EARLY LROC VIEWS OF LUNAR 'HERITAGE' SITES. P. J. Stooke[1], [1]Department of Geography, and Centre for Planetary Science and Exploration, University of Western Ontario, London, Ontario, Canada N6A 5C2, pjstooke@uwo.ca.

Introduction: The Lunar Reconnaissance Orbiter has been in operation at the Moon since mid-2009, and by December 2009 had imaged all Apollo landing sites and several other 'heritage' sites. Images already released permit the identification of previously unseen items such as the Surveyor 3 retro-rocket, the revision of astronaut EVA routes and (possibly) science station locations. Future images may help locate uncertain sites such as Luna 17/Lunokhod 1, and may contribute to heritage site designations and commercial mission planning. Results to December 2009 are described in this abstract, and may be extended in the associated poster.

Apollo Landing Sites: Apollo sites with both low and high sun angles were early LROC targets. Hardware and surface disturbances are easy to see in all images, but tracks are much easier to identify with high sun angles. In general, tracks show up clearly close to the Lunar Module and less well at a distance. For instance at Apollo 17, rover tracks between the ALSEP and SEP (Surface Electrical Properties) areas are clear at all sun angles, but difficult to see at the Station 6 boulders even at high sun (Figure 1). This relationship is well known from Apollo surface images and is apparently due to surface brightening by LM exhaust during landing. Tracks disturb the brightened surface, leaving darker marks. Footprints seem darker than rover tracks in most locations, indicating more intense surface disruption.

At Apollos 12 and 14 the contemporary EVA maps can be improved. Figure 2 compares the USGS Apollo 12 traverse map with the tracks seen by LROC. At Apollo 11, Neil Armstrong's excursion to Little West Crater and the deployed hardware can be located more accurately than before, including discarded covers and packing materials (Figure 3).

Artificial Impact Sites: The Apollo 14 SIVB (upper stage) impact crater, first located by Ewen Whitaker [1], has now been revealed by LROC at high sun (Figure 4). LROC images will reveal details of crater morphology and possibly impactor fragments, perhaps helping explain why some artificial impacts have dark rays and others do not in Apollo images. Are rapidly venting fuel vapors involved? Perhaps venting fuel brightens the surface, and then ejecta rays darken it in a manner akin to features seen at each Apollo site. LROC images already show many natural impact craters at high sun, showing some of them have partial dark ray systems. Do they involve comet impacts with similar volatile effects? The study of these features may help reveal impacts of other hardware including the SIVB stages from later Apollos, some Luna missions such as Luna 8, and recent events such as the SMART-1, Chang-e 1, Chandrayaan MIP and Kaguya impacts.

Other Landing Sites: LROC images offer the potential to reveal new details of other landing sites. This has already occurred at the Surveyor 3 site, where the discarded retro-rocket may have been identified [2]. Figure 5 shows a dark spot 200 m north of the Surveyor 3 lander and about 2 m across, with possible bounce marks to the south. It was not present in early 1967 when a Lunar Orbiter image was taken, but it is visible in both low sun and high sun LROC images. It was first noticed in the high sun image, suggesting that this lighting will be most usefull for finding other examples. The released LROC image of the Surveyor 1 site does not show any similar dark spot near the old lander, suggesting its retro-rocket may have fallen in an area in shadow in that low-sun image.

Other Surveyors can be examined in future LROC images. The retro-rockets should be located fairly easily using Surveyor 3 as a guide. Surveyor 2's crash site is poorly constrained and may be difficult to locate. Surveyor 4 may be easier to locate and images may reveal its failure mode. If one impact is seen, its attempt to discard the retro-rocket may have failed. Two impacts would suggest that the separation occurred, but one or more of the vernier thrusters failed. Surveyor 5 was not located precisely as it landed outside high resolution Lunar Orbiter coverage. It may be found by comparing images with maps made from surface images. Of other landers, the easiest to find may be the Lunokhods, using comparisons of LROC images with craters in Soviet-era traverse maps. For Lunokhod 1 this may validate the predicted location in [3], and the discovery may aid attempts to reacquire its LRRR.

Acknowledgements: I thank NASA, GSFC, ASU, the LROC team and PI Mark Robinson for the early release of the spectacular LROC images discussed here.

References: [1] Whitaker, E. A., 1972. Apollo 16 Preliminary Science Report, NASA SP-315, pp. 29-39 to 29-45. [2] LPOD (Lunar Picture of the Day, lpod.wikispaces.com), 7 November 2009. [3] Stooke, P. J. (2007) *The International Atlas of Lunar Exploration,* Cambridge University Press.

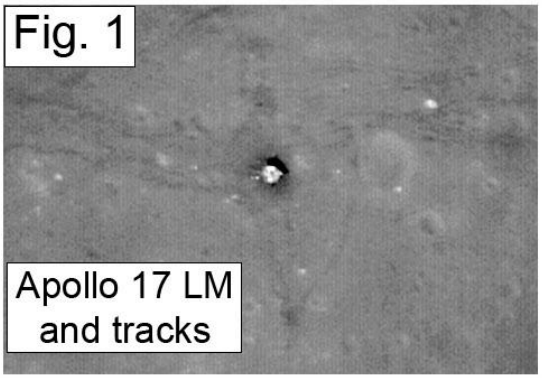
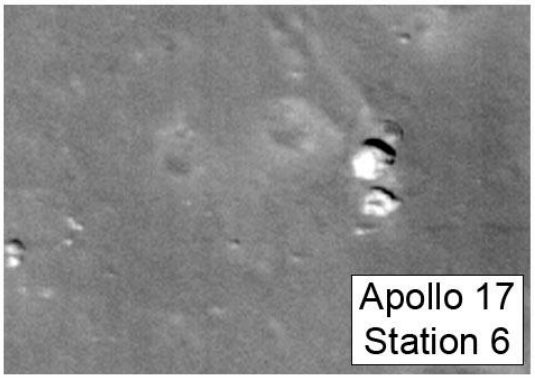


Fig. 1
Apollo 17 LM and tracks


Apollo 17 Station 6

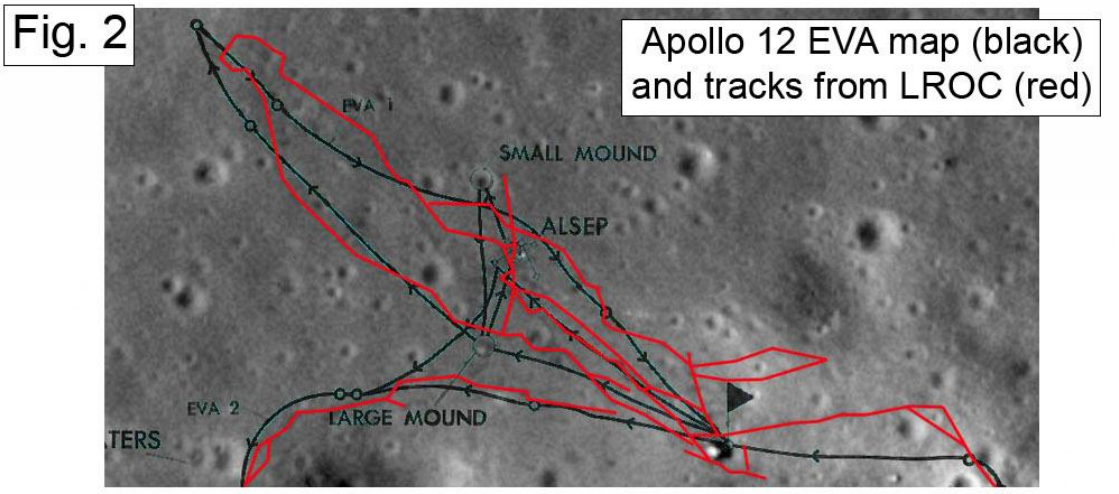


Fig. 2
Apollo 12 EVA map (black) and tracks from LROC (red)
EVA 1
SMALL MOUND
ALSEP
EVA 2
LARGE MOUND

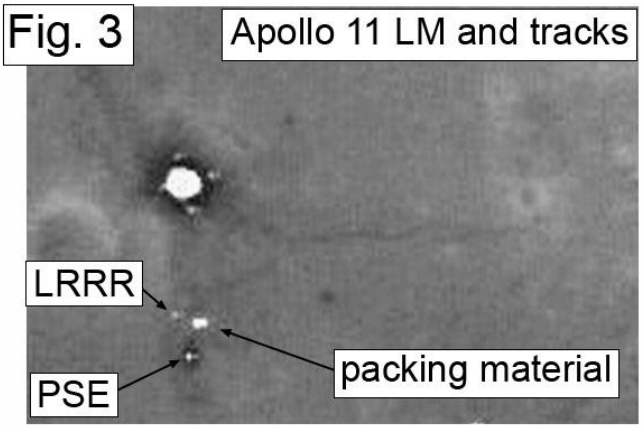


Fig. 3
Apollo 11 LM and tracks
LRRR
PSE
packing material

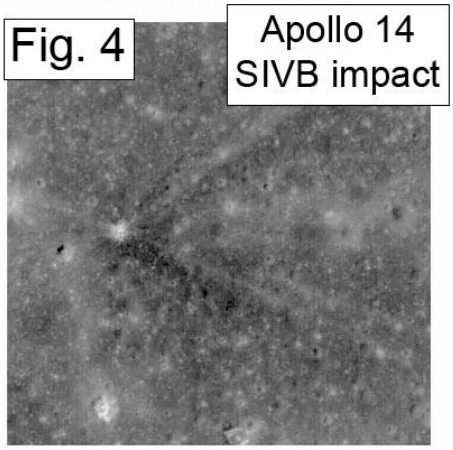


Fig. 4
Apollo 14 SIVB impact

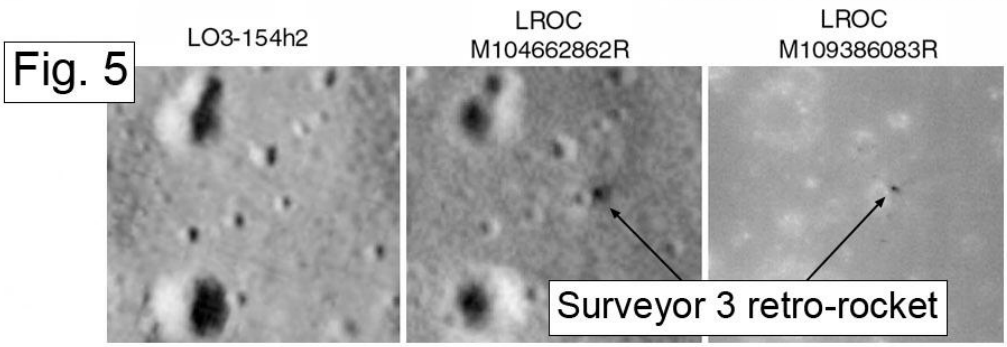


Fig. 5
LO3-154h2
LROC M104662862R
LROC M109386083R
Surveyor 3 retro-rocket