THE UNRELIABILITY OF SMALL CRATER COUNTS: A CASE STUDY IN SINUS IRIDUM ON THE MOON. Yuan Li[1] , Zhi Yong Xiao[2], Zesheng Tang[1], [1]Space science Institute, Macau University of Science and Technology, Macao (lysongly@sina.com), [2]Faculty of Earth Sciences, China University of Geosciences (Wuhan), Wuhan, Hubei, 430074, P.R.China.

Introduction: Estimating crater size-frequency distributions and densities is a fundamental and widely used technique in dating ages for planetary surfaces. With the available of more and more high-resolution images, planetary geologists are trying to study evolutionary histories for small geological units on Solar System bodies by counting small impact craters (D<1 km). However, the reliability of small crater counts has been questioned since the early 1960s [1] and has been seriously debated since then. The major concern of this techenique is about the contamination of secondary craters (i.e., secondaries) in the crater counting results. Some secondaries form from high-velocity impacts of ejecta that have large ejection angles. Named distant secondaries, they have a similar morphology with same-szied primary craters (primaries) that are caused by bolide-impacts of asteroids or comets. Distant secondaries are widespread on planetary surfaces and hard to be clearly discern from primaries. Hartmann [2, 3, 4], Ivanov [5] and many others argued that except for small secondary crater chains and clusters, most small craters (D<1 km) on the Moon and Mars are primaries. Recent studies by Bierhaus et al. [6], McEwen and Bierhaus [7], Xiao and Strom [8] and others challenged this argument and suggested that the small crater populations on terrestrial planets are dominantly distant secondaries, therefore rendering results of crater counting unreliable. Here, we revisit this problem using new data obtained from the Chang'E-2 (CE-2) and Lunar Reconnaissance Orbiter (LRO) spacecrafts to count small craters in Sinus Iridum on the Moon.

Research material and method: Sinus Iridum is a bay area of flooded basalt at the lunar nearside (44 °N, 32 °E). Previous study [9] performed stratigraphic, lithological and geological research for this region. Hiesinger et al. [9] dated different mare units within Sinus Iridum by counting craters. Here we repeated the counts of Hiesnger et al. [2000] using the small crater population (D<1 km) in this area in higher resolution images.

Using images obtained from the CE-2 mission (7 m/pixel), we counted craters in a diameter range of ~200-500 m for five mare surfaces within Sinus Iridum (Fig.Fig. 1). Areas 1 and 2 have a same model age of 3.01 Ga in Hiesinger et al. [9]. The model ages for Areas 3 and 4 are 3.26 Ga and that for Area 5 is 3.39 Ga [9]. We then selected ten smaller surfaces (Fig.Fig. 1), two for each of the counting area in CE-2 data, in images obtained from the Lunar Reconnaissance Orbiter Camera, Narrow Angle Camera (LROC NAC, ~0.5-2 m/pix; Robinson et al. [10]). Each counting area in LROC NAC images are larger than 1 km^2 in area and craters from ~10-100 m in diameter were counted. The counting areas are away from impact rays, crater clusters or chains, and chaotic terrains in order to reduce the containmination of secondaries as others have advocated [11].

Results and discussions: We compared the crater size-frequency distributions (SFD) for the counting areas in relative plot (R plot) [12]. Fig. 2 shows the results. Major results shown in this plot are the following:

(1) Craters counted in CE-2 images (D>~200 m) exhibit steep SFD curves in R plot and their differential slopes are about -4 or smaller [8, 13]. This indicates that the small crater populations in these areas, and possibly in the whole Sinus Iridum, are dominated by secondaries [8].

(2) Areas 1 and 2 have a same model age according to the crater counts of [9]. They have a similar relative crater density within error bars in the CE-2 counts (Fig. 2A). However, Areas 1 and 2 have different relative crater densities for craters smaller than 100 m diameter in the LROC NAC counts (Fig. 2A). These phenomena are also observed in the crater count results for Areas 3 and 4 (Fig. 2B).

(3) Area 2 has a smaller model age, thus a lower crater density, than Area 4 in the counts performed by [9]. In our plots, Area 2 has a larger density than Area 4. This observation is identical with previous findings that distant secondaries are not uniform on lunar surfaces [8, 14].

(4) In the LROC counts, Areas 1-5 have a somewhat similar crater density within error bars. This contradict the results of [9].

(5) The SFD curves of craters counted in LROC NAC images have complicate shapes. This is probably caused by crater saturation [15]. Theoretically, an impact crater forms more secondaries at smaller diameters. Smaller craters on lunar surfaces should have a larger percentage of secondaries compared with larger craters. The SFD curves in the LROC counts (Fig. 2) should have steep slopes similar with typical secondaries populations [8].

Conclusions: This case study shows that small crater counts are problematic in dating surfaces on the Moon. The small crater population on the Moon (D<1 km) is dominated by secondaries that vary in density at different locations. Our future work will (1) use the small crater counts to test potential discrepancies in dating abosolute model ages; (2) look for potential solutions to avoid this problem.

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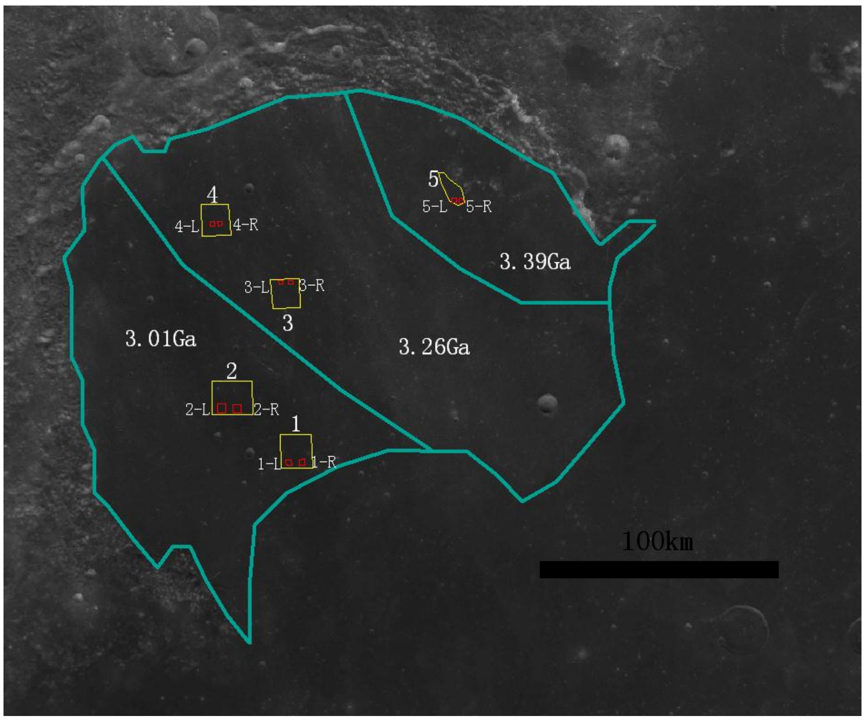

Fig. 1. Panchromatic image of Sinus Iridum with different geological units (bule lines). Five areas (yellow circles) titled 1, 2, 3, 4, 5 are selected as the counting areas in CE-2 images. Ten small areas (red circles; L-left, R-right)are selected as the counting areas in LROC NAC images. The squares are not to real scale. The base image is in Moll-weide projection (7 m/pixel).

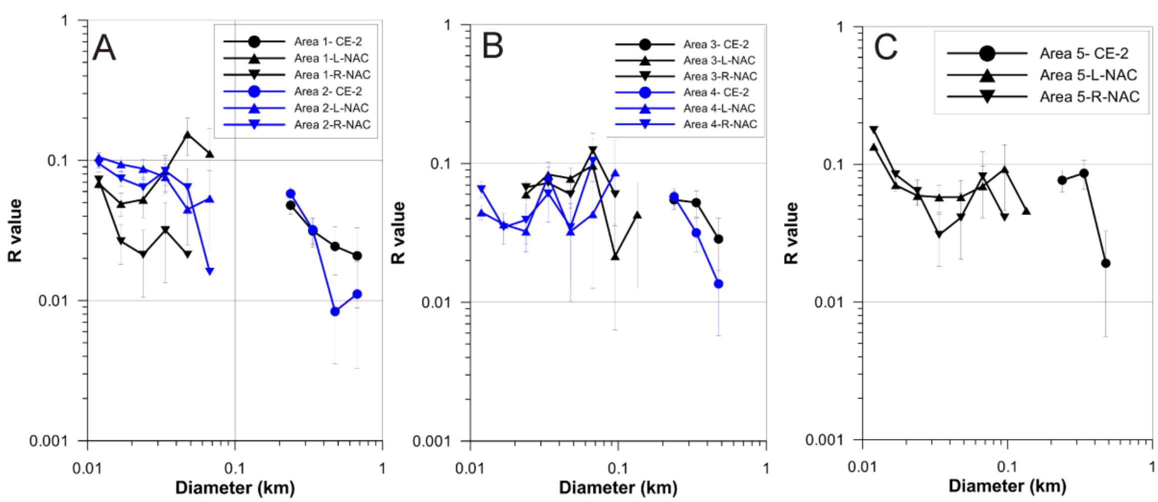

Fig. 2: R plot curves for the counting areas shown in Fig. 1.