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Shape of boulders ejected from small lunar impact craters

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Abstract

The shape of ejecta boulders from 7 lunar impact craters < 1 km in diameter of known absolute age was measured to explore whether it correlates with the crater age and the boulder size. The boulders were mapped and then measured by rectangular fitting and the shape was represented by the axial ratio or aspect ratio (A) of the rectangle. The main conclusions from the analysis of our measurement results are: 1) the percentages of the number of boulders of studied craters decrease with the increase of the axial ratio. Most (~90%) of the boulders have the axial ratio in the range of 1-2; no boulder with axial ratio larger than 4 was found. 2) the axial ratios of mare ejecta boulders decrease with their exposure time, whereas that for highland ones show unchanged trend. This difference may be probably due to target properties. 3) The shape of ejecta boulders are influenced by mechanical strength of bedrocks and space erosion. 4) surface peak stresses caused by thermal fatigue maybe play a significant erosion role in the shape of boulders of various diameter.

Keywords: Moon, shape of boulders, axial ratio, crater age

1. Introduction

Impact craters and rocks/boulders are the predominant features on the lunar surface. In most cases, rocks appear on the lunar surface as a result of ejections from impact craters and come from the regolith layer and bedrock basement underlying the regolith. The bedrocks in lunar maria are composed of various basalts. In highlands these are impact breccias, which can be essentially fragmental breccias or contain different contents of solidified shock melt (e.g., Florensky et al., 1981; Heiken et al., 1991). Accordingly, lunar rocks/boulders studied by us are fragments of basalts or impact breccias.

The shape of ejecta boulders may provide an insight into the impact fragmentation process (e.g., Melosh, 1989; Kumar et al., 2014). Krishna and Kumar (2016) described shapes of boulders by rectangular fitting, and defined the axial ratio (or aspect ratio) between long and short axes of rectangular as a measure of the boulder shape. They suggested that the axial ratio (or aspect ratio) of boulders depends on ejection velocity, and an increase in the ejection velocity leads to a decrease of the axial ratio for boulders. In the following, the axial ratio or aspect ratio will be abbreviated as A .

After their formation, boulders exposed on the airless body surface are affected by a number of agents: solar wind ion implantation and sputtering, cosmic-ray bombardment, electromagnetic radiation, micrometeoroid and meteoroid bombardment and thermal stresses due to diurnal temperature changes (e.g., Clark et al., 2002). Solar wind, cosmic ray and electromagnetic radiation change the optical properties of the exposed materials within the rather thin surface layer. Micrometeoroid bombardment was found to work mostly in the form of sand-blasting without destroying the rocks (Hörz et al., 1975; Hörz et al., 1977; McDonnell, 1977). Only meteoroid bombardment and thermal stresses are considered as the major factors for the destruction of boulders on the airless body surface (see e.g., Basilevsky et al., 2013, 2015; Cintala and Hörz, 2008; Delbo et al., 2014; Hörz et al., 1975; Molaro et al., 2016).

It should be noted that catastrophic rupture of exposed rocks on the airless body by meteoroid bombardment has a stochastic character with some boulders destroyed very soon after their appearance on the surface while some other that may stay untouched for very long time (e.g., Hörz et al., 1975). Meanwhile the destruction process by thermal stress should be more uniform in time if given same mass

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