PETROLOGY, MINERALOGY, AND NOBLE GAS COMPOSITION OF THE DUBROVNIK L CHONDRITE BRECCIA. T. Yokoyama[1], T. Nakamura[1], R. Okazaki[1] and K. Saiki[2] [1] Department of Earth and Planetary Science, Faculty of Science, Kyushu University, Hakozaki, Fukuoka 812-8581, Japan (rikken@geo.kyushu-u.ac.jp), [2]Department of Earth and Space Science, Graduate School of Science, Osaka University, 1-1 Machikaneyama, Toyonaka 560-0043, Osaka, Japan.

Meteorites of regolith breccia preserve the records of formation and evolution of surface material on the asteroids. With longer residence time, the surface material changes its textural and mineralogical properties, so called "space weathering", mainly due to cosmic dust bombardment and solar-wind implantation. In addition, cosmogenic nuclides are produced via spallation reactions between in-coming cosmic rays and the surface material. Therefore, it is expected that the meteorites that have experienced heavier space weathering contain higher concentrations of implanted solar winds and cosmogenic nuclides.

In the present study, as a first step, we studied mineralogical and noble gas signatures of Dubrovnik regolith breccia. Reflectance spectra measurements of selected areas in Dubrovnik are now underway.

A polished slice of Dubrovnik shows typical dark-light structure and consists of a dark part and 3 white parts (hereafter, w-1, w-2, and w-3). The dark part seems to have suffered space weathering on the surface of an asteroid and reduced the reflectance to become darker in color.

SEM observation showed that the dark part consists of mineral grains with sizes slightly smaller than the whites. It also contains a local, vein-like blackened part. The local blackened part was probably a shock-induced melt, because it is composed of very fine silicate with Fe-Mg zoning.

Synchrotron X-ray diffraction analysis of the dark and the white indicates that both parts consist of similar mineral assemblages: olivine, pyroxene, plagioclase, troilite, and Fe-Ni metal. But the dark has an Fe-Ni metal (kamacite) abundance higher than the whites.

EPMA analysis indicated that olivine in both parts has homogeneous composition peaked at $Fa_{23.5}$, and it was in a compositional range of L-chondrite [1]. As for pyroxene, both low-Ca and high-Ca pyroxene were present in the dark and the whites, and in the whites the composition of low-Ca pyroxene concentrates at $Wo_{1.3}En_{78.7}$, while high-Ca pyroxene is at $Wo_{43.2}En_{49.5}$. In contrast, the composition of pyroxenes in the dark was inhomogeneous, although the average composition was nearly equal to that of white. Many Mg-rich low-Ca pyroxenes occur only in the dark that ranges in composition from $En_{97.4}$ to $En_{71.3}$.

Homogeneous pyroxene composition in the whites suggests that they were in thermally equilibrium during their formation. We applied pyroxene compositions of the whites to the two-pyroxene thermometer proposed by [2]. The results indicated that the whites had been in equilibrium at about 900℃. These pyroxenes compositions of the Dubrovnik indicate that petrologic type of materials in the whites is 6.

The dark and the whites include both kamacite and taenite, and their Co contents are in the range of L-chondrites. But the range of Ni contents are 3.5~6.6 wt% for kamacite and 10.2~49.7 wt% for taenite, which is wider than that of equilibarated L chondrites (5~7 wt% for kamacite, and 25~55 wt% for taenite) [3]. This suggests the possibility of reheating and quenching [cf. 4].

The measurement of noble gases revealed that large amounts of solar-wind derived noble gases were detected from the dark portion: amounts of solar ^{4}He ($^{4}He_s$), ^{20}Ne ($^{20}Ne_s$) and ^{36}Ar ($^{36}Ar_s$) are 1.65×10^{-3}, 3.01×10^{-7} and 7.65×10^{-6} cm^3STP/g, respectively. In contrast, the white portion is free of solar noble gases. This confirms that Dubrovnik is a breccia derived from the surface of a parent asteroid. The elemental ratios of $^{4}He_s/^{20}Ne_s$ (215) and $^{20}Ne_s/^{36}Ar_s$ (30) in the dark portion are comparable with those of Lunar soil, which suggests a small degree of elemental fractionation [5].

Cosmic-ray exposure ages based on ^{3}He and ^{21}Ne in the white portion (T_3 and T_{21}) are 51.0 and 55.5 Ma, respectively. Gas retention ages based on ^{4}He and ^{40}Ar (T_4 and T_{40}) are 2.9 and <4.6 Ga assuming Th, U and K concentrations of the L-chondrite average [6]. The dark portion has T_{21} and T_{40} similar to those of the white portion. The ratios of T_3/T_{21} and T_4/T_{40} are 0.92 and 0.64, respectively. This suggests that Dubrovnik suffered the isotopic fractionation neither on the parent body nor in outer space [cf. 7]. Consequently, both of the measurements in the dark and light portions of noble gases suggest that Dubrovnik has never experienced high temperature heating after implantation of solar wind.

Based on the results of a series of analysis, we infer the formation and evolution history of the surface of Dubrovnik parent asteroid. First, the whites formed in the interior of the parent body during prolonged thermal metamorphism at around 900℃. Then a large impact destroyed the parent body which excavated the deeper-seated white to the asteroid surface and, at the same time, might have disturbed the composition of Fe-Ni metals due to impact heating. The dark material was produced with time on the surface by space weathering. The whites and the dark were mixed due to repeated impacts. Mg-rich pyroxene in the dark would have incorporated from least metamorphosed portions of the surface, or as in-coming meteoroids during the impact-induced mixing processes, and the black melt pocket was also produced due to local shock heating. During impacts, the dark and the whites consolidated together to form a chondritic regolith breccia. After consolidation, there is no heating enough to degas noble gases.

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