resulted in localized salt

concentration in ORX20007. This implies a potential link between N-H-bearing species and late-stage brine chemistry during aqueous alteration on Bennu’s parent body.

References:
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