ADVANCES IN UNDERSTANDING THE FORMATION, DISTRIBUTION, AND AGES OF LUNAR LOBATE SCARPS. J. D. Clark[1], C. H. van der Bogert[1], and H. Hiesinger[1], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 49149 Münster, Germany (j.clark@uni-muenster.de).

Introduction: The Moon is covered by a wide suite of tectonic features, which is evidence of both ancient and recent activity. Long-term interior cooling, tidal stresses and contraction of the Moon resulted in compressional features called lobate scarps, the surface expression of low angle thrust faults [1-4]. Their fresh morphologies and the absence of large superimposed craters (> 400 m) are evidence that these features were created in the last (< 1 Ga) [5-7].

Early investigations of lobate scarps were conducted using images from the Apollo Panoramic Camera [8]; however, new high-resolution images obtained by the Lunar Reconnaissance Orbiter Camera (LROC) [9] allow the identification of smaller and more widely distributed scarps [4, 6]. [8] determined model ages for select scarps using crater degradation techniques. These model ages coupled with the fresh morphology of the scarps [6] attest to their late Copernican ages. More recently, using crater size-frequency distribution (CSFD) measurements [10,11], [12] showed that shaking during scarp formation seems to cause local resurfacing of the small craters and allows the derivation of absolute model ages for many scarps. We applied the technique on 40 lobate scarps, to investigate the range of scarp ages and the effects of seismic shaking.

Data and Methods: Using NAC (Narrow Angle Camera) image data from the Lunar Reconnaissance Orbiter [9] and applying the technique of [12], we generated count areas in ArcGIS and conducted CSFD measurements using CraterTools [13]. In Craterstats [14], we plotted and fit the CSFDs using the techniques described in [10]. Absolute model ages (AMAs) were derived based on the chronology function (CF) and production function (PF) of [11].

Discussion: *Global Distribution.* Our results show that lobate scarps formed in the last 700 Ma [15]. The global distribution of the scarps' AMAs is spatially random [15], which is in agreement with these small-scale features being mostly created in an isotropic stress field [4]. Such a stress field would generate a homogeneous distribution of thrust faults on the Moon [4].

Seismic Shaking Effects. Young ages derived for count areas proximal to scarps suggest that small craters are destroyed during scarp formation, therefore resetting the surface age. For example, at the Mandel'shtam hanging wall, craters ≥ 20 m in diameter exhibit significant degradation, whereas craters < 20 m have fresh crater morphologies. The small craters produce a CSFD that can be fit with the lunar PF. Therefore, the pre-existing population of small craters was likely erased by seismic activity associated with scarp formation. With increasing distance from the proximal hanging wall, the AMAs generally increase (Fig.1), as would be expected if localized seismic shaking causes resurfacing. The distal locations were less affected by seismicity, such that their ages were not completely reset. Variations in the degree of local seismic shaking would be expected to cause variations in the amount of alteration to the crater population.

Conclusion: Data sets provided by recent lunar missions have allowed significant advancement in the understanding of the formation, distribution, and ages of lunar lobate scarps.

References: [1] Hartmann W.K. and Davis D. (1975) *Icarus*, 24, 504-515. [2] Cameron A.G.W. and Ward W.A. (1976) Lunar Science VII, 120-122. [3] Binder A.B. (1982) *Moon and Planets*, 26, 117-133. [4] Watters et al., (2015) *Geology*, 43, 851-854. [5] Schultz (1976) *Moon Morphology*, Austin, TX. [6] Watters T.R. et al. (2010) *Science*, 329, 936-940. [7] Binder A.B. (1986) *Papers Presented to the Conference on the Origin of the Moon*, 425-433. [8] Binder A.B. and Gunga H. (1986) *Icarus*, 63, 421. [9] Robinson et al. (2010) *Space Sci. Rev*. 150, 55. [10] Neukum (1983) *Meteoritenbombardement und Datierung planetarer Oberflächen*, Habil. Thesis, Univ. Munich. [11] Neukum et al. (2001) *Space Sci. Rev*., 96, 55. [12] van der Bogert et al. (2012) *LPSC XLIII*, Abstract #1847. [13] Kneissl et al. (2011) *PSS*, 59. [14] Michael and Neukum (2010) *EPSL*, 294, 223. [15] Clark et al., (2016) *LPSC XLVII*, Abstract #1380.

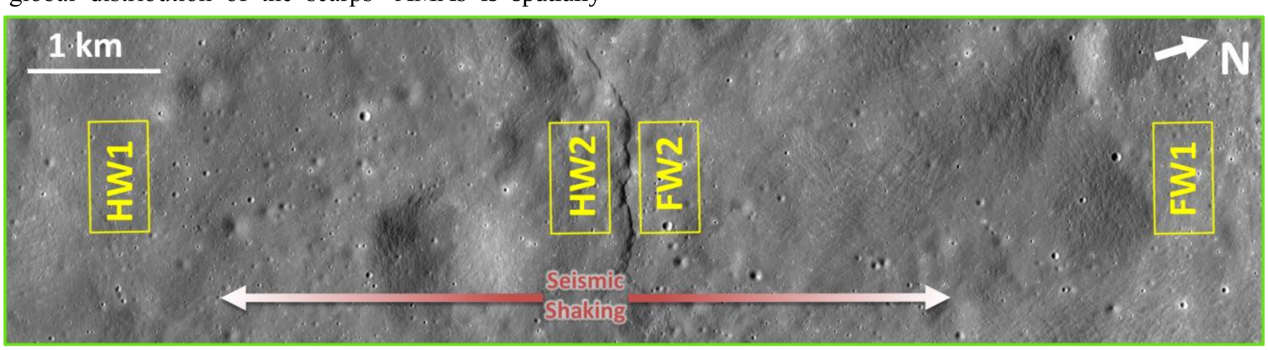

Figure 1. Location of count areas at Barrow scarp (69.9°N, 4.80°E) on NAC image pair M1116516111. The areas adjacent to the fault (HW2/FW2) typically experience more seismic shaking than their distal counterparts (HW1/FW1).