IMAGING OF THE CHANG'E 3 LANDING SITE. M. S. Robinson[1], J. B. Plescia[2], and R. V. Wagner[1]. [1]Arizona State University, Tempe, AZ, [2]The Johns Hopkins University, Applied Physics Laboratory, Laurel, MD.

Introduction: Chang'e 3, the third mission in China's Lunar Exploration Program [**1**], was launched on 6 December 2013 and landed on 14 December 2013. The vehicle included a lander and a rover (Yutu - Jade Rabbit). High-resolution descent imaging released to the web made identification of the landing site using pre-existing Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) and Wide Angle Camera (WAC) images relatively easy (**Figs. 1, 2**). Here we describe the landing area as seen in LROC images, report precise lander coordinates, and report future imaging opportunities.

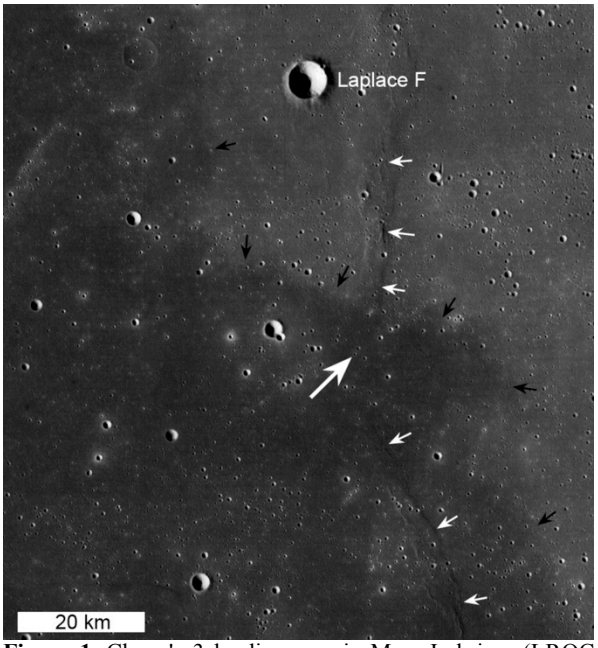

Figure 1. Chang'e 3 landing area in Mare Imbrium (LROC WAC mosaic). Large white arrow denotes the landing site; small white arrows note the location of the wrinkle ridge; black arrows delimit the mare contact.

Chang'e 3 Mission: The overarching goals of the Chang'e 3 mission were to land on the lunar surface, deploy the rover, and collect scientific measurements [**2**]. The rover includes a stereo imaging experiment, infrared spectrometer, alpha-proton X-ray spectrometer, and a ground penetrating radar [**2**]. The lander payload includes an ultraviolet telescope, an extreme ultraviolet imaging system, visible imaging, and a soil probe [**2**].

LROC Image Acquisiton: LRO was not in a position to acquire images immediately after the landing. It was ten days later, on 24 December, when LROC began a sequence of 6 NAC image pairs acquired over 36 hours (19 orbits; **Table 1**). A near vertical view was acquired on 25 December 03:52:49 UT, when LRO was at an altitude of ~150 km; the pixel size was 160 cm (**Fig. 2**).

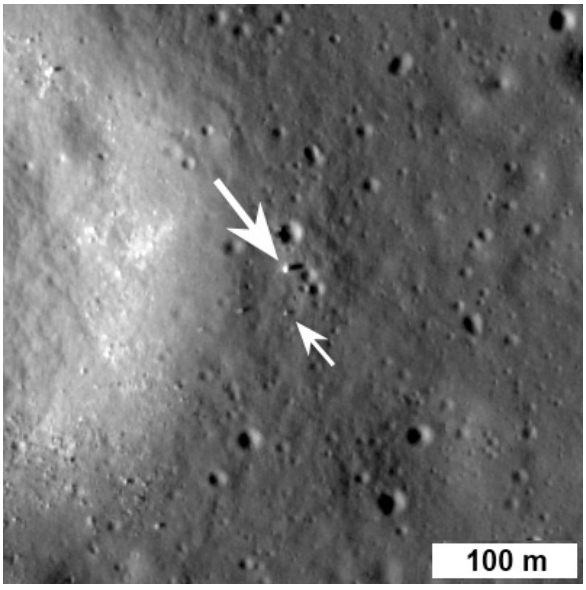

Figure 2. The lander is denoted by the large white arrow, the rover by the small white arrow (M183661683LE).

Given the relatively small size of the lander (body 2.5 m across; leg diameter 4.8 m), confident identification within a NAC image is potentially problematic. However, a comparison of LROC images taken before and after the landing provide confirmation of the presence of the lander and rover. Additionally, a localized (>15-m radius) change in local reflectance (5% to 10% increase relative to a before image with nearly identical illumination) is consistent with engine exhaust perturbation of the surface [**3, 4**]. While the rover is only about 1.5 m across, the same size as a pixel, it was also detected because sunlight reflects strongly off the rover (solar panel?) and the low Sun allows it to cast a distinct shadow. The rover was about 30 m to the south of the lander when imaged on 25 December (**Fig. 2**).

Landing Site: The landing site is in the northwest portion of Mare Imbrium at 44.1213°N, 340.4885°E [**5**], at an elevation of -2640 m (**Figs. 1, 2**). The vehicle set down on a relatively flat area with few blocks, 60 m east of the rim of a 450 m diameter impact crater ("CE3" crater) that is 40 m deep (shadow measure). During the formation of the CE3 crater, basalt was excavated from depths of perhaps 50 meters or more, thus the lander is sitting on the ejecta from deep within the crater, and can sample deeper basalt layers. As the rover moves away from the CE3 crater it will, in a geologic sense, be ascending up and out of the crater (ejecta from the original surface lies one to two crater radii from the rim [**6**]) revealing any vertical changes in mare composition (stratigraphy). There are many small and large craters within reach of the rover, and each provides an opportunity to investigate the 3-D nature of the basalts that filled the Imbrium basin.

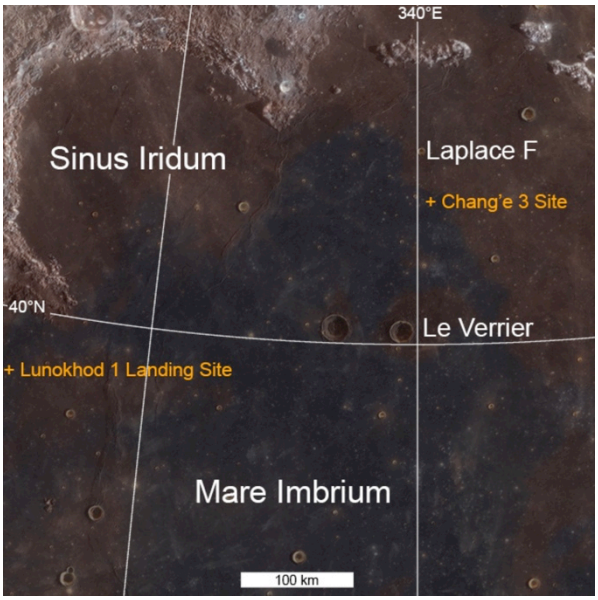

Figure 3. LROC WAC color composite (R=689 nm, G=415 nm, B=321 nm) highlighting the proximity of the Chang'e 3 landing site to a blue-red mare contact.

The surface consists of Eratosthenian-aged (3.0 Gy) mare basalts [**7**], deformed by a large-scale north-south trending wrinkle ridge and lies to the south (10-km) of a contact with an older Imbrian-aged basalt (3.5 Gy [6]; **Figs. 1, 3**). Lunar mare basalts are divided into two main spectral types: "red" and "blue" [**8**]. The presence of ilmenite ($FeTiO_3$) results in lower reflectance and a "less-red" (or "blue") color. The landing site is on a blue mare (higher titanium).

Future imaging: LRO will pass over the Chang'e 3 site about every 28 days, each time with unique solar illumination conditions. By slewing the spacecraft, LROC can obtain a series images with varying emission angles (intersection of camera boresight relative to the surface normal) and nearly invariant incidence angle (solar vector relative to the surface normal) across a range of phase angles (angle between the incidence and emission vectors) each month. Over time, a robust incidence-emission-phase characterization of the putative high reflectance blast zone and unaffected areas will be possible. Additionally NAC stereo imaging is planned that will enable topographic mapping of the area at 5 m scales.

References: [**1**] Zheng, Y, et al. (2008) *Planet. Space Sci.*, 56, 881-886. [**2**] http://www.asianscientist.com/topnews/chang-e-3-china-first-moon-rover-launch-in-2013 [**3**] Clegg, R. N., et al. (2014), *Icarus,* 227, 176-194 [**4**] Kaydash, V. et al. (2011), *Icarus, 211*, 89-96 **[5]** Wagner, R. V., et al., this volume [**6**] Melosh, H. J. (1989) *Impact Cratering*, Oxford Univ. Press [**7**] Hiesinger, H., et al. (2010) *JGR*, 115, doi:10.1029/2009JE003380 [**8**] Pieters, C. M., et al. (1978), *PLPSC 9th*, 2825-2849.

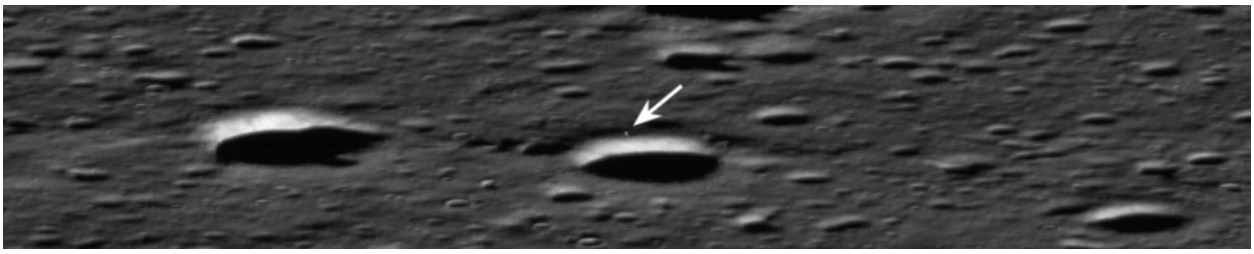

Figure 4. NAC east-to-west oblique view of Chang'e 3 site (M114268234). Arrow denotes landing site, north is to the left.

Image	Sample	Line	Incidence	Emission	Phase	Scale (m/px)	Date
M102285549LE	2645	48154	-81	2	82	1.7	2009-07-15
M181302794LE	2478	39772	-72	2	74	1.6	2012-01-15
M183661683LE	4784	22098	-54	0	54	1.6	2012-02-12
M1116664800RE	3639	6405	-44	2	44	1.5	2013-02-28
M1127248516RE	2283	33974	-76	1	75	1.5	2013-06-30
M1129602407LE	2846	31480	-59	2	60	1.6	2013-07-27
M1142554338LE	*4549*	*15684*	*-74*	*33*	*106*	*1.8*	*2013-12-24*
M1142568554LE	*4184*	*20330*	*-75*	*17*	*92*	*1.6*	*2013-12-24*
M1142582775RE	*1550*	*20621*	*-77*	*2*	*75*	*1.5*	*2013-12-25*
M1142596997RE	*845*	*20800*	*-78*	*20*	*58*	*1.6*	*2013-12-25*
M1142625444RE	*1477*	*16571*	*-81*	*48*	*36*	*2.1*	*2013-12-25*
M1142682346RE	*1112*	*10474*	*-87*	*72*	*21*	*3.8*	*2013-12-26*

Table 1. Summary of LROC NAC images and pixel coordinates of Chang'e 3 lander, entries in italics acquired after landing. Future imaging opportunities occur 2014-01-22, 2014-02-19, 2014-03-19. Negative incidence angle indicates Sun from the west.