FRESH TRANSITIONAL LUNAR IMPACT CRATERS. J. Clayton[1], G. R. Osinski[1], L. L. Tornabene[1, 2], J. D. Kalynn[3], and C. L. Johnson[3,4], [1]Centre for Planetary Science and Exploration/Dept. Earth Sciences, Western University, London, ON N6A 5B7, Canada [2]SETI Institute, Mountain View, CA 94043, USA, [3]Dept. of Earth, Ocean and Atmospheric Sciences, University of British Columbia, BC V6T 1Z4, Canada, [4]Planetary Science Institute, Tucson, AZ 85719, USA (jclayto6@uwo.ca; gosinski@uwo.ca; ltornabe@uwo.ca).

Introduction: Impact cratering is an important geological process that occurs throughout our Solar System. On Earth, it is difficult to conduct morphological studies of impact craters due to active surface processes (e.g., plate tectonics, weathering, etc.). However, the Moon provides fresh and well-preserved craters with minimal post-impact modification. In general, impact craters are subdivided into two main groups based on morphology: simple and complex. Complex craters are then sub-classified according to their central uplift. Studies of lunar complex craters have long shown that there is a progression with increasing crater size from central peak, central-peak basin, to peak-ring basins [1].

On the Moon, the transition from simple to complex occurs at an average diameter of 19 km [2]. This transition diameter, D_t, has been reported as being dependent on target (Mare, D_t = 16 km; Highlands, D_t = 21 km) where the larger onset diameter has been explained by a less stratified target [2]. However, there is a small but significant group of craters that cannot be defined as simple or complex. Instead, there are termed "transitional". The mechanisms by which transitional craters form and the relationships to large simple craters and small complex craters are poorly understood and are the focus of this study.

Methodology: We constructed a database of transitional craters based on a database of 111 'fresh' craters of Eratosthenian (3.2-1.1 Ga) age or younger and diameters, $D \geq 15$ km, compiled in the recent study of lunar complex craters by Kalynn et al. [3, 4]. We define a transitional crater here as a flat-floored crater that does not display the deep bowl-shaped form of a simple crater and that lacks a central uplift emergent through the crater-fill. Transitional craters often display slumps and even terraces in some cases. Lunar Reconnaissance Orbiter Camera (LROC) images within the Java Mission and Remote Sensing (JMARS) for Earth's Moon software package [5] was used to map out terraces within craters as a function of their diameters. In order to map terraces, multiple datasets were needed. The LROC Wide-Angle Camera (WAC) mosaic data set served as a basis for studying the crater and LROC Narrow-Angle Camera (NAC) data was used where possible. In addition, the Lunar Orbiter Laser Altimeter 512 pixels per degree (ppd) Topography layer and 3D layer function in JMARS were both used.

Results and Discussion: There is considerable variation in the morphology of transitional craters, both with increasing diameter and between craters of similar size. We found transitional craters in mare targets from 15 to 42 km in diameter (Fig. 1), and from 21 to 38 km diameter in highlands terrains (Fig. 2).

Variations between Mare and Highlands. Figure 3 shows a plot of the number of terraces versus crater diameter. The trend in the plot shows that the number of terraces increases at smaller diameters in the mare vs. highlands targets. It is hypothesized that this could be due to the layered nature of the mare target, which aids crater collapse. This is consistent with studies of terrestrial craters, which show that complex crater morphologies form at smaller diameters in layered, sedimentary targets versus crystalline rocks [6].

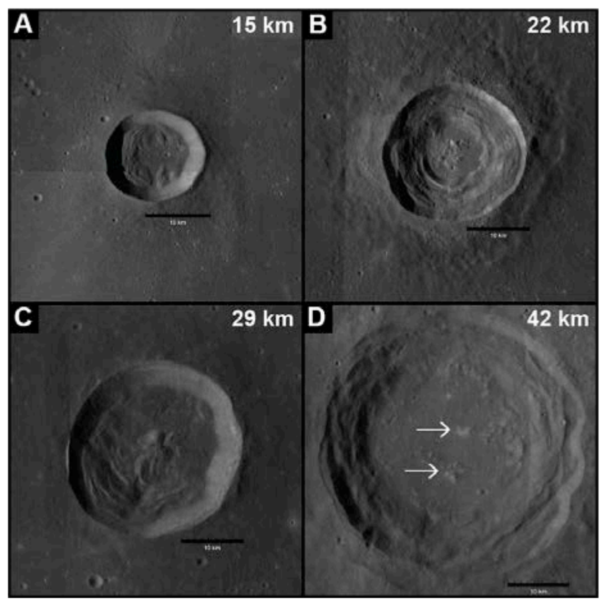

Figure 1: Comparison of transitional craters in Mare target. (A) Bessel (15 km, 21.80N, 17.9E); (B) Picard (22 km, 14.60N, 54.7E); (C) Reiner (29 km, 7.00N, 305.1E); (D) Reinhold (42 km, 3.30N, 337.2E). (LROC WAC Mosaic).

Variation within Mare: Bessel is the smallest crater of the study and has no terraces present. The relatively flat floor is made up of melt and crater-fill deposits and partially coherent slumped material along the walls. Compared to Bessel, Picard has a slightly larger diameter (by about 7 km) yet the changes in morphology are dramatic. Picard displays concentric terracing with a relatively flat floor consisting of crater-fill and melt deposits. At 29 km diameter, Reiner has very irregular terracing that dominates the southern floor of the crater. There does not appear to be a dramatic increase in terracing compared to Picard. Reinhold is the largest crater of this study with a diameter of 42 km. It has several well developed terraces and two small "mounds" present off the centre of the crater, which may represent an almost emergent central peak.

Variation within Highlands: In the smallest transitional crater of study for the highlands target, Conon (d = 21 km), both terracing and slump blocks are apparent. With a slightly larger diameter of 30 km, Keeler S exhibits an irregular shaped rim with a relatively flat floor. Nicholson and Van Gent X are the largest craters within the highlands, both with a diameter of 38 km. Nicholson appears to have concentric terracing while Van Gent X has less continuous terraces.

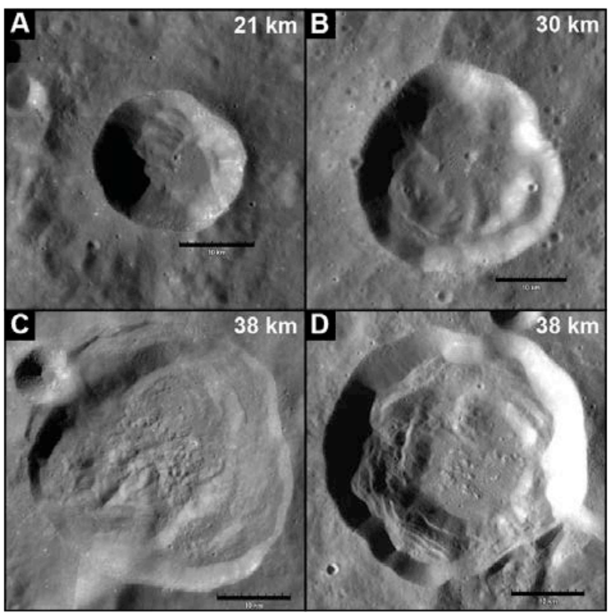

Figure 2: Comparison of transitional craters in Highlands target. (A) Conon (21 km, 21.60N, 2.0E); (B) Keeler S (30 km, 158.00N, 11.4W); (C) Nicholson (38 km, 85.10S, 26.2W); (D) Van Gent X (38 km, 159.70N, 16.4E). (LROC WAC Mosaic).

Summary: This work provides new important insights into the nature of transitional impact craters on the Moon. It is apparent that there are progressive changes in morphology with increasing crater size, with a change from slumping – that may be analogous to debris sliding in simple craters – to terrace formation, which would appear to represent large collapse along curved, listric faults, in the crater rim region.

We have also found important differences between craters of similar size in different targets, consistent with the observation from terrestrial craters of the important role that target lithology plays during crater collapse. There are also differences in morphology at similar size ranges in craters apparently formed in the same target, which suggests that other mechanisms may also be responsible for the morphological characteristics of transitional craters.

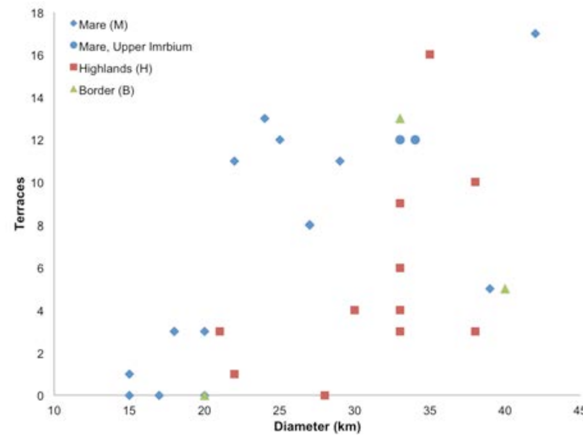

Figure 3: Plot of number of terraces versus diameter (km) for transitional craters in mare, highlands and border target.

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