SPATIAL VARIABILITY AND CORRELATION OF MULTIPLE BIOMARKERS IN ICELANDIC MARS ANALOGUE ENVIRONMENTS AND THE IMPLICATIONS FOR LIFE DETECTION MISSIONS.

A. H. Stevens[1], E.S. Amador[2], M. L. Cable[3], T. Cantrell[4], N. Chaudry[5], T. Cullen[5], Z. Duca[4], D. M. Gentry[6], M. B. Jacobsen, H. McCaig, G. Murukesan[7], V. Rennie[1], E. W. Schwieterman[2], G. Tan[4], C. Yin[8], A. Stockton[4], D. C. Cullen[5], W. Geppert[8], [1]UK Centre for Astrobiology, University of Edinburgh, UK adam.stevens@ed.ac.uk, [2] Astrobiology Program, University of Washington, USA [3] NASA Jet Propulsion Laboratory, California Institute of Technology, USA [4] School of Chemistry & Biochemistry, Georgia Institute of Technology, USA [5] School of Engineering, Cranfield University, UK, [6] Biospheric Science, NASA Ames Research Center, USA [7] Department of Biochemistry, University of Turku, Finland, [8] Astrobiology Centre, AlbaNova University Center, Royal Institute of Technology or Stockholm University, Sweden

Introduction: We conducted expeditions to Mars analogue sites in Iceland to investigate the variability and correlation of three common biomarker assays: cell quantification via fluorescence microscopy, ATP quantification via bioluminescence, and quantitative PCR with universal primer sets. Sample sites were nested at four spatial scales (1 m, 10 m, 100 m, and > 1 km) in areas of volcanic tephra that appeared homogeneous at 'remote imaging' resolution. Full details of the initial expedition methodology are given in [1].

Understanding the spatial and temporal distributions of biomarkers will assist in planning life detection strategies for future planetary missions. The landing site for a hypothetical life-detection or sample-return mission will be chosen using remote sensing data, but the specific sampling locations may not be representative of the wider context, especially if a difference of a few tens of meters or centimeters makes a significant difference in the results, and the most scientifically lucrative locations may be missed.

Results: Our results suggest that the biomarkers under scrutiny in such a mission must be carefully selected. Statistical analysis shows that all spatial scales were highly diverse in ATP, bacterial 16S, and archaeal 16S DNA content (see Figure 1 for an example); nearly half of sites were statistically different in ATP content at $\alpha = 0.05$. Cell counts showed significant variation at the 10 m and 100 m scale. At the > 1 km scale, the mean cell counts were not distinguishable, but the median cell counts were, indicating differences in underlying distribution. Fungal 16S DNA content similarly varied at 1 m, 10 m, and 100 m scales only. Cell counts were not correlated with ATP or DNA content at any scale. ATP concentration and DNA content for all three primer sets were positively correlated. Bacterial DNA content was positively correlated with archaeal and fungal DNA content, though archaeal correlation was weak.

Discussion: While the biomarkers chosen for this study might not be the most applicable to extra-terrestrial life detection missions, these results highlight the difficulty of choosing a 'good' biomarker. The high spatial variability and variation in correlation between biomarkers that are measuring similar things suggests that not only may different methods yield conflicting results, but they may also be differentially representative of the overall area.

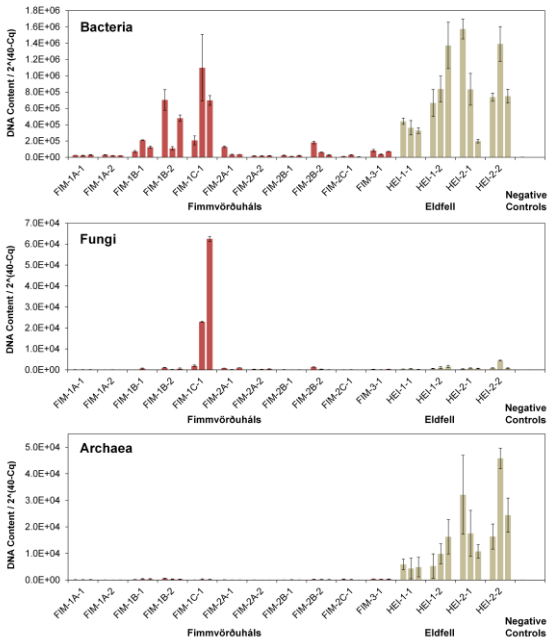

Figure 1 - An example of the variability in DNA concentration in samples at different scales.

A further expedition repeated the sampling strategy, with the addition of a smaller-scale sampling grid of 10 cm and a third > 1 km location and more are planned. We have also incorporated 'remote sensing' equivalent measurements using aerial drones, and IR and Raman spectroscopy in order to better distinguish between effects of geochemical variation and intrinsic biomarker variation. Correlating remote sensing data with the variability of different biomarkers will allow us to identify methods

References:

[1] Amador, E.S., et al. (2015) *Planetary and Space Science*,106(0): p. 1-10.