OCEAN FERTILIZATION FROM GIANT ICEBERGS ON EARTH AND EARLY MARS.

Esther R. Uceda[1], Alberto G. Fairén[2,3], J. Alexis P. Rodríguez[4], Christoper Woodworth-Lynas[5]. [1]Universidad Autónoma de Madrid, 28049 Madrid, Spain (mariae.ruiz@uam.es); [2]Centro de Astrobiología (CSIC-INTA), 28850 Madrid, Spain; [3]Cornell University, Ithaca 14853, USA; [4]Planetary Science Institute, Tucson, AZ 85719, USA; [5]PETRA International Ltd., Newfoundland & Labrador, Canada A0A 2B0.

Ocean fertilization from icebergs: On Earth's oceans, giant icebergs release melting water containing nanoparticulate iron and other micronutrients, which support biological metabolism and growth to the near-coastal euphotic ecosystems, many of which are iron limited [1]. This iron limitation of primary producers has been documented in large regions of the Earth's oceans, most notably in polar areas proximal to significant glacial activity, and is counterbalanced by the substantial enrichment of terrigenous material supplied by icebergs [2-4]. The biological productivity extends hundreds of kilometres from the giant icebergs, and persists for over one month after the iceberg passes [1]. Here we propose that iceberg activity on early Mars could have promoted a similar enhancing of biological productivity on the planet's oceans. The identification of specific biosignatures in icebergs trails on Earth could give clues as to what kind of biosignatures could be expected on the ancient Mars ocean floors, and where to look for them. In particular, assuming that life existed on Mars coeval to glacial activity, enhanced concentrations of organic carbon could be anticipated near iceberg trails, analogous to what is observed in polar oceans on Earth.

Identification of iceberg rafting on Mars: We have previously presented [5-9] evidence for furrows, dump structures and chains of craters (Figs. 1-3) that we interpret as indication for iceberg transport and grounding on very cold oceans on early Mars, both in the northern plains and in the Hellas basin. Structures include:

1. Furrows: The furrows are located in elevated areas or on local topographic highs, particularly on the Hellas basin (Fig. 1). We interpret these features in terms of iceberg rafting and grounding. We propose that the furrows were formed in submerged unconsolidated sediments, when floating ice keels touched down and displaced loose material to the sides as they continued to move forward, possibly driven by both wind and water currents.

2. Chains of craters: High-resolution images of Utopia and Isidis Basins also reveal chains of crater-like structures several hundred meters wide and 1 to 5 km long (Fig. 2). We interpret that overlapping pits are formed by periodic liftoff of the scouring keel as the floating ice mass moves forward. They may be caused by large amplitude deep ocean swell or by instabilities in the ice mass causing it to "wobble".

3. Dump structures: Dark boulder clusters are revealed at large scales by their slightly darker tonality with respect to the surrounding terrain (Fig. 3). These clusters have sizes ranging from several hundred meters to 1-2 km. We suggest that large boulder concentrations originated when debris-rich icebergs grounded and remained stationary for a lengthy period of time as they melted, resulting in localized clusters of boulders and cobbles.

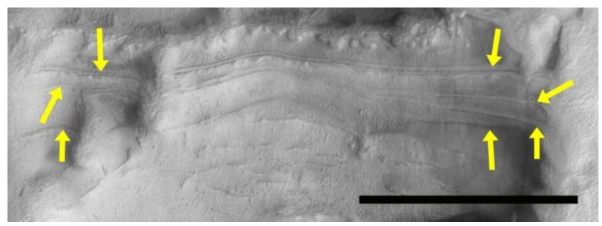

Fig. 1: Scour marks (arrows) in Hellas Basin (HiRISE image PSP_009548_1420). Scale bar = 1 km. HiRISE image credit: NASA/JPL/University of Arizona.

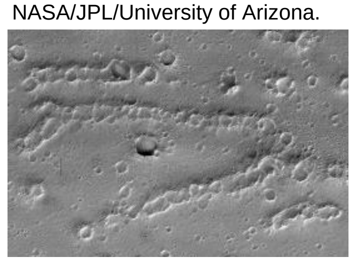

Fig. 2: Chains of crater-marks in Utopia Planitia.

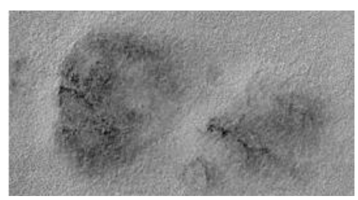

Fig. 3: Dark regions with a high concentration of boulders.

References: [1] Duprat, L. P., et al. Nature Geoscience, 9, 219–221 (2016). [2] Smith, K. L., et al. Science 317, 478–482 (2007). [3] Death, R. et al., Biogeosciences 11, 2635–2643 (2014). [4] Hawkings, J. R., et al. Nature Commun. 5, 3929 (2014). [5] Fairén, A.G., et al. 41st LPSC, #2478 (2010). [6] Uceda, E. R., et al. LPSC, #1349, 2015. [7] Uceda, E. R.,et al. AbSciCon, #7292, Chicago 2015. [8] Uceda, E. R., et al. AGU Fall Meeting, Abstract #79966, San Francisco, 2015. [9] Uceda, E. R., et al. LPSC, #1102, 2016.

Acknowledgements: The research leading to these results is a contribution from the Project "icyMARS", funded by the European Research Council, Starting Grant no 307496.