PIZZA OR PANCAKE? FORMATION MODELS OF GAS ESCAPE BIOSIGNATURES IN TERRESTRIAL AND MARTIAN SEDIMENTS. R. Bonaccorsi[1,2] A.G. Fairen[3,4], L. Baker[5]; C. P. McKay[2]; and D. Willson[2]. [1]SETI Institute – Carl Sagan Center (rosalba.bonaccorsi-1@nasa.gov); [2]NASA Ames Research Center (M.S. 245-3, Moffett Field CA 94035); [3]Department of Planetology and Habitability, Centro de Astrobiologia, Spain; [4]Department of Astronomy, Cornell University; [5]Dept. of Geological Sciences, University of Idaho (PO Box 442339, Moscow, ID).

Introduction: Fine-grained surface sedimentary structures referred as to "Hollow nodules" (HNs) were discovered at *Yellowknife Bay Site* by the Curiosity rover (Fig. 1A). Plausible abiotic [1,2] and biological formation mechanisms have been proposed, but no biomarkers have been detected to support their biogenic origin in Gale Crater [3].

In an ephemeral pond in Ubehebe Crater (UC), Death Valley, Calif., we found sedimentary structures (Fig. 1B) strikingly similar to those imaged by the MSL rover (Fig. 1A). Potential biogenic and abiogenic processes of HN formation on Mars could not be discerned based on a morphological approach. Yet, studies of their terrestrial analogues could inform about potential biogenic activities that might be responsible for intriguing sedimentary structures on Mars.

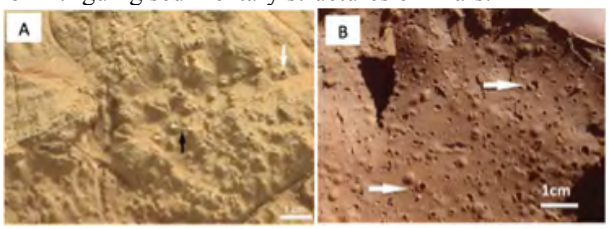

Figure 1*. HNs in mudstone (white arrows) imaged by Mastcam-100, sol 159, Yellowknife Bay Site (A). Mini hollows in the terrestrial mud gas escape structures (B)*

Methods: As part of long-term monitoring of the surface water cycle, and microclimate conditions at UC [e.g., 4,5], H_2O content/ground moisture, temperature and relative humidity (*rH*) were acquired with miniature sensor/data loggers.

Observations: During the pond's 11-day life (August 5th to 16th, 2014), from accumulation thru total evaporation of shallow standing water (5-20 cm-depth) we witnessed the active formation of HNs-like gas escape features (Fig. 1B) under conditions of extreme evaporation (~2 cm/day) and preceded by an unusual cyanobacterial bloom and decay during the first 2 days of pond's life (Fig. 2). The intra-crater mud's surface is otherwise extremely dry for most of the year (Air_*rH* ~2-5%; moisture 1-2 wt.%; Summer air/ground T: 45-48ºC/ 67-70ºC).

Formation Model of Ubehebe's HNs. Based on terrestrial observations/measurements and literature data a plausible model could involve H_2S/CO_2 gas bubbles released by fermenters and/or Sulfur Reducing Bacteria (SRB) using decaying cyanobacterial biomass (Fig. 2A). In this model, the HN-forming clay-rich mud is the most habitable layer with bacteria plausibly supported by redox reactions involving sulfides (FeS_2, FeS) from HS^- and Fe^{2+} in reduced sediments, sulfates, iron-bearing minerals and biological S.

Pizza or Pancake? Are HNs from biological fermenting processes (very much like bubbles rising from our fermenting pizza dough)? Or, are they from abiological processes, just like CO_2 bubbles forming in fluffy pancakes by baking soda? If the former is the case, gas-escape strictures on Mars might offer an intriguing evidence of cryptic, yet metabolically active and ephemeral life leaving gas-escape strictures in lacustrine deposit.

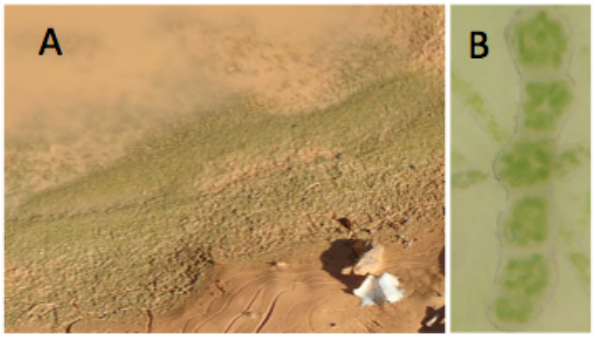

Figure 2. *Pond's cyanobacterial biomass (B) and underwater bubbles forming gas escape structures (A).*

Conclusions: UC surface HNs represent a novel type of microbially-induced sedimentary structures (MISS) [e.g., 6-8] and offer an unequivocal evidence that short-lived and cryptic terrestrial microbial mats are fundamental for their formation.

References: [1] Vaniman D.T. et al. (2014) *Science 343*, 1243480. [2] Kim, J.D. et al., (2013). *PNAS. U.S.A.* 110, 10073–10077. [3] Grotzinger J.P. et al. (2014), *Science 343*, 124277. [4] Bonaccorsi R. et al. (2012) *AGU Fall Meeting*, Abstract #P11B-1839. [5] Bonaccorsi, R. et al. (2014) *AGU Fall Meeting,* Paper #EP53A-3632. [6] Noffke, N. (2015) *Astrobiology,*15(2). [7] Mariotti, G. et al. (2014) *Nature Geoscience*, 7,736–740. [8] Allwood, A. C et al. (2009) *PNAS* 106(24): 9548–9555.