A RELOOK AT THE ORIGIN OF SMALL FRACTURES IN THE FLOOR OF LUNAR COPERNICAN-AGED COMPLEX CRATERS. Zhiyong Xiao[1], Zuoxun Zeng[1], and Zhiyong Li[1]. [1]Faculty of Earth Sciences, China University of Geosciences (Wuhan), Wuhan, Hubei, China, 430074 (xiaobeary@gmail.com).

Introduction: In the floor of lunar Copernican-aged complex craters (diameter *D*>15 km), small fractures that are tens to hundreds of meters wide and kilometers long are common features. Xiao et al. [1, 2, 3] studied the morphological, geometrical, and distribution characteristics for the small fractures (<1 km wide). Some of the fractures have a similar morphology with pit chains on Mars which are interpreted to have a tectonic origin [4]. Xiao et al. [3] suggested that some of the fractures were recently formed extensional ones caused by laccolith/dike intrusion beneath crater floors, or that solidification contraction of impact melt had formed some of the fractures. Recent studies [e.g., 5, 6, 7] provide additional evidence that late-stage tectonism and volcanism are occurring on the Moon. However, given that such fractures occur in floors of almost all Copernican-aged complex craters, shallow volcanism on the Moon is not likely to be that intense or widespread. On the other hand, morphologically similar fractures, though not with same scale, are observed in buried impact craters on Mercury [8, 9]. Classified as graben, these mercurian fractures were interpreted to be caused by thermal contraction in the filled lava in the craters [8, 9]. Understanding the origin of the small fractures in floors of lunar Copernican-aged craters is helpful to (1) better understand the geological evolution of impact craters; (2) shade light on the intensity of late-stage tectonism and volcanism on the Moon. Here we reinvestigate the morphology for the small fractures in floors of lunar Copernican-aged complex craters to reevaluate their possible origins.

Methodology: Several Copernican-aged complex craters on the Moon, including Copernicus (*D*=93 km; 10 °S, -20 °E), Tycho (*D*=85 km; 43 °S, -11 °E), Aristarchus (D=40 km; 24 °N, -47 °E), and Giordano Bruno (*D*=22 km; 36 °N, 103 °E), are selected for this study. High-resolution images (as good as 0.5 m/pixel) obtained from the Kaguya Terrain Camera (TC) [10], Narrow Angle Camera of the Lunar Reconnaissance Orbiter Camera (LROC NAC) [11] and Lunar Orbiter (LO) are used to study the morphological, geometrical and distribution characteristics for the fractures. Based on these observations, we analyzed their possible formation mechanisms.

Morphology of the Fractures: The small fractures in floors of lunar Copernican-aged complex craters are classified into two groups judging by their occurrence and morphology (e.g., Figs. 1-2). Those occurring around borders of crater walls and floors are circular in the planar view and groups of closely-spaced (<100 m) subparrallel fractures usually occur together. Termed "Ring fractures (RFs)", these fractures are narrow and have steep slopes in appearance. The RFs in Aristarchus are not as pristine in preservation state as those in Tycho (Fig. 1A *vs* Fig. 2A). Another type of fractures in the crater floors are located closer to the crater centers than RFs (Figs. 1-2). The fractures have no optimized orientation and some form polygonal patterns in the crater floors. The edges of the polygons are sometimes composed by several closely-spaced subparrallel fractures (e.g., Fig. 1B). Named "randomly-distributed fractures (RDFs)", these fractures are generally wider than RFs in a same crater [3]. RDFs in Aristarchus are fewer and more eroded than those in Tycho (Fig. 1B *vs* Fig. 2B). Both RFs and RDFs occur in relatively flat areas in the crater floors, especially for RDFs.

Possible Formation Mechanisms: Morphologically similar fractures on planetary bodies may have different origins including solidification contraction [8, 9], isostatic adjustment [12], subsidence of melt and/or fill [13], and shallow dike intrusion [3, 5]. The observed RFs and RDFs in floors of Copernican-aged complex craters do not have associated compressional structures. This observation suggests that the scenarios of isostatic adjustment and subsidence of melt and/or fill may not be appropriate to explain their origin. Shallow dike intrusion could form similar features on planetary surfaces [5], but it is unlikely that intense volcanism have widely occurred in the shallow crust of the Moon to form such common features in young crater floors [3].

During an impact process, impact melt collect in crater floors after the end of the excavation stage. Different crystallization rate in impact melt could form extensional fractures (e.g., column joints) which are similar in morphology with those developed in terrestrial lava pools [14]. For the observed small RFs and RDFs in fresh lunar craters, solidification contraction is the most plausible model to explain their origin. The reason is threefold: (1) RFs and RDFs mostly occur in relatively flat areas in crater floors that are covered by impact melt; (2) RFs and RDFs are observed in almost all Copernican-aged lunar complex craters; (3) Cooling fractures developed in pure impact melt pools have a similar distribution pattern with RFs and RDFs (Fig. 3), as subparrallel ring fractures occur around rims of impact melt pools and randomly-distributed fractures occur in the center.

Conclusion and Outlook: We studied small fractures in floors of several lunar Copernican-aged complex craters. Their morphological and distribution characteristics suggest that solidification contraction may be the most plausible formation mechanism.

Finite element modeling and physical simulations will be used to test this hypothesis.

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References: [1] Xiao Z. et al. (2010) *LPS XXXXI*, Abstract #1526. [2] Xiao Z. et al. (2010) *LPS XXXXI*, Abstract #1034. [3] Xiao Z. et al. (2010) *Science China Physics, Mechanics&Astronomy*, *53(12)*, 2145-2159. [4] Ferrill A. D. et al. (2004) *GSA Today*, *10 (14)*, 4–12. [5] Watters T. R. et al. (2010) *Science*, *329*, 936-940. [6] Watters T. R. et al. (2012) *Nature geoscience*, *5*, 181-185. [7] Banks M. E. et al. (2012) *J Geophys Res*, *117*, E00H11. [8] David M. B. et al. (2012) *J Geophys Res*, in press. [9] Watters T. R. et al. (2012) *Geology*, in press. [10] Kato M. et al. (2008) *Adv. Space Res. 42*, 294–300. [11] Robinson M. S. et al. (2010) *Space Sci Rev*, *150*, 81 –124. [12] Phillips R. J. et al. (1976) *LPS*, 688-690. [13] Solomon S. C. and Head J. W. (1979) *J Geophys Res*, *84*, 1667-1682. [14] Lachenbruch A. H. (1961) *J Geophys Res*, *66 (12)*, 4273-4292.

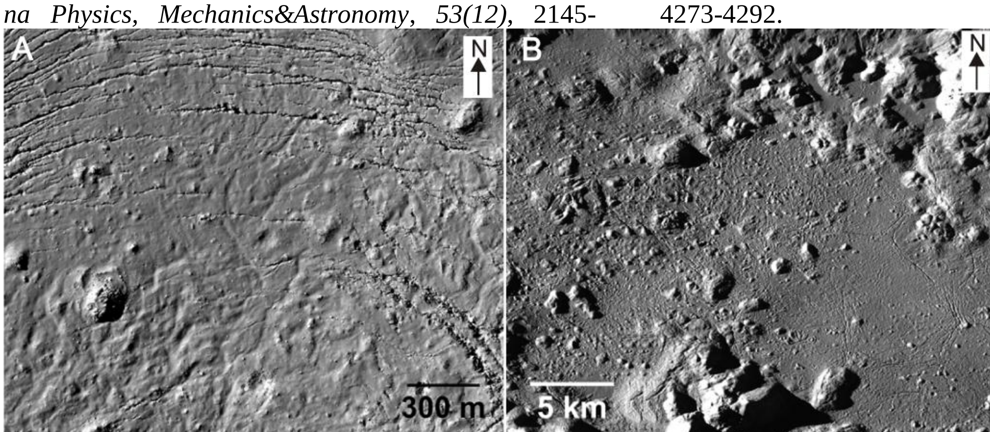

Fig. 1. RFs (A) and RDFs (B) in the crater floor of Tycho. The base images of (A) and (B) are from LROC NAC M104584909LE and Kaguya TC_EVE_02_S42 E348S45E351SC, respectively.

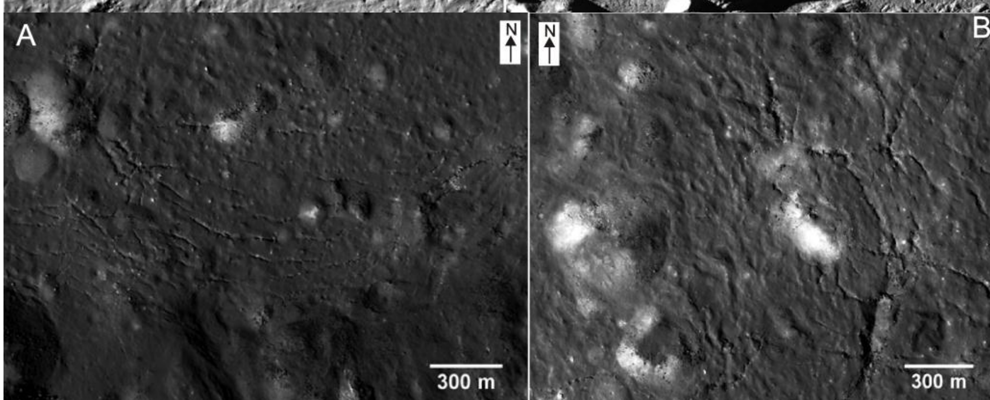

Fig. 2. RFs (A) and RDFs (B) in the crater floor of Aristarchus. The base image of both (A) and (B) are from LROC NAC M104826902L.

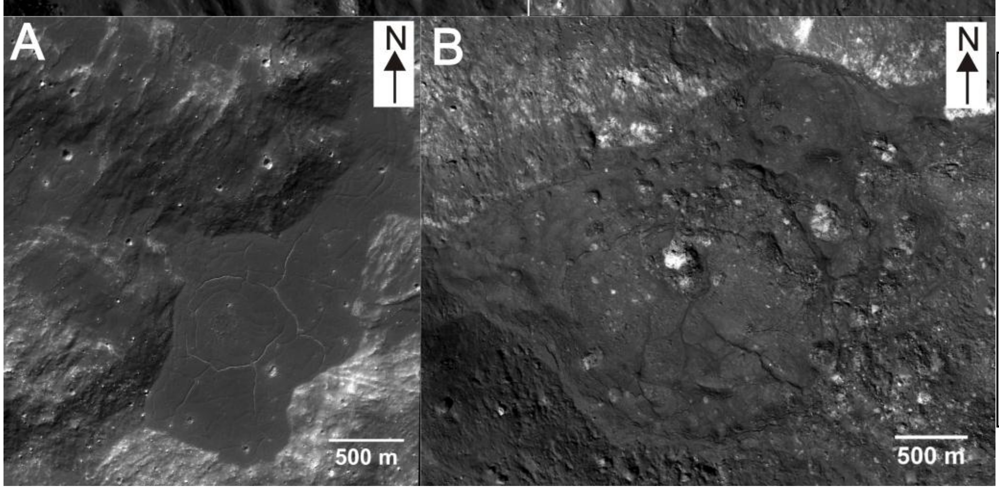

Fig. 3. Extensional fractures caused by solidification contraction in impact melt. (A) An impact melt pool on the eastern rim of Tycho. (B) An impact melt pool in the floor of Giordano Bruno.