

SPACECRAFT IMPACTS ON THE MOON: CHANG'E 1, APOLLO LM ASCENT STAGES. P. J. Stooke¹,

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Introduction: Numerous spacecraft have crashed on the lunar surface and for many the impact sites have been observed by Lunar Reconnaissance Orbiter [1]. Three not previously identified are described here. Two are Apollo Lunar Module Ascent Stages, from Apollo 12 and Apollo 14. The third site is from Chang'E 1, whose impact site was previously imaged by Apollo 16 for comparison with LRO images.

Apollo 12: The Apollo LM ascent stage impacts have proven elusive. The Apollo 12 impact site was discovered by means of a very unusual (in fact apparently unique) field of small dark markings suggestive of shrapnel strikes (Fig. 1), located at 3.90° S, 21.23° W just west of the tracking location of the impact. By tracking back along the orbit path the impact site was discovered (Fig. 2). The expected fan-shaped spray of ejecta (also seen at the GRAIL and LADEE impact sites) was visible and seems to originate from a linear gouge oriented along track. The gouge is roughly 25 m long and 2 to 3 m wide at 3.920° S, 21.172° W. Topographically, the gouge is on the crest of a small rise in topography, and the shrapnel markings commence 800 m to the west and extend for about 1500 m. The gap between those markings and the impact site is a shallow depression in LOLA topography, apparently overflowed by a cloud of debris which was probably generated when a grazing impact induced catastrophic rotation in the spacecraft.

Apollo 14: Ewen Whitaker [2] described a dark marking near the expected location in Apollo 16 Metric image 2508 as the possible impact site of the Apollo 14 LM Ascent Stage. LRO images do not reveal anything obvious at that dark spot, but a smaller dark marking closer to the tracking location has now been identified (Fig. 3). It also shows a fan of ejecta emanating from a gouge-like feature in the expected direction. A more distant spray of shrapnel-like impacts is not observed here. The proximity to the tracking location and the similarity of the site to the Apollo 12 feature suggests that this is the LM Ascent Stage impact site. The location is 3.420° S, 19.637° W.

Chang'E 1: Chang'E 1 struck the Moon on 1 March 2009, travelling from south to north in Mare Fecunditatis. Liu *et al.* [3] described the location based on analysis of images taken during the descent. The expected location was 1.80° S, 52.23° E. This area was also imaged by Apollo 16, and the Panoramic Camera images are sufficiently detailed to compare with LROC-NAC images to search for new impacts. A

fan-shaped spray of ejecta can be seen at 1.66° S, 52.27° E in LROC images (Fig. 4) which is clearly not present in image AS16-P 5202 (Fig. 5). This must be the Chang'E 1 impact site.

References: [1] Wagner, R.V. et al. (2014) *45th LPSC*, abstract #2259. [2] Whitaker, E.A., 1972. *Apollo 16 Prelim. Sci. Rep.* NASA SP 315, p.29-39. [3] Liu, et al., 2012. *Sci. China Earth Sci.*, 55 (1), pp. 83-89.

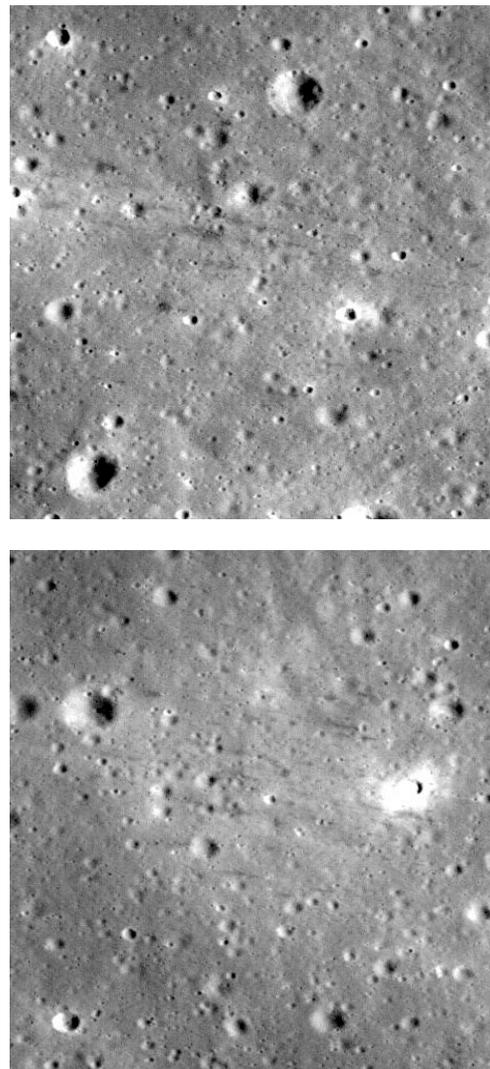


Fig. 1. Two sections of LROC image M129431676L showing parts of the 'shrapnel' field west of the Apollo 12 LM Ascent Stage impact. Each image is 150 m wide.

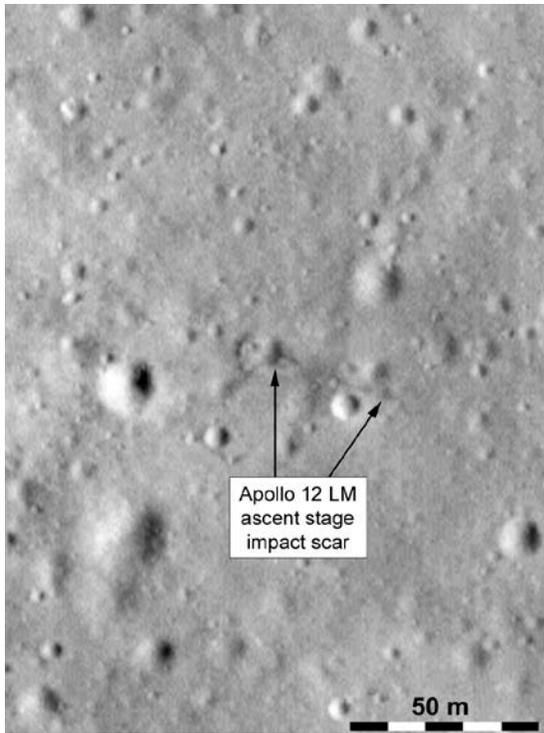


Figure 2. Part of LROC image M114091363R showing the Apollo 12 LM Ascent Stage impact site.

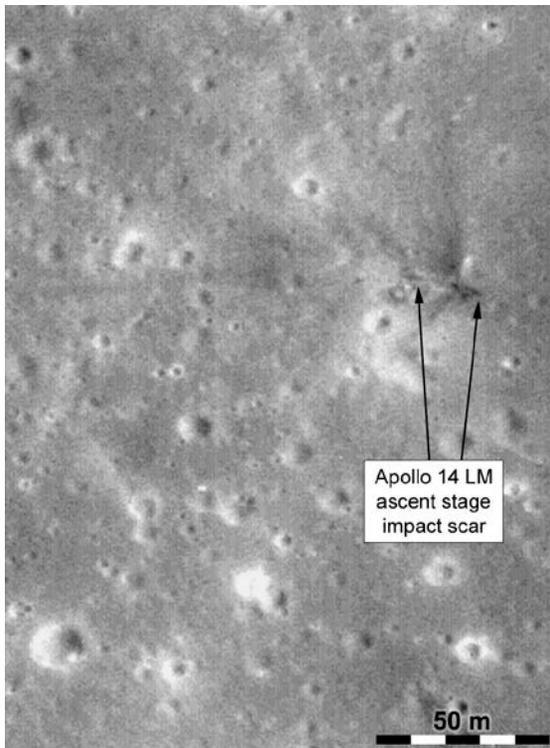


Figure 3. Part of LROC image M111721735L showing the Apollo 14 LM Ascent Stage impact site.

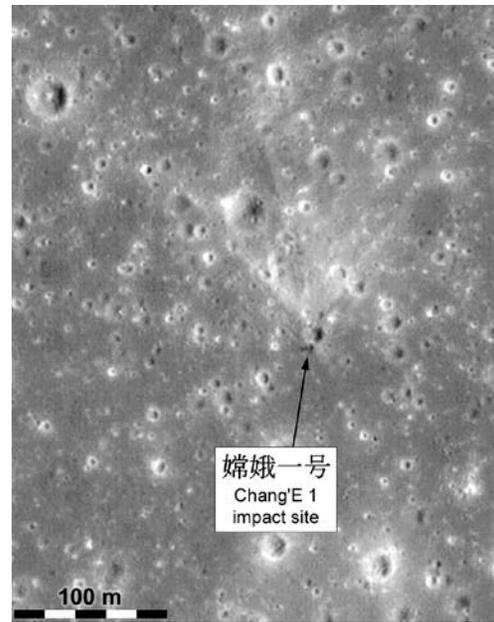


Figure 4. Part of LROC image M111253255R showing the Chang'E 1 impact site.

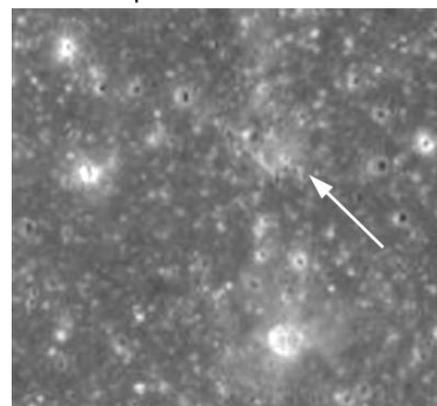
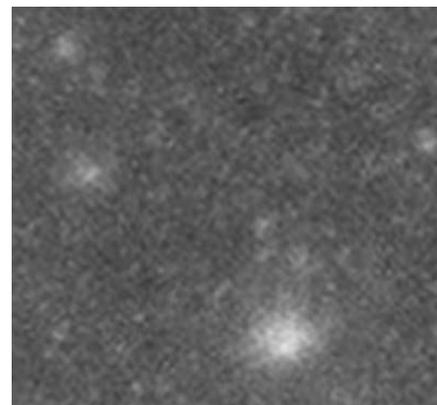


Figure 5. Before/after images for Chang'E 1. The ejecta is indicated by the white arrow.