**ANALYSIS OF “STONE” SAMPLES FROM C-TYPE ASTEROID RYUGU.**

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**Introduction:** As a part of activities of initial analysis [1], we analyzed eighteen Ryugu “stone” samples of 1 ~ 8 mm in size: seven stones from the 1st touch down site and eleven from the 2nd touch down site. Ryugu stones were analyzed first using X-rays, UV, visible, near-infrared, mid-infrared, and muon probes for surface reflectance spectra, internal 3D structure and element distribution [2], crystal structures, and bulk composition of light elements such as C, N, and O. Measurements for magnetic, thermal, and physical properties using some stones were also performed. TOF-SIMS analysis of fluid inclusions is being continued [3]. Small particles separated from some stones were analyzed by IR-CT [4]. Based on 3D-CT images of individual stones, objects of interests were identified, separated by pFIB cutting, and exposed by polishing on the surface of epoxy disks. FE-EPMA/FE-SEM analysis was made on ~40 polished epoxy disks for chemical composition and textural observation [5, 6]. FIB sections and small (~15 μm in size) fragments were separated from polished surface and analyzed by TEM, STXM, XRF, and nano-CT.

**Results and discussion:** Eighteen stone 2D and 3D images indicate that Ryugu samples are breccias of small fragments (< ~1mm in size) of basically CI chondrite mineralogy [7]. Most of the fragments are heavily altered and consists mainly of phyllosilicates, carbonates (dolomite and breunnerite), Fe sulfides and oxides, and phosphates (F-bearing apatite); this mineralogy we call the major lithology. The mineralogy of the fragments of the major lithology show some diversity: abundance and shape of carbonates and phosphates differ among fragments. On the other hand, some fragments in many stones are less altered and contain anhydrous silicates such as olivine and low-Ca pyroxene of typically Mg#>97 but down to Mg# ~50, which we call the less-altered lithology.

In the less-altered lithology, the abundance of olivine and pyroxene differs between fragments and some fragments contain them up to ~ 10 vol%. Therefore, fragments with the less-altered lithology can be classified as CI2-type chondrite material. Most, but not all, fragments with the less-altered lithology contain only calcite as carbonate, phosphides (FeNi)3P and (Fe, Ni)2P instead of apatite, and poorly-crystallized amorphous silicates. Small (< 20μm in size) type-I barred and porphyritic chondrules and CAI with spinel+hibonite+perovskite assemblages occur. GEMS-like objects are abundant in the least-altered fragments. In summary, mineralogical and physical properties of Ryugu samples reveal incipient to advanced aqueous alteration in its parent asteroid.

**References:**

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