P232-017 **Room: 301B** **Time: May 18 16:06-16:18**

On the determination of lunar surface age for the detailed small geologic unit by the new method

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It is well known that the magnitude of the crater size-frequency distribution (CSFD) which is the functional relationship between the number density of craters and crater diameter simply increase with time on the planets and satellites since the volcanic or fluid resurfacing. In the ideal case, the CSFD is an efficient function for the determination of surface age of these bodies. The average CSFD on the lunar maria, however, consists of three parts. These segments are divided at around 300 m and 4 km in the diameter, and each segment has a characteristic slope. In the segment of smaller diameter than 300 m, the CSFD reveals 'saturation equilibrium' meaning that the number density of craters changes little in appearance on the CSFD. The saturation equilibrium is represented as the 1 ~10 % of the magnitude of geometric saturation which is expressed as a function of crater diameter, 1.5 D^-2, although there is no definitive function such saturation equilibrium. The ambiguity of equilibrium saturation has been anticipated by the consequence of the ejecta blanket from the adjacent impact cratering or the different erosion speed of craters caused by the different ability of modification of crater morphology with different regolith thickness. In the segment of larger diameter than 4 km, the CSFD simply indicates the surface age of planets and satellites with the index of power law, -2. However, there are not statistically craters for the determination of the surface age of the lunar surface, because the recent detailed explore missions for the Moon such as the Clementine and Lunar Prospector has shown that the lunar surface has the property of the refined geologic units. As the consequence, we cannot use for the determination of surface age by the CSFD in the larger than 4 km for the future mission such as SMART-1 or SELENE. On the other hand, in the segments between 300 m and 4 km, the CSFD has a steep slope compared with other segments. In generally, the steep slope in this segment is attributed by the secondary craters which have a steep slope, a functional effect of projectile which would produce craters in this segment, or admixture of these two effects (Namiki and Honda, 2003; Nakamura et al., in this meeting). In addition to these causes, Morota et al. (in this meeting) points out that the number of craters is too statistically small to estimate the surface age in the area of 1000 km^2.

We propose the new method of determination of surface age of the planets and satellites using smaller craters than 300 m in diameter which reveal the equilibrium saturation. In the fact, the depth of regolith layer grows up with time by a number of impact craterings. These craters and the depth of regolith layers are closely related, because the scaling laws within the impact cratering on the thin regolith and thick regolith layers probably relate to strength and gravity regimes, respectively. As a result, the magnitude of the CSFD in the equilibrium saturation on the thin regolith layer would be smaller than that on the thick regolith, although the modification speed of the crater morphology on the thicker regolith layer is fast. The former characteristic let us to determine the relative surface age in the first-order approximation. In the future missions, we will be able to estimate the mostly absolute surface age if the accurate relationship between the crater diameter on the lunar surface and the structure under the lunar surface will become apparent.