THE POTENTIAL OF LONAR CRATER, INDIA TO BE AN ANALOG FOR EXOBIOLOGY SUGGESTED BY MICROBIAL DIVERSITY ANALYSES OF SHOCKED BASALT AND SHOCKED BASALTIC SOIL

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Summary: Microbes were found in three samples from Lonar Crater, India: an unshocked paleosol, a shocked soil, and a shocked basaltic rock. Characteristics of the microbes will be described along with details on the samples, the field locality, and implications for panspermia and biological measurements by rovers.

Introduction: This work represents a preliminary microbial diversity analysis for constraints on if microbes could have survived low (<~50 GPa) shock pressures, though the next step would be to date the age of microbial activity. In addition to on-surface measurements by rovers, this preliminary work has implications for panspermia in that shergottites (Class 2 shocked basalts from Mars) and recent sedimentary breccias from Mars [1] are basalts or breccias delivered from Mars. These may have clues to Martian exobiology without the need for Mars missions. All of the shergottites are shocked 25-45 GPa [2] just as the shocked basalt sample from Lonar used in this study. The samples are described along with the number of microbes and their range of abundances (with their total being set to 100%). Microbes shared between the three samples will be discussed in detail at AbSciCon 2015, though [3] (link) lists all microbes > 5%.

Methodology: Analyses of the three samples included polymerase chain reaction (PCR) amplification and RNA sequencing of the 16S ribosomal gene. These analyses return microbial identification and diversity. The 16S or 18S functional gene is generally used for metagenome analyses. The samples were amplified using fusion primers and then sequenced. The data generated is then denoised and compared to several databases of curated sequences of 6 broad assays: bacteria, fungi, archaea, mycobacterium, algae, and cyanobacteria. The goals of the analyses are to see what microbes are in the three samples, relate their microbial characteristics to the geologic history or details of their "host" sample, and make comparisons between the two shocked and one unshocked sample. This is relevant given that the shocked soil is roughly the shocked equivalent of the unshocked soil.

Shocked basalt: LC09-275 was chosen for analyses due to its shock level of Class 2 [4,5], matching the shergottites [2], but also due to obvious hematite and decompression cracks (seen here [6]) that we suggest may spur microbial growth and access to nutrients. Whether or not the microbes *survived* the shock ~670 ka [7] cannot be answered by this work. We are currently looking into a method to place age constraints on the microbes. The sample contained 211 microbes, including fungi and two bacteria generally found in hot springs or thermal environments [3].

P**aleosol:** LC09-PS-261 was collected *under* the lithic breccia layer in the Lonar ejecta. Paleosol represents the uppermost soil in the Deccan region before the Lonar impact event deposited ejecta on top of it. The sample contained 12 microbes, including aerobic, thermophilic bacteria, green sulfur bacteria, and several bacteria generally found in soils [3].

Shocked soil: A gray, frothy sample was found in the suevite / impact melt-bearing breccia unit. The density is unlike basalt and resembles that of frothy, gray pumice. Petrography suggests this sample is a shocked soil due to its similiarity to the petrography of paleosol [3, 6] in that tiny, comminuted fragments of augite and labradorite are found in a soil-like matrix, but with flowing carbonate and glass (Figure 1). 202 microbes were detected, including several types of iron-oxidizing bacteria [3].

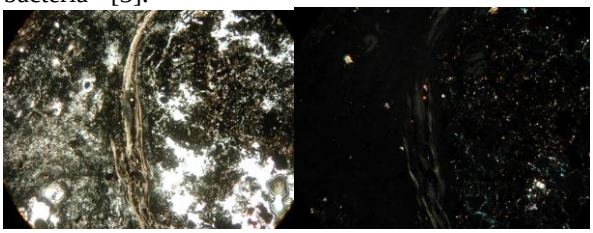

Figure 1. Petrography with 5X magnification of shocked soil LC09-316 in PPL (left) and CPL (right).

Discussion: Several findings suggest that more samples should be analyzed for comparison. Only 12 microbes in the (unshocked) paleosol suggest that its location under ~5 m of lithic breccia, only recently made available for the field geologist to sample at a quarry [8,9], might not be conducive to microbes.

Implications: More analyses of unshocked and shocked basalts and soils from Lonar Crater [4-5, 7-9] are warranted given these preliminary findings. Potential future work would involve more shock levels/Classes [4], along with searching for superposition relationships in high-resolution imaging that could indicate if microbes survived the shock event.

References: [1] Agee et al. (2013), *Science 339*, 780-785 [2] Fritz et al. (2005), *MaPS 40*, 1393-1411 [3] Wright & Bales (2015) *LPSC 2015*, #2758 [4] Kieffer et al. (1976) *LPSC*, 1391-1412 [5] Wright et al. (2011) *JGR-Planets* [6] Wright (2012) *43rd LPSC*, #2765 [7] Jourdan et al. (2011) *Geology 39*, 671-674 [8] Maloof et al. (2010) *GSA Bulletin 122*, 109-126 [9] Komatsu et al. (2014) *PSS 95*, 45-55