LUNAR CRATERING CHRONOLOGY: STATISTICAL FLUCTUATION OF CRATER PRODUCTION FREQUENCY AND ITS EFFECT ON AGE DETERMINATION. T. Morota[1], J. Haruyama[1], C. Honda[1], Y. Yokota[1], M. Ohtake[1] and T. Matsunaga[2], [1]Institute of Space & Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Sagamihara 229-8510, Japan (morota.tomokatsu@jaxa.jp), [2]National Institute for Environmental Studies.

Introduction: The crater size-frequency distributions (CSFD) of various features on terrestrial planets and satellites have been used for determination of its formation ages. However, the crater frequency is complicated by contamination by secondary craters [e.g., 1, 2], horizontal heterogeneity of surface structure [e.g., 3], the spatial variation in crater production rate [4], the effect of the photometric condition on the crater detectability [e.g., 5], a statistical fluctuation of the crater production frequency, etc.

A Japanese lunar explorer, SELENE, will be launch in 2007. Terrain Camera (TC) installed on SELENE will take images of surface of the whole Moon with nominal spatial resolution of 10 m/pixel [6, 7]. The extensive high-resolution images are feasible for the statistical study of crater distribution. Therefore, it is necessary to evaluate the error of the dating technique before the new image data are acquired. The purpose of this study is to evaluate errors in age determination due to statistical fluctuation of crater production frequency by a simple numerical simulation.

Numerical Simulation: We randomly sample craters according to a power-law probability distribution $P(D) \propto D^{-b}$, where D is crater diameter and $P(D)$ is a probability that crater larger than D is sampled. The size-frequency distribution of the sampled craters is measured and converted to the age using the lunar cratering chronology curve [8]. Iterating this procedure, we evaluate the fluctuation of the CSFDs and the error of age determination due to the statistical fluctuation. Here we use b=3.4. The exponent is well fitted for a size distribution of lunar sub-kilometer craters [e.g., 2].

We suppose test geological units assigned various areas and ages. In each case, craters are sampled by the time the number of the sampled craters amounts to an ideal crater frequency calculated from the area and the age using the cratering chronology curve [8] and the power-law size-frequency distribution, $N(D) \propto D^{-3.4}$. The minimum size of the sampled craters is set at 7 m in diameter. We postulate that a minimum size of detectable crater is 70 m in diameter since the nominal resolution of the TC image is 10m. Therefore, we use craters ≥ 70 m for CSFD measure.

According to previous studies by impact experiments and simulations [e.g., 9], crater saturation equilibrium occurs between $N(D=1)$ = 0.015 ~0.15 and the CSFD exponent of saturated craters is close to -2. In general, a number density of craters smaller than a few hundred meters in diameter on lunar maria is expected to reach the saturation level [e.g., 10]. In our simulation, saturated craters must be excluded from CSFD measure. We judge as "saturation equilibrium condition" when the crater density is higher than $N(D) = N_e D^{-2}$. We use N_e = 0.015, 0.045, and 0.075 km^{-2}.

Results and Discussion: Firstly, we investigate a fluctuation of estimated CSFD exponents. Figure 1 shows the estimated exponent as a function of the number of sample craters. The exponent is slow to converge. To estimate the exponent of the crater population CSFD with accuracy, craters more than 1000 must be used. From Fig.1, it can be seen that the maximum likelihood method qualifies for estimate of the exponent of crater population CSFD compared to the least squared method.

Figure 2 shows a comparison between the average of estimated ages and the assigned age to the test geological unit. The ages estimated for units of 2.5-3.5 Gyr have tendency to be too small when the numbers of craters are insufficient, because the cratering chronology curve has an inflection point at 3.2 Gyr.

Figure 3 displays the histogram of age estimated for each test unit. The ages estimated for units of 2.0-3.0 Gyr are largely dispersed. In Fig. 4, the standard deviation of estimated ages is shown as a function of the assigned age to the test geological unit. We can see that age determination for Eratosthenian units is most inaccurate. The standard deviations are ~0.5 Gyr for units of 1000 km^2 and ~0.7 Gyr for units of 100 km^2, respectively.

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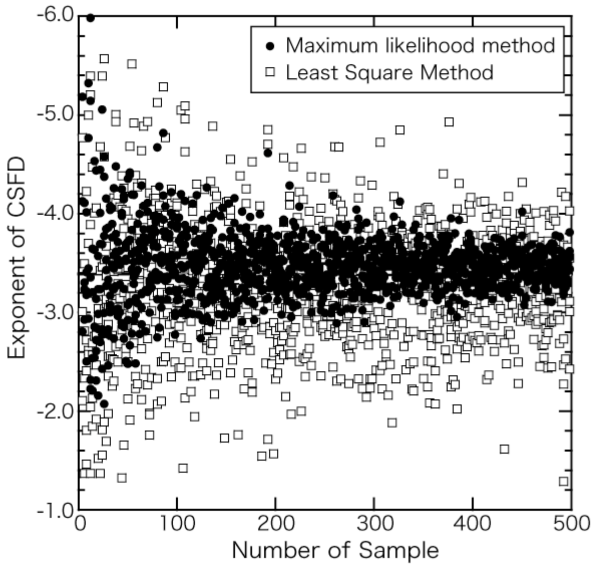

Fig. 1. Exponent of the power-law fitted to CSFD for the sampled crater set. Assigned exponent to the crater population is –3.4.

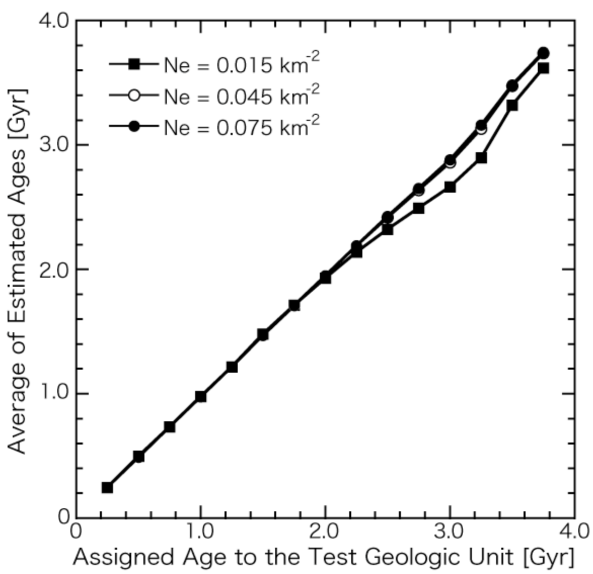

Fig. 2. Comparison of the average of estimated ages and the assigned ages to the test geologic units in the case of area = 1000 km^2.

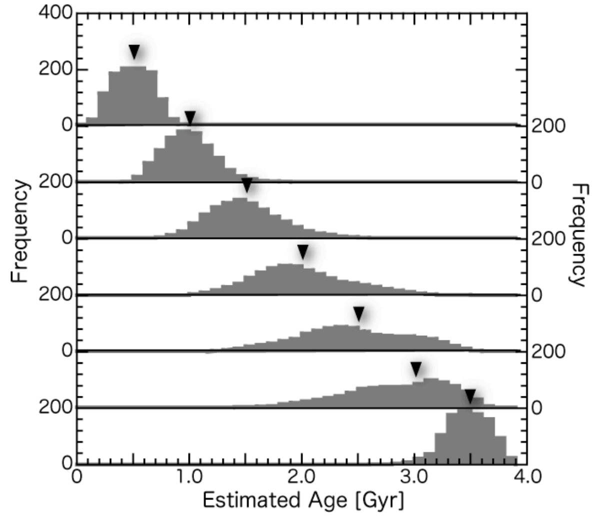

Fig. 3. Histogram of estimated ages in the case of area = 1000 km^2 and N_e=0.015. Filled inverse triangle indicates the age assigned to the test geological unit.

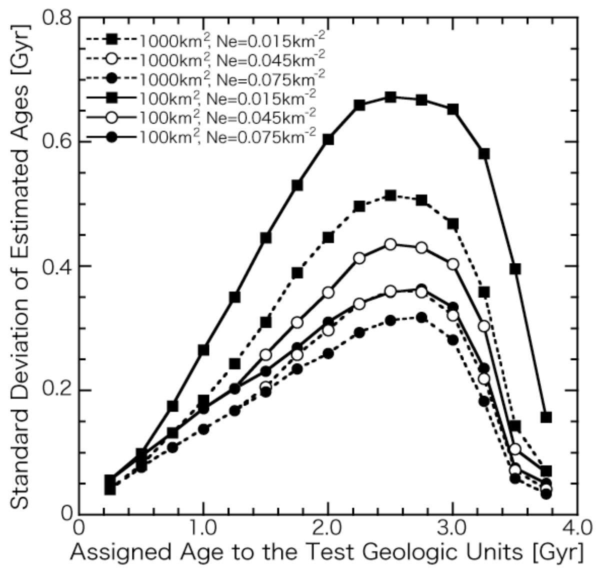

Fig. 4. Standard Deviation of estimated ages as a function of the age assigned to the test geological unit.