THRESHOLDS OF DETECTABILITY FOR HABITABLE ENVIRONMENTS IN THE ATACAMA DESERT, WITH IMPLICATIONS FOR MARS EXPLORATION. M. S. Phillips[1], J. E. Moersch[1], N. A. Cabrol[2], A. F. Davila[3] and the SETI Institute NAI Team, [1]Planetary Geosciences Institute, Department of Geological Sciences, University of Tennessee, Knoxville, Tennessee 37996-1410, USA, (mphill58@vols.utk.edu), [2]SETI Institute Carl Sagan Center, [3]NASA Ames, Space Science Division.

Introduction: Detection and characterization of past or present habitable environments on Mars from orbit is a necessary step in selecting landing sites for robotic missions with this same goal. Recent Mars rover missions have successfully landed in such locations [1, 2]. However, ambiguity often remains prior to a landing site decision as to what specific features or habitable environments might be found. For example, the Spirit landing site was chosen because of the evidence for past water activity, but the results from the rover indicated a predominantly basaltic surface rather than a sedimentary one [3]. Furthermore, the hydrothermal deposit, Home Plate, was not predicted from orbital observations of Gusev crater, yet it has proven to be one of the most interesting aspects of the Spirit's landing site, and one of the most promising past habitable environments [4].

A habitable environment contains liquid water, has conditions favorable for the assembly and sustained presence of complex organic molecules, and provides energy to sustain metabolism [5]. Defining terrestrial habitats, and features diagnostic of their presence, that are likely to be relevant on Mars can guide how we search for habitats on Mars and what features should be searched for in specific Martian environments. Such features also allow for well-defined engineering goals to be set, *e.g.*, spatial resolution thresholds necessary to detect features diagnostic of the habitat of interest.

We conducted analog studies in the Atacama Desert and the Altiplano of Chile with the goal of determining the thresholds of detectability for habitats that are plausible for Mars. *Threshold of detectability* is defined in the context of this work as the spatial resolution required to resolve and identify diagnostic features of habitats, and consequently each type of habitat has a unique threshold of detectability. The particular habitats examined in this study are *halite nodules* [6] at Salar Grande (figure 1a) and *gypsum domes* [7] at Salar de Pajonales. Halite nodules have been shown to be habitable in an otherwise inhospitable environment by several researchers [6, 8], and these features will be the focus of the remainder of this abstract.

Regional Setting: The Atacama Desert of Chile lies west of the Cordillera de Domeyko, approximately between latitudes 28° S and 18° S. This region has experienced hyper-arid conditions since 10 Ma to 15 Ma, and is the driest desert on Earth [9]. The Atacama Desert's extreme and continued dryness is an analogous condition for Hesperian Mars, when surface conditions transitioned from relatively wet to dry and evaporitic conditions were prevalent.

Of interest in the Atacama Desert are the continental, chloride-bearing, Miocene salt-encrusted playas, or salars [10]. Salars host habitats with a taphonomic window. That is, they contain environments where life exists, and the sedimentary and diagenetic circumstances are conducive to preservation [10, 11]. This is true for two reasons: a) their formation requires water; b) the crystal matrices of salts are conducive to preservation [12, 13]. The aforementioned endolithic habitable environments in salars include halite nodules and gypsum domes. In this preliminary report, we describe our first results in studying the threshold of detectability for halite nodules at Salar Grande.

Data and Methods: Visible images were gathered using an unmanned aerial vehicle (UAV). High-resolution image campaigns were flown at 20 m altitude collecting 0.009 m/pixel (ground sampling distance, or GSD) images. Campaigns to retrieve context imagery were conducted at 50 – 60 m altitude with a GSD of 0.026 m/pixel. Flights were conducted with solar elevation angles between 25.6° and 66.7°. Images retrieved from UAV campaigns were resized using a bicubic interpolation from 0.026 m/pixel to 0.05 m/pixel, 0.10m/pixel, 0.25 m/pixel (Hi-RISE resolution), and 6 m/pixel (CTX resolution). Thresholds of detectability for halite nodules were then determined through visual inspection. Collectively, the following features are considered diagnostic of halite nodules: a distinctly high albedo relative to the surrounding colluvial sediments, rounded margins, positive topographic relief from the surroundings, (±) interconnectivity between nodules.

Results and Discussion: Results are shown in figure 1b-e. We preliminarily determine halite nodules to have a detectability threshold between 0.10 m/pixel and 0.25 m/pixel. The first recognizable feature is the high albedo of the nodules at 0.25 m/pixel. It takes a finer GSD (at least 0.10 m/pixel) to resolve the remaining diagnostic features outlined above.

Our preliminary results indicate that if halite nodules like those in Salar Grande exist on Mars, better resolution imagery than is currently available would be necessary to detect a diagnostic set of features. Martian halite nodules might have a different appearance than terrestrial nodules due to differing conditions of formation and modification (*e.g.,* water availability, gravity, wind activity, time exposed on the surface). However, understanding the spatial resolution necessary to detect halite nodules at places like Salar Grande is a first step to detecting these intriguing features on Mars.

References: [1] Crisp, J.A., et al., (2003), *JGR,* **108**(E12). [2] Grotzinger, J., et al., (2012) *SpSciRev*, **170**(1): p. 5-56 [3] Squyres, S.W., et al., (2004) *Sci*. **305**(5685):p. 794. [4] Ruff et al., (2016) *NatCom*. **7:**13554. [5] Des Marais, D.J., et al., (2008) *Astrobio*, **8**(4): p. 715 [6] Davila, A.F., et al., (2008) *JGR* **113**(G1). [7] Rasuk, M., et al., (2014) *MicbioEco*. **68**(3): p. 483-494. [8] Wierzchos, J., (2006) *Astrobio*. **6**(3): p. 415. [9] Houston, J. and A.J. Hartley, (2003) *Int.JofClimatology*, **23**(12): p.1453-1464. [10] Artieda, O., et al., (2015) *ESP&L*. **40**(14):p.1939-1950. [11] Fernández-remolar, D.C., et al., (2013) *JGR*. **118**(2): p. 922-939. [12] Stan-Lotter, H., S. et al., (2006) *Elsevier*. p. 15. [13] Steven, A.F., et al., (2002) *Nature*. **417**(6887): p. 432.

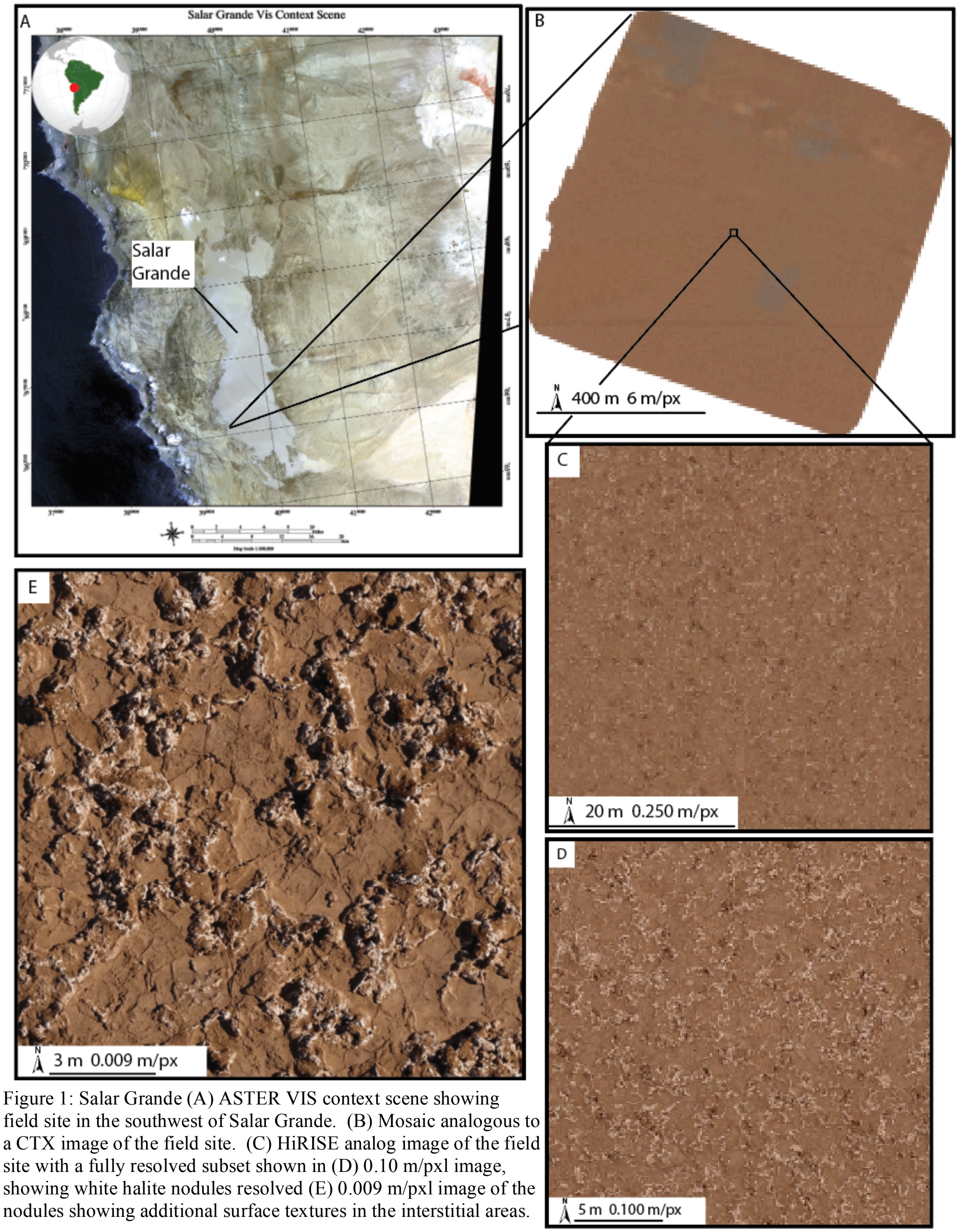

Figure 1: Salar Grande (A) ASTER VIS context scene showing field site in the southwest of Salar Grande. (B) Mosaic analogous to a CTX image of the field site. (C) HiRISE analog image of the field site with a fully resolved subset shown in (D) 0.10 m/pxl image, showing white halite nodules resolved (E) 0.009 m/pxl image of the nodules showing additional surface textures in the interstitial areas.