EPSC Abstracts
Vol. 12, EPSC2018-629, 2018
European Planetary Science Congress 2018

Investigating the Mandel'shtam lobate scarp complex

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Abstract

We performed crater size-frequency distribution (CSFD) measurements and determined absolute model ages (AMAs) for the scarps in the Mandel'shtam lobate thrust fault scarp complex. The scarps were determined to be late-Copernican in age, ranging from ~33 Ma to ~187 Ma. However, the crater population measured around the southern scarps in this complex may have been disturbed by crater ejecta from the Copernican-aged rayed Mandel'shtam F crater because the ages (around ~35 Ma) of these southern scarps are notably younger than other AMAs in the complex. We plan to perform CSFD measurements on the Mandel'shtam F crater ejecta to determine if the young scarp ages are the result of recent ejecta emplacement.

1. Introduction

Lobate scarps are the surface expression of low-angle thrust faults formed by contraction of the crust due to principally long-term interior cooling [1-6] and tidal deformation [7]. Lunar scarps are relatively small compared to most lobate scarps on other terrestrial planets (e.g., Mars and Mercury) and are typically <10 km in length and tens of meter in relief [3-5, 8-9].

Based on their crisp appearance and cross-cutting relationships with small-diameter (< 40 m) craters, lobate scarp are among the youngest landforms on the Moon [6, 10-12]. Lunar scarps typically occur in clusters often referred to as complexes [10]; these series may consist of several en echelon stepping scarps [8, 10].

Mandel'shtam Scarp Complex:

Located in the farside highlands, the Mandel'shtam lobate scarp complex (Fig. 1) is comprised of 8 distinct scarps with a total cumulative length of ~80 km. The complex's name derives from the close-by large Mandel'shtam craters, which range from ~ 25 to 60 km in diameter.

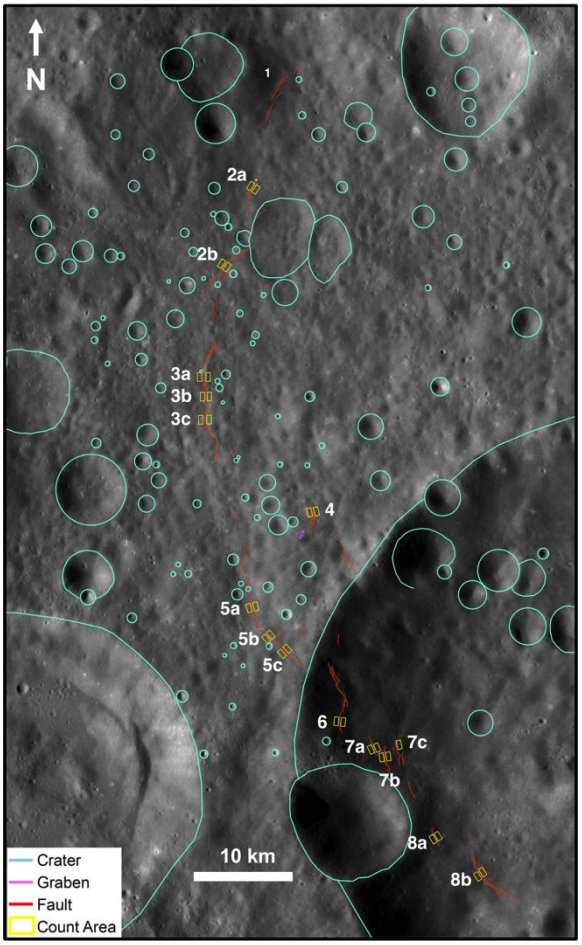

Figure 1: Simple structural map of the Mandel'shtam scarp complex (6.2°N, 161.2°E) displaying lobate scarps 1-8 (red lines) over a Lunar Reconnaissance Orbiter (LRO) Wide Angle Camera (WAC) mosaic. Count locations are mapped with yellow boxes and surrounding craters are mapped with an aqua outline.

Age determinations by [11] place the craters at Imbrian to pre-Nectarian in age (~3.5 to 4.2 Ga). Using crater degradation rates, [10] first determined ages for the scarps within the Mandel'shtam complex (Table 1). Individual scarp ages range from 100 ± 70 to 190 ± 70 Ma, with a calculated complex age of 180 ± 50 Ma [10]. Using more recent scarp dating

techniques, [12] and [13] determined the scarps within the complex to be ~ 33 Ma to 187 Ma, (Table 1). Comparing the ages for the individual scarps, we found that our ages were younger than those calculated by [10].

Table 1: List of ages for the lobate scarps within the Mandel'shtam scarp complex. (*) means an age was not determined due to inadequate image coverage or (**) because CSFDs were in equilibrium.

Scarp	Age (Ma) [10]	Age (Ma) [12-13]
1	170 ± 70	*
2	180 ± 60	
a		94 ± 8
b		146 ± 23
3	180 ± 50	
a		120 ± 9
b		100 ± 8
c		99 ± 8
4	100 ± 70	139 ± 15
5	190 ± 50	
a		**
b		187 ± 15
c		**
6	*	34 ± 4
7	180 ± 50	
a		36 ± 5
b		33 ± 4
c		125 ± 17
8	190 ± 70	
a		39 ± 11
b		87 ± 7

By dating individual scarps within the complex, we wanted to assess if there was an order to the development of the fault complex. Scarp 5 in the middle of the complex was determined to be the oldest or the scarp that ceased fault activity longest ago. Comparing the ages in the complex, there appears to be no clear trend of scarps becoming progressively younger towards the north or south terminus of the complex. We did, however, find that scarps 6-8 in the southern portion of the complex shared similar ages of ~34 Ma to ~39 Ma (yellow box in Fig. 2; Table 1).

Upon further inspection, an ejecta ray from Mandel'shtam F crater that appears blue in the Clementine color-ratio mosaic covers the southern area of the scarp complex (Fig. 2, yellow box).

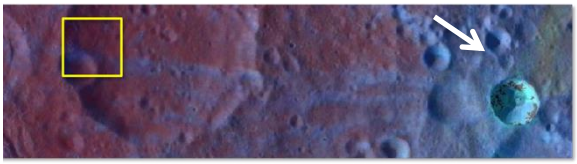

Figure 2: Clementine color-ratio image showing the 15 km-wide Mandel'shtam F crater in the east (indicated with white arrow) and scarps 6-8 in the west (yellow box).

We speculate that the cluster of ages of around 35 Ma might reflect an age for the crater and not the timing of the most recent fault activity.

2. Future Investigation

In order to determine an age for the Mandel'shtam F crater, we will conduct CSFD measurements on the crater ejecta, using LROC high-resolution Narrow Angle Camera (NAC) images. Conducting CSFD measurements on the ejecta blankets of Copernican-aged craters is a typical procedure because the crater floor units might give younger apparent ages due to target property effects [14, 15]. Additionally, we will date the surfaces distal to the scarp trace to investigate the extent and severity of seismic activity on the faults, and investigate the regional geology to provide context for the scarp measurements [13, 16]

3. Summary and Outlook

With CSFD measurements on the Mandel'stham F ejecta, we hope to determine the age of the crater and to resolve if the scarps' surfaces in the southern portion of the Mandel'shtam complex were last altered by fault activity, ejecta emplacement, or by other resurfacing processes.

References

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