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INVESTIGATING SPACECRAFT LUNAR LANDING EFFECTS THROUGH ANALYSIS OF LRO NARROW ANGLE CAMERA LANDING SITE IMAGES AND PHOTOMETRY

Abstract

Spacecraft descent rockets alter the regolith surrounding landing sites, creating areas of increased reflectance, herein referred to as blast zones ("BZs"). Owing to a lack of rapid weathering on the Moon, surface alterations associated with Surveyor, Luna, and Apollo landings are still visible as photometric anomalies in Lunar Reconnaissance Orbiter (LRO) Narrow Angle Camera (NAC) images. These areas extend tens to hundreds of meters from the landers. Our previous study using NAC photometry concluded that increased reflectance is most likely caused by smoothing and destruction of fine-scale surface structure, and redistribution of fines. Here we compare the Chang'e-3 effects to those from previous missions and investigate the relationship between spacecraft mass and thrust, and the area disturbed by rocket exhaust.

We use ISIS software (USGS) for image processing, and data for lander mass and maximum thrust of each spacecraft to investigate relationships between the intensity of exhaust and BZ size. The average area of increased reflectance at the Apollo sites is 23,800 m2, excluding Apollo 12 because of effects related to Surveyor Crater. The average Luna BZ area is ten times smaller at only 2400 m2, and the average Surveyor BZ is 80 times smaller, at 300 m2. We estimate the Chang'e-3 BZ to be 2100 m2. The magnitude of the reflectance increase (15-20%), however, is similar for all sites.

Comparing reported values for either maximum thrust or lander mass with BZ area indicates an exponential relationship. Fitting a curve to the Surveyor, Luna, and Apollo sites, we find the Chang'e-3 BZ area is greater than expected from the Apollo, Luna, and Surveyor correlation, but given the uncertainties; the offset may not be significant. We consider the possibility of degradation of the BZs at the older landing sites; however, it is not obvious that such has occurred. Variations in descent trajectory, which certainly occurred for the Apollo landings, or different engine configuration and design likely also contributed to BZ size variations among the different missions. We have an incomplete understanding of how descent engine exhaust interacts with the regolith, but the effects have implications for protecting assets at future landing sites. Until we can return to the Moon and investigate blast zones in more detail, we can use their photometric characteristics to infer the effects of rocket exhaust during landing.