

EVALUATING FLAT-CRATER FLOOR FILL COMPOSITIONS: INSIGHTS INTO VOLCANIC AND SEDIMENTARY PROCESSES. C. S. Edwards¹ and A. D. Rogers²; ¹USGS Astrogeology Science Center, Flagstaff, AZ. cedwards@usgs.gov; ²Stony Brook University, Stony Brook, NY.

Introduction: Infilled craters on Mars were first observed by Mariner 4 in 1965 and have remained an enigma ever since. Several processes to fill martian craters have been proposed, including aeolian sedimentation [e.g. 1, 2, 3], lacustrine sedimentation [e.g. 4, 5] and impact processes such as impact melt ponding [e.g. 6, 7, 8]. However, these explanations cannot account for all occurrences of infilled craters [9], as critical morphologies, along with thermophysical and compositional differences likely indicate other processes may be key to the observed characteristics [10].

Initially, Edwards et al., [9] mapped the distribution of high-thermal inertia surfaces, defined as $>1200 \text{ J K}^{-1} \text{ m}^{-2} \text{ s}^{-1/2}$ and interpreted as exposed bedrock, globally on Mars between 75°S and 75°N [9] using Thermal Emission Imaging System (THEMIS) nighttime infrared data. Follow-on work [10] conducted a globally comprehensive compositional, thermophysical and morphological study of ~ 2800 flat floored, high thermal inertia craters (Fig.1), where rockier material is exposed in the floor directly adjacent to the lower thermal inertia crater walls/surrounding regolith (Figs. 1 & 2). To understand the timing of the crater infilling, Edwards et al., [10] derived crater size frequency model ages from over 110 crater floors (resulting in formation ages of $\sim 3.5\text{-}4\text{Ga}$). The geologic characteristics of some of these crater floor deposits (rocky, enriched in olivine/pyroxene, lobate margins and wrinkle ridges) resulted in an interpretation that the infil-

ling material was likely volcanic in origin. However, the source for the infilling material is enigmatic, as no vents are observed and these deposits do not occur in association with any specific volcanic or geographic provinces. Edwards et al., [10] proposed that a different process – impact excavation-induced decompression melting of the martian mantle and more recently pervasive fracturing of the crust resulting in the release of pre-existing melt [11] – are responsible for the primary intra-crater materials.

While globally comprehensive, Edwards et al. [10] did not conduct crater specific compositional, thermophysical and morphological analysis to robustly determine variations in the formation process and alteration history.

Methods: In this work, we will examine a representative subset of the craters from Edwards et al. [10] using compositional (e.g. Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), Thermal Emission Spectrometer (TES) and THEMIS), thermophysical (e.g. TES and THEMIS) and high resolution morphology (e.g. High Resolution Imaging Science Experiment (HiRISE) and Context Imager (CTX)) datasets over each crater to determine the primary infilling mechanism, compositional differences (indicating source region variability) and any post-filling alteration (mechanical or chemical).

Given the large number of craters identified (~ 2800) as having higher thermal inertia associated

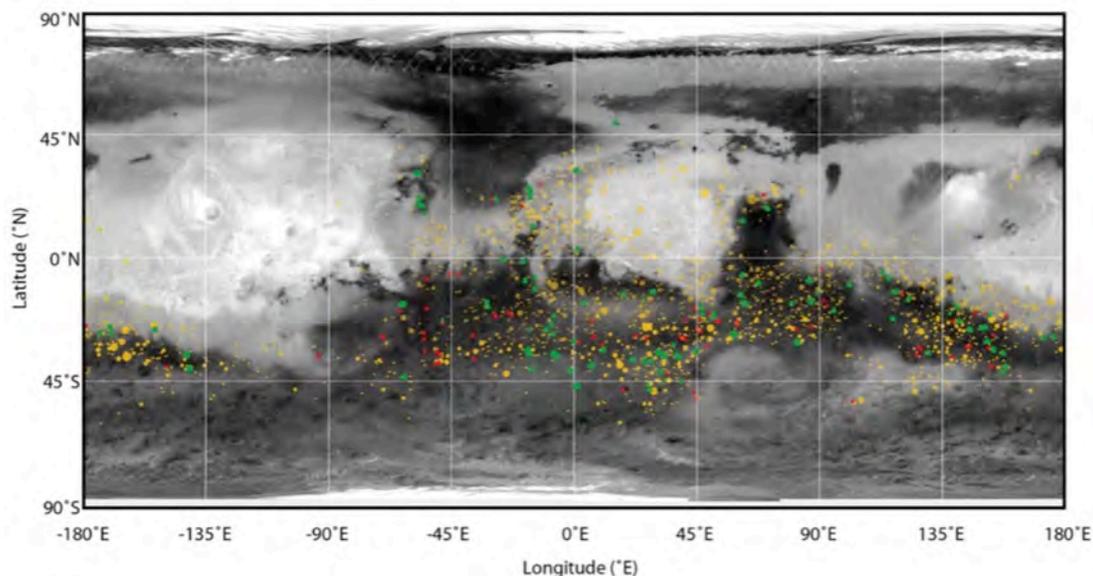


Fig. 1. Global distribution of high thermal inertia, flat-floored craters that are commonly enriched in pyroxene and olivine relative to plagioclase and high-Si phases compared to typical surrounding highlands material. Red=[10]; Yellow=[9], Green=craters selected for detailed examination in this work.

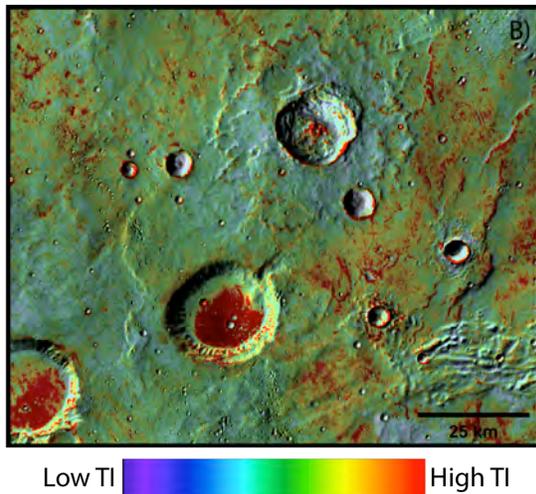


Fig. 2: Example high thermal inertia, flat crater floor [9]

with the floor than the surrounding terrain or crater walls [10], we have used a series of selection criteria to sample an unbiased and uniformly distributed set of craters for examination.

These selection criteria include the following parameters:

- 1) Regional albedo ($\sim 0.3\text{--}3.0 \mu\text{m}$) over 100km length scales must be <0.225 to ensure high quality compositional data of both the crater and surrounding regolith can be obtained,
- 2) Regional thermal inertia over 100km length scales must be $>150 \text{ J m}^{-2} \text{ K}^{-1} \text{ s}^{-1/2}$ to ensure dusty regions are excluded,
- 3) Craters must be $>15 \text{ km}$ in diameter to provide adequate surface area to investigate the detailed composition,
- 4) Craters must be $<75 \text{ km}$ in diameter to preclude very large basins that have experienced many episodes of resurfacing, alteration by subsequent impacts etc., that may complicate the resulting interpretation and may ultimately be due a long and complex history and
- 5) Craters must have $>80\%$ CRISM MSP coverage. While somewhat arbitrary, this coverage requirement ensures that at least some visible near infrared compositional data will be available for use. While other datasets (e.g. THEMIS, TES) are available, they have near-global coverage and are therefore less useful to place selection criteria constraints.

The resulting subset of craters is relatively evenly distributed when compared to the overall distribution of high thermal inertia crater floors [10] and provides sufficient geographic coverage to ultimately draw regional conclusions.

Outcomes and Expected Significance: Interpreted compositional maps, thermophysical characteristics and proposed event sequences will be determined for

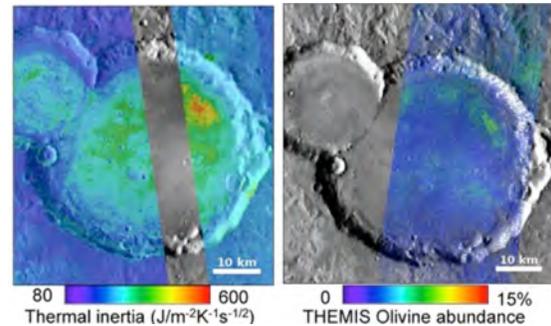


Fig. 3: Unnamed Crater in Noachis Terra

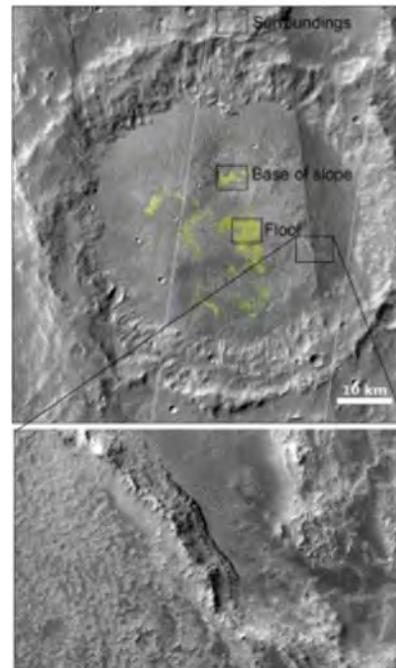


Fig. 4: Gringuaz Crater layered morphology where yellow hues indicate thermal inertias $> 600 \text{ J m}^{-2} \text{ K}^{-1} \text{ s}^{-1/2}$

each crater and then subsequently included in the global context to understand any regional correlations. For example an unnamed crater in Noachis Terra (Fig 3.) exhibits a clear correlation between olivine content and thermal inertia, as well as embayment morphologies. This indicates a volcanic origin for the fill material, with minimal subsequent modification. However, another crater in approximately the same region crater (Fig. 4) exhibits no compositional correlation, has significant layering in the floor materials, and contains channel-like features, indicating a sedimentary origin for these materials. Future work will make such interpretations for all ~ 120 crater floors identified.

- References:**[1] P. R. Christensen, (1983) *Icarus* **56**, 496. [2] R. E. Arvidson, (1974) *Icarus* **21**, 12. [3] M. L. McDowell, V. E. Hamilton, (2007) *J. Geophys. Res.* **112**, E12001. [4] M. Pondrelli *et al.*, (2005) *J. Geophys. Res.* **110**. [5] N. A. Cabrol, E. A. Grin, (1999) *Icarus* **142**, 160. [6] P. H. Schultz, (1976) *The Moon* **15**, 241. [7] S. Smrekar, C. M. Pieters, (1985) *Icarus* **63**, 442. [8] D. E. Wilhelms *et al.*, (1987). [9] C. S. Edwards *et al.*, (2009) *J. Geophys. Res.* **114**, E11001. [10] C. S. Edwards *et al.*, (2014) *Icarus* **228**, 149. [11] C. Edwards *et al.*, (2014) *LPI Contributions* **1791**, 1303.