# THE ASTROBIOLOGICAL POTENTIAL OF MARTIAN CRATERS: EFFECT OF METEORITE IMPACT ON THE HABITABILITY OF BASALT.

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**Introduction:** Impact cratering has long been considered to be a solely destructive process for life, resulting in catastrophic damage on both local and global scales. However, impact-induced alteration to target rocks can favourably affect their habitability for endolithic microorganisms (i.e., those living within rocks) which may colonize the rock post-impact [1]. The extreme temperatures and pressures generated during impact can mobilize bioessential elements [2], as well as increase the porosity of target rock, thereby increasing the internal surface area available for colonization. Additionally, such endolithic habitats are well-suited to protecting inhabitants from environmental stressors. For example, studies of shocked gneisses at the Haughton impact structure have revealed them to be a refuge for endolithic communities in the polar desert environment of the Canadian High Arctic [3, 4]. Given this ability of impact-shocked rocks to support life in otherwise inhospitable terrestrial environments [5], it has been proposed that such a strategy may have been utilized by extraterrestrial life, if it has ever existed.

Terrestrial impact craters formed in basalt represent important analogue sites for the study of how impact cratering may have influenced the habitability of the primarily basaltic surface of Mars, whose lack of an appreciable atmosphere and magnetic field results in inhospitable environmental conditions which can be buffered by endolithic modes of living, including extremes of radiation, temperature, and dryness. To the best of our knowledge, endoliths in impact-shocked basalts have been studied only at India's Lonar Lake [e.g. 6], though it remains unknown whether the habitability of such basalts is directly related to their impact-generated features. We aim to address this current gap in knowledge on the effects of impact shock on the habitability of basalt.

**Geological Context:** Of the six known preserved basaltic craters on Earth, two are found ~100 km apart in the Serra Geral Formation located in Brazil's Paraná Basin— (1) Vargeão Dome (26° 49.0' S, 52° 10.0' W) and (2) Vista Alegre (25° 57.0' S, 52° 41.5' W). Samples were aseptically collected at exposed sites in various locations within both craters. Samples of unshocked basalt were collected outside of Vista Alegre to serve as a control. As described by Posnov et al. [7], petrographic analyses were carried out to characterize the shock level of each sample based on constituent minerals and their shock porosity, corresponding to the shock pressures the rock was exposed to upon impact [7].

**Purpose:** The aim of this work was to characterize microbial biomass and community composition as a function of shock level in order to assess the habitability of basaltic substrates from a planetary exploration context. A culture-independent characterization of microbial diversity within the shocked basaslts was conducted to determine whether microbial diversity in a given basaltic sample increases with increasing shock level. This would suggest that shock-related changes to the basaltic substrate have had favourable effects on its habitability for life on Earth, and thus potentially for life on Mars.

**Methods:** DNA was extracted from 10 samples with shock levels ranging from 2-4 (based on the classification scheme of Stöffler et al. [8]), as well as 2 unshocked (control) polymict breccias. Extracted DNA was sent for Illumina amplicon sequencing of 16S rRNA, 18S rRNA, and ITS genes. The R-based DADA2 pipeline was used to derive the abundance of amplicon sequence variants (ASVs), complete taxonomic classification of ASVs, and compute alpha diversity indices (including Shannon and Simpson indices).

**Preliminary Results and Discussion:** Issues with the quality of the data have prevented completion of data analysis. DNA has been re-extracted after troubleshooting the extraction procedure to allow for higher yields. Updated sequencing data will soon be received.

Preliminary 16S rRNA sequencing data from 9 (8 shocked basalts + 1 unshocked control) of the 12 samples showed the communities to be dominated by Actinobacteria, Proteobacteria, and Cyanobacteria (Figure 1). A clear trend in microbial biodiversity (as indicated by alpha diversity measures) and the shock level of a given sample was not apparent (Figure 2). If these preliminary findings reflect a true lack of correlation between shock level and community diversity, it may be, in part, due to the dense vegetation covering both craters, as well as other characteristics of the natural environment which may be stronger drivers in determining surface and near-surface microbial communities than shock level or shock-related alterations to the basalts. However, issues with the quality of the data call into question the validity of these preliminary findings, thus they will be re-considered when updated sequencing data has been received and analyzed.

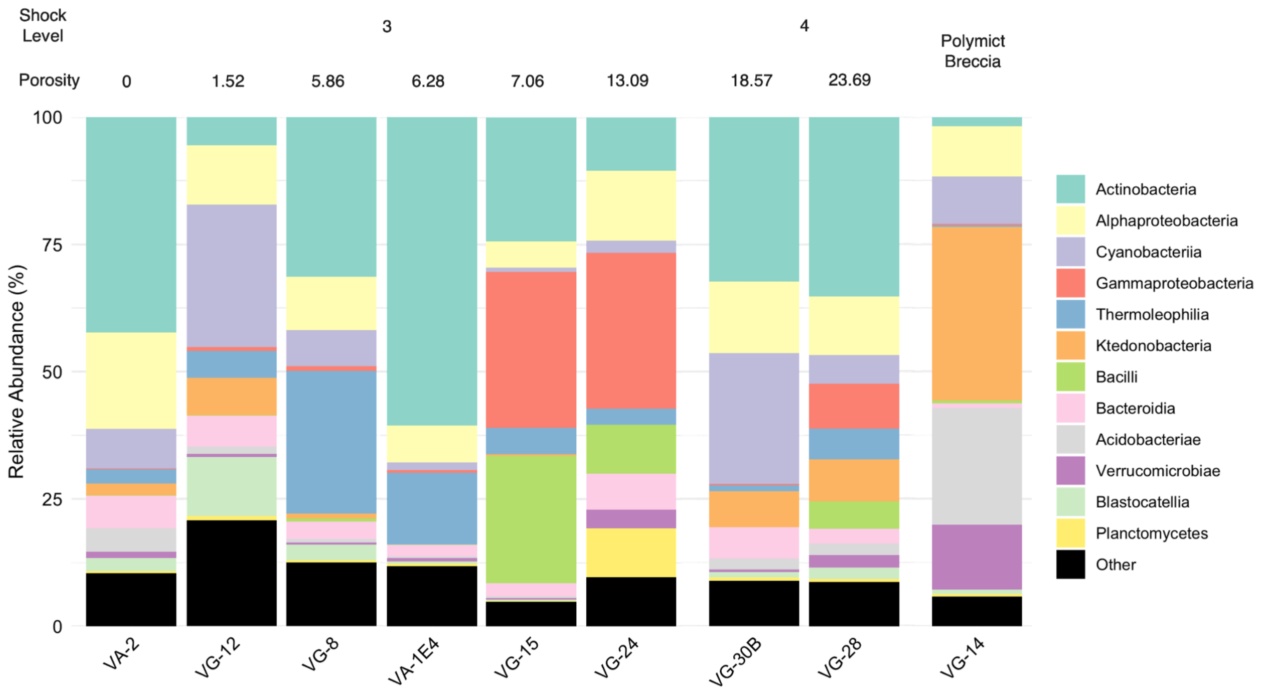

**Figure 1.** Bacterial community composition of shocked basalts from Vargeão Dome and Vista Alegre. Class-level taxonomic classifications assigned based on 16S rRNA sequencing. VG and VA sample prefixes denote sampling from Vargeão Dome and Vista Alegre, respectively. Comminities were dominated by Actinobacteria, Proteobacteria, and Cyanobacteria.

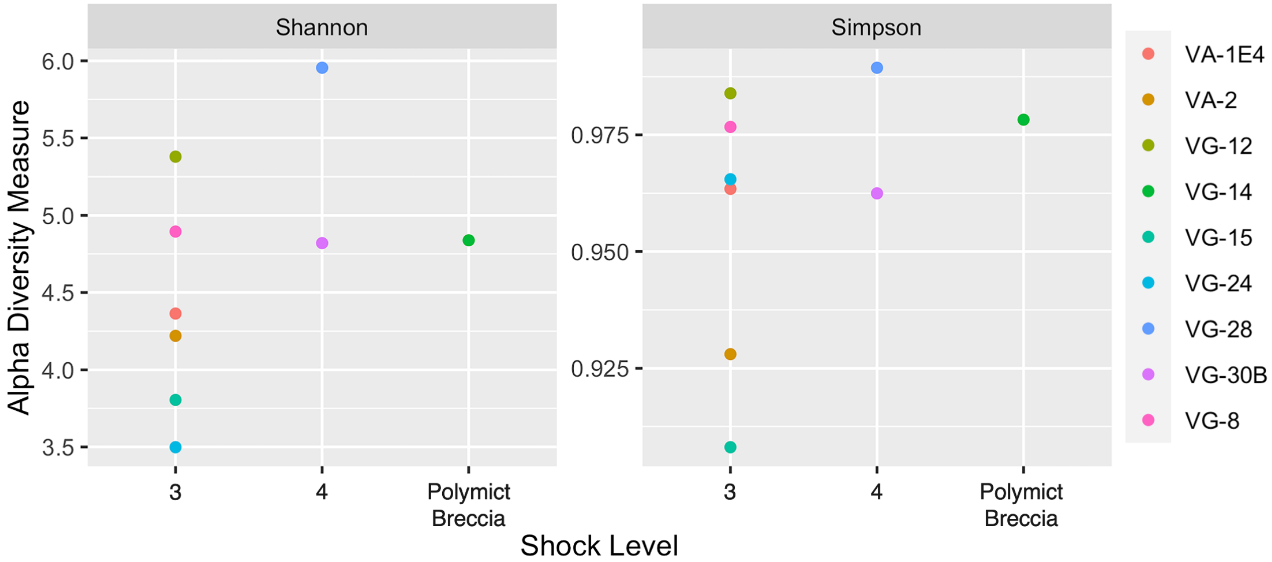

**Figure 2.** Microbial diversity (Shannon and Simpson alpha-diversity) as a function of shock level within Vargeão Dome and Vista Alegre shocked basalts. VG and VA sample prefixes denote sampling from Vargeão Dome and Vista Alegre, respectively. No clear trend between alpha-diversity and sample shock level was apparent.

**References:** [1] Osinski, G. R. et al. (2020) *Astrobiology* 20:1121-1149. [2] Pontefract, A. et al. (2012) *Meteoritics & Planetary Science* 47:1681-1691. [3] Cockell, C. S. (2004) *Advances in Space Research* 3:1231–1235. [4] Pontefract, A. et al. (2014) *Astrobiology* 14:522-533. [5] Cockell et al. (2005) *Meteoritics & Planetary Science* 40:1901-1941. [6] Paul, D. et al. (2016) *Frontiers in Microbiology* 6:1553. [7] Posnov, N. et al. (2019) *LPSC 50*, Abstract #2863. [8] Stöffler, D. et al. (2018) *Meteoritics & Planetary Science* 53:5-49.