# THE IMPORTANCE OF LUNAR SAMPLE RETURN IN DETERMINING THE NATURE OF EJECTA PROCESSES.

P. H. Donohue*[1], R. W. K. Potter[2], Z. Gallegos[3], N. Hammond[4], C. R. Neal[1] and D. A. Kring[5]
[1]University of Notre Dame, Notre Dame, IN (*pdonohu1@nd.edu), [2]Imperial College London, London, UK, [3]University of New Mexico, Albuquerque, NM, [4]University of California, Santa Cruz, CA, [5]Lunar and Planetary Institute, Houston, TX.

**Introduction:** Impact cratering is a fundamental geologic process that is ubiquitous in the Solar System. Impact generated meteorites and breccias allude to the intense energies required for their creation. A large volume of material displaced during impacts interacts with preexisting terrain [1,2]. Despite the scarcity of well-preserved ejecta blankets on Earth, those studied have greatly aided our understanding of the interaction of ejecta and local material [3,4]. The lunar surface is a uniquely preserved and accessible laboratory to characterize the nature of ejecta processes [5].

**Sample Site Selection:** To characterize the nature of ejecta and local material interaction, we need to

*I. Target young and well-preserved craters.* Although all planets have been affected by impacts, in most cases the evidence is masked or destroyed by weathering, resurfacing (*i.e.*, burial), or subsequent impacts. Target sites include the most recent impacts and planets with a long surface residence time.

*II. Target sites with ejecta blankets distinct from underlying lithologies.* The simplest method to determine compositional ratios of any two substances is to start with distinct end-members. The best candidates will be those craters near lithologic contacts or those that excavate through to underlying lithologies.

*III. Target craters of variable size* Ejecta velocity and volume increase proportionally to crater size. Scaling relationships have been developed from small-scale experimental impacts, high-energy explosions and a small number of terrestrial crater studies [1,6,7]. Their application for craters at all scales remains uncertain. To broaden and refine these models, a range of crater sizes should be investigated.

**The Lunar Case**:

*I. Preservation* The lunar surface is not subject to the same degree of weathering as that of Earth, Mars and other planets with atmosphere. Craters younger than ~1.1 Byr generally have readily distinguishable (*i.e.*, high albedo) ejecta deposits, and this time scale may be lengthened by compositional differences [8,9,10]. Subsequent impacts are the controlling factor in ejecta preservation. Microscale impacts rework the lunar surface at a rate of ~1.5 mm/m.y. [11].

*II. Composition* The lunar surface can be divided into general compositional groups including mare basalts and highland material. Craters impacting non-mare material and ejecting onto maria include Petavius B, Tycho, Letronne A and Hayn.

*III. Size* The Moon holds the most complete record of impact events in the Solar System. Crater sizes of interest range from <1 km up to ~1000 km diameter. The 120 identified Copernican craters range in size from ~1 to ~100 km diameter [12].

*Scientific Multipliers* Collection of impact melts and subsequent age dating will better constrain the crater density curve of the Moon and, therefore, the inner solar system. Larger craters also probe the lunar interior by exposing underlying lithologies in their structure (i.e. crater wall or central peak) and ejecta.

**Mission Objectives:** The goals of a sample return mission will necessarily vary depending on mission architectural constraints. The provenance of some clasts in Apollo impact breccia samples is uncertain. Apollo 12 landed on a ray from Copernicus, and Apollo 16 may have sampled basin material from the Imbrium, Serenitatis, and Nectaris basins [13]. Sample return from such key craters may be used in conjunction with previously collected material to constrain ejecta mixing and distribution models.

Adding mobility to a sample return mission greatly increases the scientific return. In collecting multiple samples at increasing radial distances from a crater, changes in the nature of ejecta-local material interaction can be better characterized. Multiple samples would also reduce the effects of unrepresentative sample collection. A 10- or 20-km mission radius (for missions with one or two rovers, respectively) could fully explore the majority of crater ejecta from craters up to ~30 km in size, such as Petavius B, Euclides M, Beer, and Conon. For larger craters such as Hayn (83 km) and Copernicus (93 km), the focus may instead be on characterizing ejecta interaction at key locations in the ejecta blanket.

**References:** [1] T. R. McGetchin *et al.* (1973) *Earth & Planet. Sci. Letters, 20*, 226-236. [2] C. M. Pieters *et al.* (1985) *JGR, 90*, 12393-12413. [3] F. Hörz *et al.* (1983) *Rev. Geophys. & Space Phys., 21*, 1667-1725. [4] E. C. T. Chao *et al.* (1977) *Proc. 8th Lunar Sci. Conf.*, 163-165. [5] NRC (2007) *The Scientific Context for Exploration of the Moon*, 107p. [6] S. K. Croft (1985) *Proc. 11th LPSC*, 2347-2378. [7] D. A. Kring et al (2005) *Chemie der Erde, 65*, 1-46. [8] C. M. Pieters *et al.* (1994) *Science, 266*, 1844-1848. [9] V. R. Oberbeck (1975) *Rev. Geophys. & Space Phys., 13*, 337-362. [10] D. E. Wilhelms *et al.* (1987) *USGS, Prof. Paper 1348*, 302 pp. [11] F. Hörz *et al.* (1991) In: *The Lunar Sourcebook, CUP*, 61-111 [12] A. Losiak *et al.* (2009) *LPS XL*, Abstract #1532. [13] N. E. Petro and C. M. Pieters (2006) *JGR, 111*, E09005.