Cratering chronology: Statistical fluctuation of crater production frequency and its effect on age determination

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Dating of geological units of planetary surfaces is one of the most important subjects of planetary science for understanding of its origin and evolution. According to simple idea that older surfaces accumulate larger numbers of craters, we can infer relative ages by the measurement of the crater frequencies with image data. Furthermore, the lunar cratering chronology formulated by relating crater frequencies to the radiometric ages of Apollo and Luna samples allows us to convert the crater frequencies into absolute ages. The dating method by crater counting has been widely used to infer the lunar geological history. However, the crater frequency is complicated by contamination by secondary craters, horizontal heterogeneity of surface structure, the spatial variation in crater production rate, the effect of the photometric condition on the crater detectability, a statistical fluctuation of the crater production frequency, etc. 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.

We randomly sample craters from a crater population with a power-law size distribution $N(D)=aD^b$, where D is crater diameter and N(D) is the number of craters larger than D. The size-frequency distribution of the sampled craters is measured and converted to the absolute age using the lunar cratering chronology curve. Iterating this procedure, we evaluate the fluctuation of the CSFDs and the error of age determination due to the statistical fluctuation.

As a result, we find that the ages estimated for units of 2.5-3.5 Gyr have tendency to be too small when the numbers of craters are insufficient. We also find 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.