

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



newsflash: now with added SMART-1

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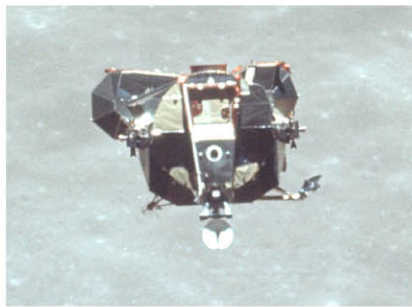
<http://publish.uwo.ca/~pjstooke/>, [pjstooke@uwo.ca](mailto:pjstooke@uwo.ca).

Introduction: Numerous spacecraft have crashed on the lunar surface and for many the impact sites have been observed by Lunar Reconnaissance Orbiter [1].

~~Three~~ **Four** 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.

The fourth is ESA spacecraft SMART-1.



NASA/LPI image AS11-44-6625

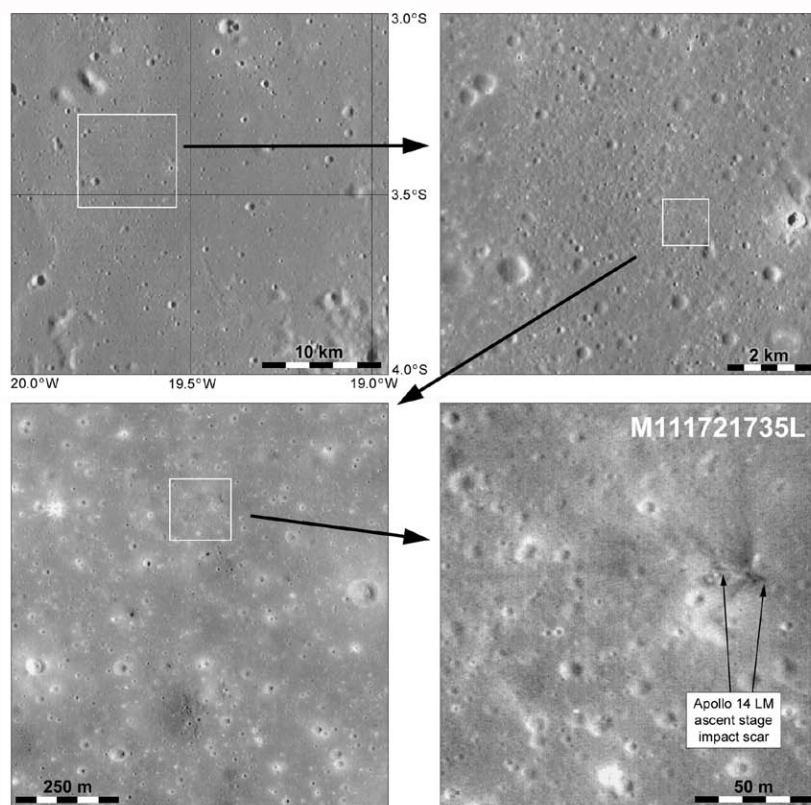


China Academy of Space Technology

## Apollo 14

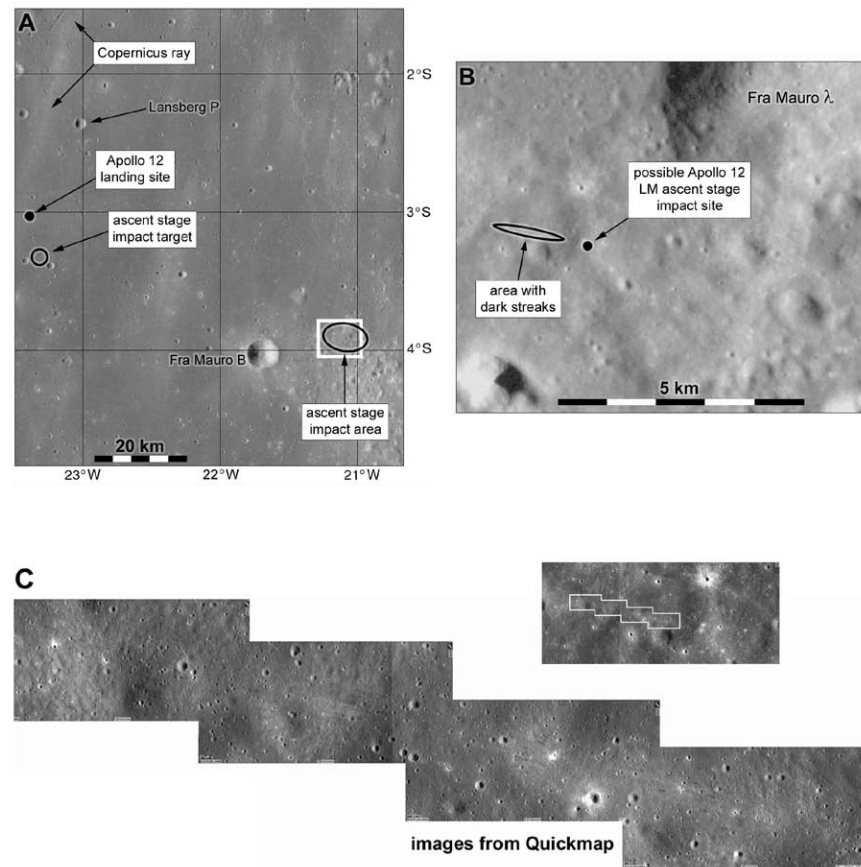
Ewen Whitaker [2] suggested a dark marking in image AS16-M-2508 was the Apollo 14 LM impact site. LRO images show nothing there.

A new candidate closer to the tracking location shows a fan of ejecta emanating from a gouge-like feature in the expected direction. Distant shrapnel is not observed here. The location and resemblance to the Apollo 12 feature suggests that this is the LM impact site. The location is 3.420° S, 19.637° W.



## Apollo 12

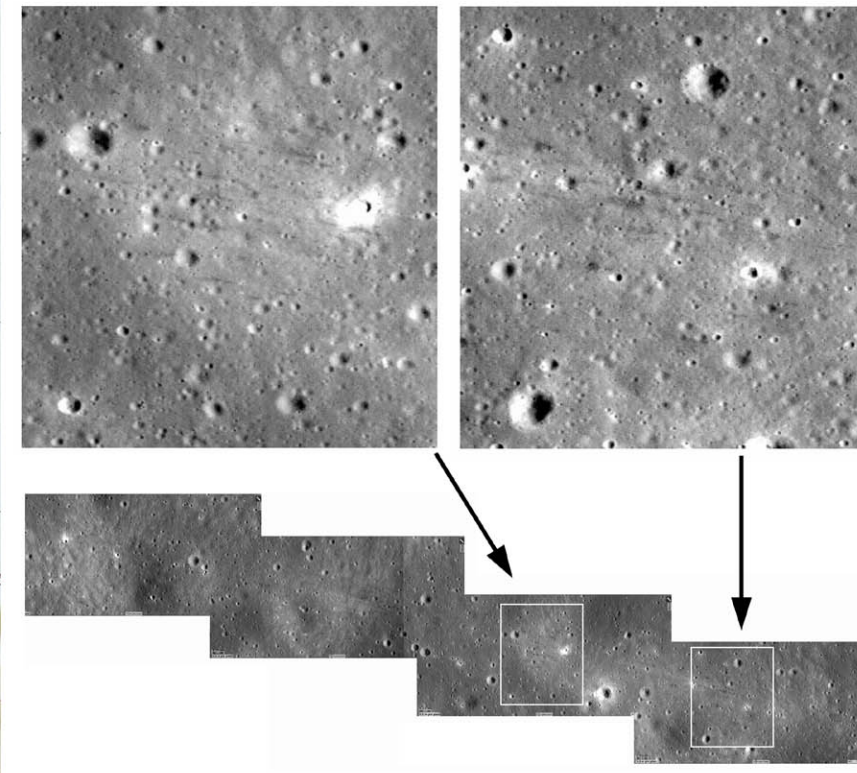
The Apollo LM ascent stage impacts have proven elusive in LRO images. The Apollo 12 impact site was discovered by means of a very unusual (in fact apparently unique) field of small dark markings suggestive of shrapnel strikes (below), located at 3.90° S, 21.23° W, just west of the expected location of the impact.



## Apollo 12

It should be noted that these two Apollo LM ascent stage impact sites have also been found independently - and for Apollo 12, earlier - by Michael Marcus, but that information had not been made public previously. I am pleased to acknowledge it here. We are now working together on a strong candidate for Apollo 15's LMAS.

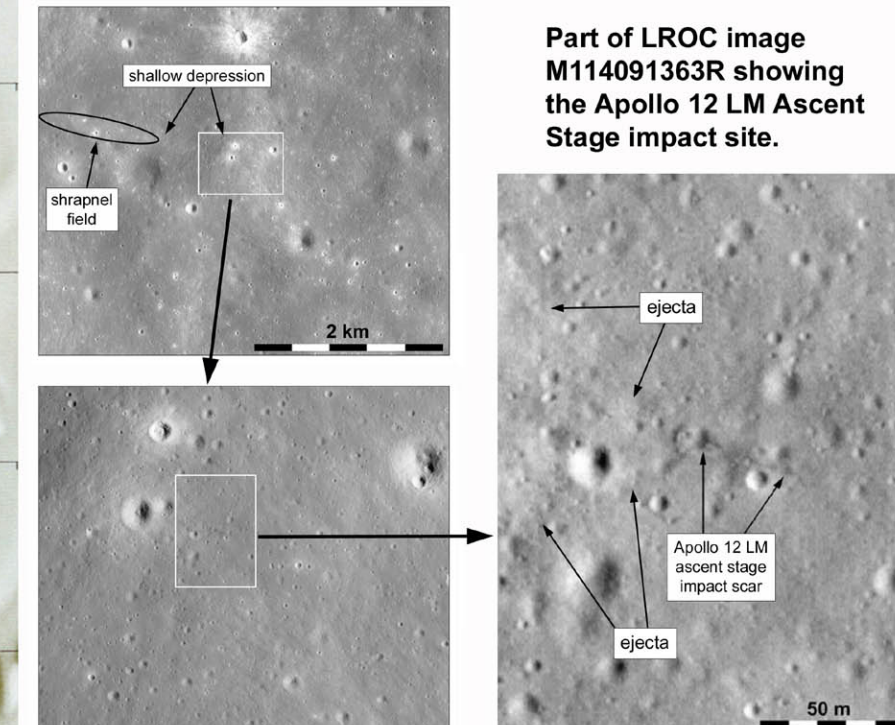
Two sections of LROC image M129431676L showing parts of the 'shrapnel' field west of the Apollo 12 LM Ascent Stage impact. Each image is 150 m wide.



## Apollo 12

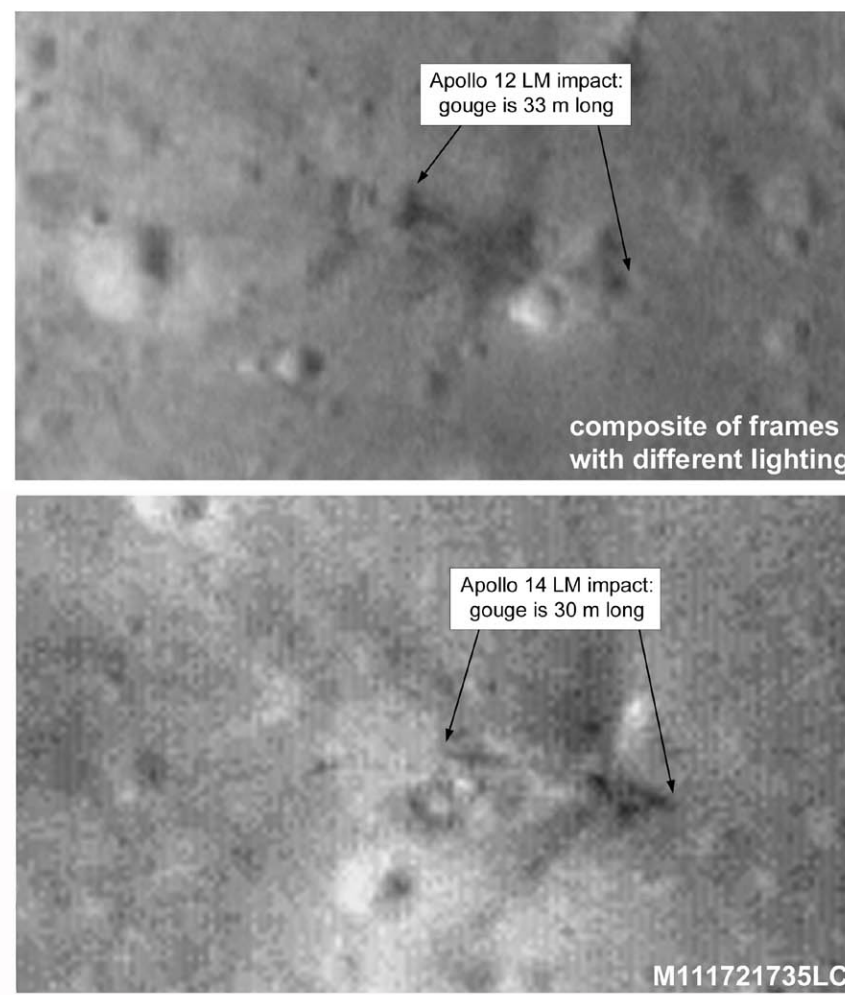
By tracking back along the orbit path the impact site was discovered. The expected fan-shaped spray of ejecta (also seen at the GRAIL and LADEE impact sites) was visible and seems to originate from a linear gouge oriented along track.

The gouge is about 35 m long and about 4 m wide at 3.920° S, 21.172° W. 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.



## Apollo 12, Apollo 14

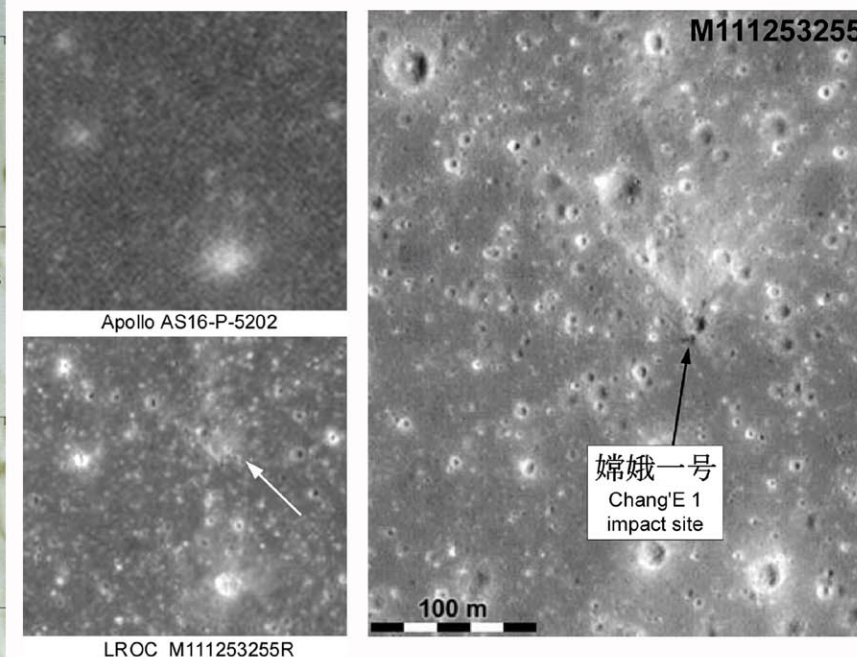
Close-up views of the LM impacts. Both are roughly the same size, 30 by 4 m, both are linear gouges in the surface, not craters, and both have sprays of bright and dark ejecta typical of spacecraft impact sites.



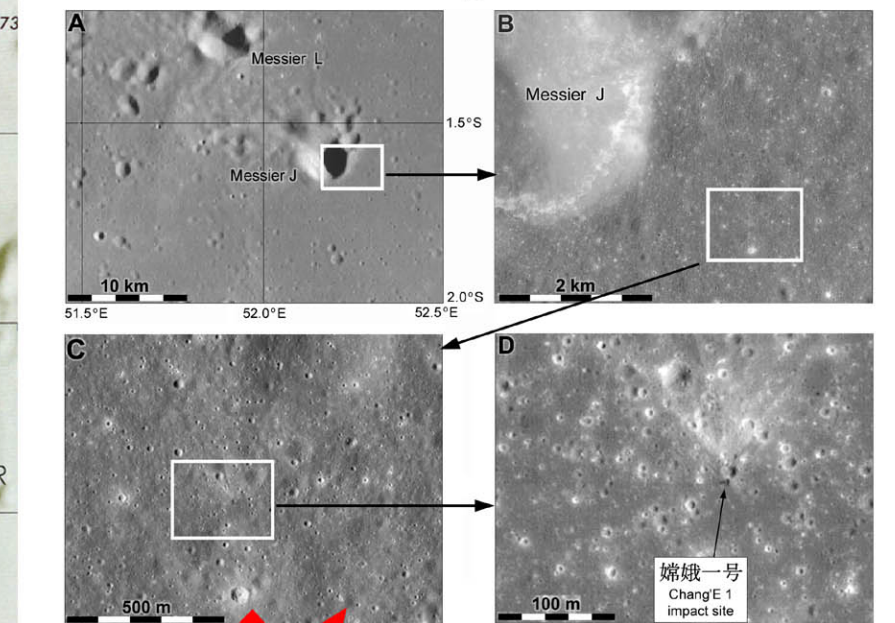
## Chang'E 1

Chang'E 1 struck the Moon on 1 March 2009, travelling from south to north over 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.

A fan-shaped spray of ejecta can be seen at 1.66° S, 52.27° E in LROC images which is clearly not present in Apollo 16 Panoramic image AS16-P 5202. A crater about 12 m across is probably a pre-existing feature. The impact site is a pit or gouge on its south rim.

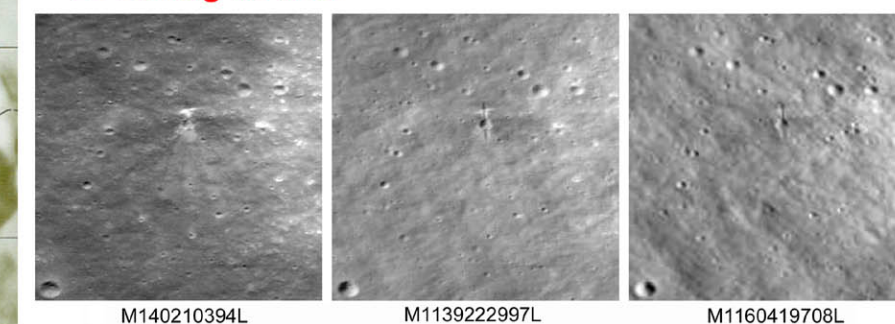


## Chang'E 1



**SMART-1**  
Breaking news...

This linear gouge, about 3 m wide and 20 m long, is near the predicted SMART-1 impact site. At its south end a faint fan of ejecta sprays out to the south. The location is 34.262° S, 46.193° W (313.807° E).



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