HETEROGENEOUS IMPACT TRANSPORT ON THE MOON. Y.-H. Huang[1], D. A. Minton[1], M. Hirabayashi[1], J. R. Elliott[1], J. E. Richardson[2], C. I. Fassett[3], and Nicolle E. B. Zellner[4] [1]Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, Indiana USA 47907 (huang474@purdue.edu), [2]Planetary Science Institute, Tucson, Arizona USA 85719, [3]NASA Marshall Space Flight Center, Huntsville, Alabama, USA, [4]Department of Physics, Albion College, Albion, Michigan USA 49224.

Introduction: Impactors not only bombard the Moon but also induce the transport of materials on the lunar surface. Excavated materials are deposited in the form of either continuous ejecta surrounding craters or discontinuous crater rays further away from them, and the relative abundances of proximal ejecta vs distal ejecta on the Moon have been debated.

An unexpected highland component in a mare soil sample must be transported from large distances, because the majority of mare plains are thick enough that small craters cannot excavate the underlying highland materials [1]. Especially for mare soil sample collected >20 km away from their nearest mare and highland contact (the source of non-mare material), the contribution of distal ejecta is important to explain the observation of an elevated abundance of a non-mare component seen in most of mare soil samples (20-70%). Yet, the importance of distal ejecta was brought into question when researchers examined samples collected within 4 km of the mare/highland boundary and found that the non-mare abundance dropped rapidly from 80-50% to about 20% at the edge of the mixing zone. The narrow mixing zone, ~4 km, had been interpreted as consistent with the limited transport distances of local materials.

It was then understood that the width of 4-5 km of the mixing zone across mare/highland contacts resulted from the contribution of distal ejecta [2]. However, the relative importance of proximal ejecta vs distal ejecta and how these affect the the transport of materials across contacts are still unclear, and at odds with an exceptionally high non-mare abundance seen in some Apollo 12 mare soil samples [3]. Here we propose a new 3D regolith tracking model that accounts for the spatially heterogeneous nature of ejecta. Using our model, we are able to demonstrate that both proximal and distal ejecta are important to regolith transport, and the nature of ejecta can result in a significant heterogeneity of surface materials seen in a sample.

Method and simulation setup: We developed a 3D regolith tracking code based on the Cratered Terrain Evolution Model (CTEM) that studies the evolution of an impact-dominated surface [4,5]. Our new model includes an ejecta layer tracking system described by (1) a first-in last-out linked list data structure to deal with the generation of a distinct ejecta layer each time, (2) sub-pixel crater mixing that accounts for craters under the resolution limit [6], (3) the crater-ray-like ejecta distribution described by the Superformula [7], and (4) the mixing of crater ray deposits [8].

We have chosen Grimaldi Crater (D =175 km), a pre-Nectarian crater that was flooded by mare basalt ~3.2 Ga ago [9]. The simulation grid space is 175 km by 175 km with the resolution of 120 meter. We split the grid space into an equal area of mare on one side and highland on the other. Our simulated mare side has a 4 km-thick mare layer sitting on the top of an infinitely thick highland layer, and the simulated highland side possesses an infinitely thick layer. We performed five simulations with key components turned on one by one. These simulations are: proximal ejecta only with no sub-crater mixing (Case A); proximal ejecta only with sub-crater mixing (Case B); distal ejecta with no sub-crater mixing (Case C); distal ejecta with sub-crater mixing (Case D); and distal ejecta with sub-crater and ray/ejecta mixing (Case E).

Results: The Case A/B result yields <1 km of the mixing zone in which materials from both sides barely cross the contact. The Case C result has the largest mixing zone, >10 km. The Case D/E results show ~4-5 km of the mixing zone. This suggests that all sizes of craters are essentially important to the transport of materials across the lunar surface. While distal ejecta is capable of carrying a significant amount of exotic material from large distances, the local small craters constantly rework/dilute them with local materials. Besides our 175 km by 175 km mare/highland contact simulation, we also have a global scale simulation that takes into accout the large craters from large distances [8]. As a highly elevated non-mare abundance of 70% is seen in some Apollo 12 mare soil samples, the easiest explanation is the contribution of a Copernicus Crater ray. Our result shows a bimodal distribution between a rayed region (20-40%) and non-rayed region (50-70%). We infer that the patchy nature of crater rays may have resulted in a high heterogeneity of exotic materials among Apollo 12 mare soil samples. Our results strengthen the idea for the presence of Copernicus crater material at the Apollo 12 landing site.

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