

EFFECT OF SUN ELEVATION ON CRATER SIZE-FREQUENCY DISTRIBUTION. C. Honda¹, S. Ono^{1,2}, T. Morota¹, T. Okada¹, J. Haruyama¹, M. Ohtake¹, M. Kato¹, ¹Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Sagami-hara, Kanagawa 229-8510, Japan. (chonda@planeta.sci.isas.jaxa.jp), ²Department of Earth and Planetary Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan.

Introduction: For evaluation of the surface evolutions of planetary bodies, the crater size-frequency distribution (CSFD) has been used to estimate the surface age, conveniently. The CSFD which is revealed as the function between the crater diameter and its crater number (cumulative or incremental) is described by a inverse power-law distribution, $\sigma(D) = \alpha D^{-\beta}$, where σ is the crater number density ($1/\text{km}^2$), D is the crater diameter, β is the slope of power-law, and α represents a magnitude of power-law. The index, $-\beta$, is usually a constant close to -2, however, increase the slope (-3.4) between 0.3 and 4 km [1]. Assuming that the erasing of crater morphology did not exist, the value of α without the range of $0.3 \text{ km} < D$ is proportional to the planetary surface age, because the CSFD of this diameter range had been produced by the projectiles scattering throughout the interplanetary space [e.g., 2].

To derive meaningful age constraints, we should consider attentively a detection of small craters. We should pay a careful attention to the observation condition, such as sun-elevation (or incident angle). The articulation of detection of small features on the planetary surface is prospected to increase with decrease of sun-elevation, except for the terminator area between day and night (sun-elevation $\sim 0^\circ$) which tends to be hidden by shadows of topographic undulation. If the effect of illumination condition to the detection of craters or the CSFD is not negligible, we could compare with each CSFD obtained from images taken at same lighted condition for the age determination. For a realistic correction of obtained CSFDs, Young (1977) demonstrated that the measured crater diameter judging from shadow in a certain crater increases by 1 m per degree as sun-elevation decreases. Young (1977) suggested that the difference of CSFDs obtained at the different sun elevations Young (1975) suggested that the difference of CSFDs obtained at the different sun elevations mainly occurs as an increase in apparent diameters of all craters rather than a real increase in the total number of craters visible. On the other hand, Boyce and Dial (1975) referred to the measured crater diameter variation of 19 % through a sun-elevation in the range of $5 - 54^\circ$, which reveals independent on a function of sun-elevation in the range of $13 - 47^\circ$. Since these studies, the detection

limit whether the craters degraded by the number of much smaller impact cratering or by ejecta blanket from adjacent large cratering was rarely referred. Wilcox et al. (2003) suggested that the difficulty of detection of small craters at the condition of high sun-elevation exists, while the difference of spatial resolution between each image is very large. It is necessary to compare with the result of crater detection at the mostly same spatial resolution and exposure time to take image for the assessment of sun-elevation effect.

To investigate the degree of effect of illumination condition for further discussion about the CSFD or small topographic features is important procedure.

Method and results: We examine the CSFD of 10 areas (Fig. 1). Each area was taken by Apollo 15 – 17 spacecraft at the condition of different sun-elevation. All images are available from Apollo Image Atlas/LPI web-site. The images were digitized from the printed pictures with nearly same scanning condition, that is to say same quality. The resolution of each image is about 70 m. We had selected 45 images. Furthermore, to avoid the complication of co-existing primary and/or secondary craters, we examined ordinary area in each picture which does not include apparent secondary craters. Using the CSFD of each picture (Fig. 2), we compared with each cumulative number of craters at 1 km in diameter (Fig. 3). In Fig. 2 and Table 1, we recognized obvious decrease of craters as a sun elevation increase. In the current status, the cause of decrease of craters is miscount of degraded craters, in addition to the miss judgement of measurement of rim-to-rim diameter [3]. Especially, a large difference of surface age estimation because of sun elevation appears in young area (e.g., area 6). It is linked that a crater production function younger than 3.0 Gya decrease gently. We should select the image with low sun elevation, because we would like to know the end of volcanic activity for one of goal of understanding of evolution of the Moon.

References: [1] Melosh, H. J., Impact cratering: A Geologic Process, New York, Oxford Univ. Press, 253 pp., 1989. [2] Basaltic Volcanism Study Project, *Basaltic Volcanism on the Terrestrial Planets*, pp. 1049-1127, New York, Pergamon, 1981. [3] Young, R. A., *LPSC*, 8th, 3457-3473, 1977. [4] Boyce, J. M., and A. L. Dial, Jr., *LPSC*, 6th, 2585-2595, 1975. [5] Wilcox, B. B., et al., *LPSC*, 34th,

#1877, 2003. [6] Hiesinger, H., et al., *JGR*, Vol. 105, E12, 29239-29276, 2000. [7] Hiesinger, H. et al., *JGR*, Vol. 108, E7, CiteID 5065, 2003. [8] Neukum, G., et al., *Chronology and Evolution of Mars*, 96, 55-86, 2001.



Fig. 1, Examined areas which are patched purple.

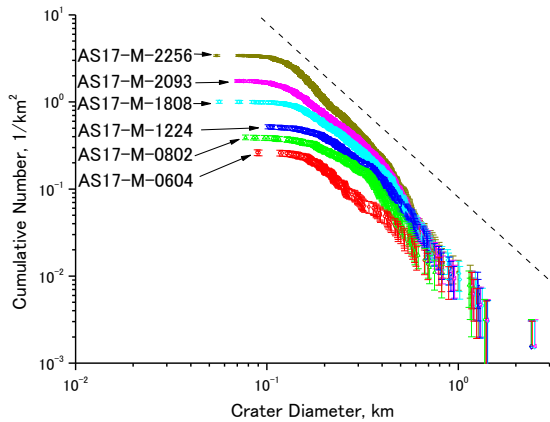


Fig. 2, Example of result of CSFDs (area 8) is shown Fig. 1 (Area 8). Dashed line reveals 7% saturation equilibrium.

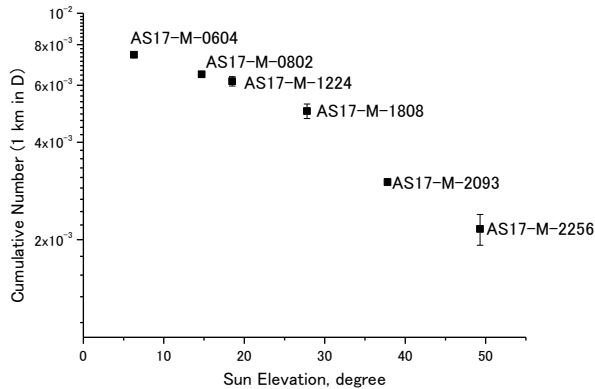


Fig. 3, Example of result of comparison of cumulative number of craters at 1 km in diameter (Area 8).

Table 1, Summary of results compared with Hiesinger’s result [6, 7].

	Hiesinger		This study			
	age, Gya	error	Picture number	Sun Elevation, deg	age, Gya	2σ
Area 1	3.45	+0.05	AS15-M-0597	5.8	3.741	0.004
		-0.06	AS15-M-1004	10.3	3.722	0.004
			AS15-M-1146	15.6	3.691	0.004
			AS15-M-1687	20.5	3.709	0.006
			AS15-M-1829	26.0	3.67	0.01
			AS15-M-2315	41.1	3.52	0.02
			AS15-M-2454	48.1	3.57	0.03
Area 2	3.55	+0.05	AS17-M-0604	4.5	3.640	0.002
		-0.09	AS17-M-1227	16.3	3.589	0.006
			AS17-M-1811	25.8	3.55	0.02
			AS17-M-2694	51.4	2.2	0.1
Area 3	3.44	+0.03	AS17-M-0449	10.7	3.586	0.005
		-0.06	AS17-M-0797	19.0	3.599	0.009
			AS17-M-1503	23.6	3.51	0.03
			AS17-M-1806	32.2	3.44	0.02
			AS17-M-2253	53.5	3.41	0.03
Area 4	3.37	+0.07	AS16-M-1680	11.5	3.610	0.004
		-0.09	AS16-M-2199	21.3	3.567	0.007
			AS16-M-2817	32.6	3.539	0.007
Area 5	3.45	+0.05	AS15-M-1010	3.2	3.04	0.05
		-0.06	AS15-M-1152	8.5	3.26	0.04
			AS15-M-1693	13.4	1.93	0.06
			AS15-M-1835	18.9	2.6	0.1
			AS15-M-2727	43.1	1.66	0.07
Area 6	3.10	+0.09	AS17-M-2292	4.7	2.00	0.06
		-0.14	AS17-M-2728	8.8	1.52	0.05
			AS17-M-2920	17.5	1.39	0.04
Area 7	3.30	+0.05	AS15-M-2076	16.9	3.708	0.005
		-0.06	AS15-M-2333	19.9	3.686	0.006
			AS15-M-2472	25.7	3.672	0.006
			AS15-M-2740	26.9	3.690	0.004
Area 8	3.44	+0.03	AS17-M-0604	4.5	3.625	0.003
		-0.06	AS17-M-0802	12.7	3.591	0.003
			AS17-M-1224	20.1	3.578	0.008
			AS17-M-1808	29.7	3.51	0.02
			AS17-M-2093	38.2	3.24	0.02
			AS17-M-2256	49.8	2.6	0.3
Area 9	3.30	+0.05	AS17-M-0807	6.3	3.486	0.008
		-0.14	AS17-M-1512	12.1	3.39	0.02
			AS17-M-1815	20.8	3.35	0.04
			AS17-M-2893	51.3	2.7	0.5
Area 10	n/a		AS16-M-1280	10.2	3.899	0.003
			AS16-M-1968	20.9	3.849	0.006
			AS16-M-2193	28.8	3.76	0.01
			AS16-M-2811	40.1	3.75	0.02

Age of this study is estimated using Neukum production function [8]. The age derived from low sun elevation image would be accurate.