LUNAR WRINKLE RIDGES: RECENT RESURFACING? A. Valantinas[1] and K. M. Kinch[1], A. Bridžius[2,3] [1]Niels Bohr Institute, University of Copenhagen, Øster Voldgade 5-7, 1350 Copenhagen, Denmark (adomas.valantinas@gmail.com), [2]Vilnius University Observatory, Čiurlionio 29, 03100 Vilnius, Lithuania, [3]Center for Physical Sciences and Technology, Saulėtekio av. 3, 10257 Vilnius, Lithuania.

Introduction: Lunar wrinkle ridges are linear or sinuous asymmetric topographic highs that appear concentric or radial in respect to maria centers and can be up to 20 km in width, 300 km in length and up to 0.5 km in relief [1,2]. The formation of these contractional tectonic features are linked to a combination of folding and thrust faulting processes within the lunar maria. The processes that created lunar wrinkle ridges are closely tied to formation of lunar maria which continued from ~4 Ga to ~1 Ga ago [3-5].

Currently, there is evidence for very recent geologic activity taking place on the lunar surface. Endogenic volcanic activity within 100 Ma has been proposed from analysis of crater size-frequency distributions (CSFD) of several small scale structures termed Irregular Mare Patches (IMPs) [6]. Furthermore, observations of small lunar graben depths and their crater crosscutting relationships indicate recent (< 50 Ma) contractional tectonism [7]. Investigations of lunar lobate scarps using stratigraphy and CSFD measurements has also shown that they can be between 1 Ga to <100 Ma old [8,9]. For wrinkle ridges only relative ages have been analyzed using crosscutting relationships [10]. In our work we identify and report model ages for selected lunar wrinkle ridges derived using the CSFD technique. We hope that this analysis might shed new light on lunar thermal and late-stage tectonic evolution.

Methods and Data: Dating by the CSFD measurement technique has been previously used by various studies for small scale structures on the Moon such as IMPs, impact ejecta, basalt flows and lobate scarps. The latter was based on the idea that seismic shaking during the scarp formation resurfaces the area giving the date of formation of these structures [11]. We argue that a similar idea may be applicable on some lunar wrinkle ridges where seismic activity might erase small craters and reset the CSFD model age. Our count areas range from 1 - 6 km^2 to satisfy account for statistically robust area size [12]. High slopes were avoided due to mass wasting and all of the analyzed areas exhibited slopes in range from 2-16^0 which is much less than the angle of repose of lunar regolith.

In this work we use the Lunar Reconnaissance Orbiter Narrow Angle Camera (LRO NAC) data set. Age measurements on all of our selected areas were done using the JMARS [13] software package and the data analysis software CraterStats [14]. This procedure relies on well-established lunar chronology and production functions [15,16].

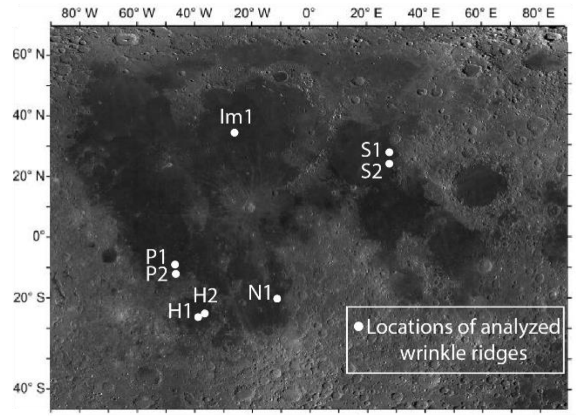

Figure 1. Global view of wrinkle ridge areas measured in this work. LRO WAC 100 m/px base map.

Results: All 8 of the analyzed wrinkle locations across the Moon are shown in Fig. 1. Selected areas for CSFD analysis have shown very low crater frequencies. This lack of craters results in low derived absolute model ages (AMAs) from our CSFD measurements, all < 30 Ma in age. One wrinkle ridge CSFD plot can be seen in Fig. 2. Coordinates and image IDs of the investigated wrinkle ridge areas is given in Table 1.

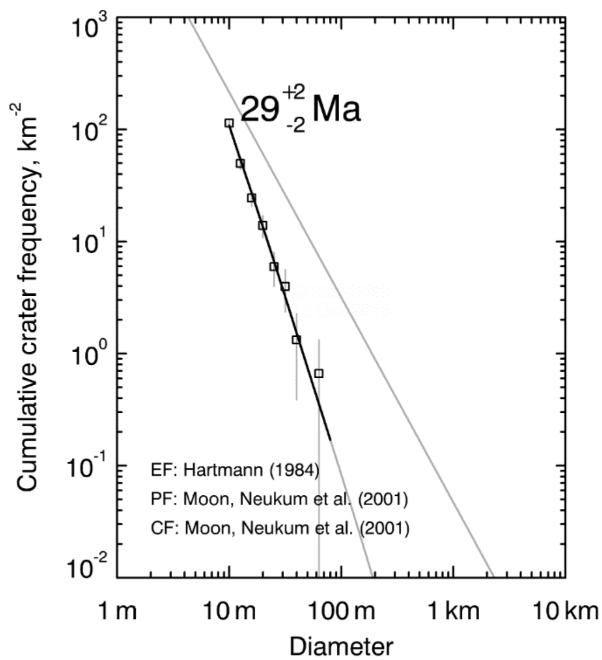

Figure 2. CSFD plot for wrinkle ridge count area Im1.

We also observe that most of the small craters, ~70 % (D=10-25 m) used for model age derivation in the count regions exhibit fresh morphologies and only the bigger craters (D > ~30 m) have a majority of degraded morphologies. Lastly, we have identified texture differences between each wrinkle ridge and the surrounding mare areas. Wrinkle ridges exhibit structures similar to 'ripples' on their surfaces, while regular mare plains are smoother. This can be seen in Fig. 3.

Table 1. Coordinates and image IDs of analyzed wrinkle ridges.

Target	Coordinates Lat, Lon	Image ID
Im1	31.13, -26.62	M166018710
S1	25.01, 29.00	M1184640003
S2	23.81, 28.68	M180980761
N1	-19.57, -10.82	M165917878
H1	-27.14, -37.37	M1173292388
H2	-25.72, -35.29	M181408612
P1	-8.56, -46.52	M1173356718
P2	-10.22, -45.93	M1127434490

Discussion: Observed low crater frequencies and derived AMAs (all <30 Ma) for wrinkle ridges are consistent with the idea of still geologically active Moon [6-8]. The technique using CSFD measurements in this work and in other works [6,9] show that it can give valuable information about lunar endogenic processes.

The differences in crater populations between fresh looking small craters and degraded bigger craters is due to the fact that small ones are erased more easily than big craters. Crater degradation phenomena has been shown to affect small crater populations in the past by [17-19]. We propose that the main degradation agent on the analyzed wrinkle ridges is punctured resurfacing. This process could be a large seismic event, e.g. a moonquake after which the whole surface would be resurfaced and all but the largest craters removed. A recent study [20] has shown that along wrinkle ridges there are global stress fields and past Apollo missions have recorded deep and shallow lunar quakes [21]. The idea also agrees with the resurfacing model active on lobate scarps [11] and would explain the observed ripple surface features in Fig. 3.

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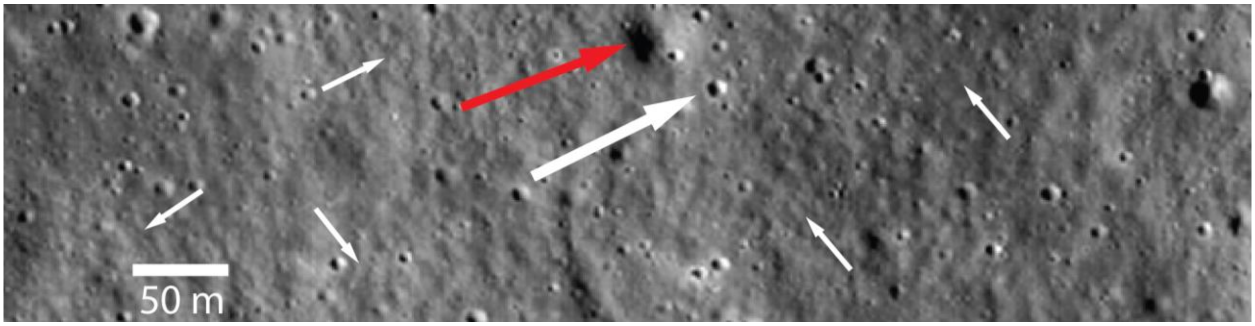

Figure 3. Surface features of wrinkle ridge Im1 count area. Fresh crater (big white arrow) and degraded crater (red arrow) examples. Terrain covered with uneven layer or 'ripples' (small white arrows), seen in the background. LRO NAC image.