ISOLATED CHAOS AND COLLES IN THE MARTIAN HIGHLANDS: POTENTIAL INSIGHTS INTO BASIN-FILL AND MODIFICATION PROCESSES. J.C Cowart, L.E. Bunce, and A.D. Rogers, Department of Geosciences, Stony Brook University, Stony Brook, NY (justin.cowart@stonybrook.edu)

Introduction: We previously reported distinctive, topographically-raised blocky/fractured units within otherwise flat Martian highlands inter- and intracrater plains [1]. These units commonly resemble chaos terrains at THEMIS resolution (100 m/px) (**Fig. 1**). We refer to these units as 'Isolated Chaos and Colles' (ICCs). ICCs show wide variability in their thermal properties, suggesting they are composed of materials with a wide range of mechanical behaviors. We have expanded on our previous work with a systematic mapping effort and morphological assessment of ICCs.

ICCs may provide insight into ancient Martian surface processes. Many highlands plains contain high thermal inertia materials with clastic lithologies [2], but their lithification pathways are unclear. Some ICCs appear to conformably overlie these materials, and may have a role in their lithification and preservation.

Many ICCs resemble chaos terrains, which may aid investigation into this enigmatic terrain type. Most large Martian chaos terrains are found near the global dichotomy boundary and are associated with Hesperian-aged outflow channels [3], which has led to models of chaos terrain formation invoking massive releases of groundwater from aquifers [e.g. 4,5] or melting subsurface ice [6]. The potential presence of chaos regions in the highlands may further constrain these models.

Finally, some ICCs resemble chaos terrains in the Eridania paleolake basin. The Eridania chaos materials are phyllosilicate-rich, and may result from aqueous or hydrothermal alteration of pyroclastic materials [7,8]. These locations are thought to have provided potentially habitable environments. Study of these ICCs may provide additional occurrences of these environments.

Mapping: Using the THEMIS global daytime radi-

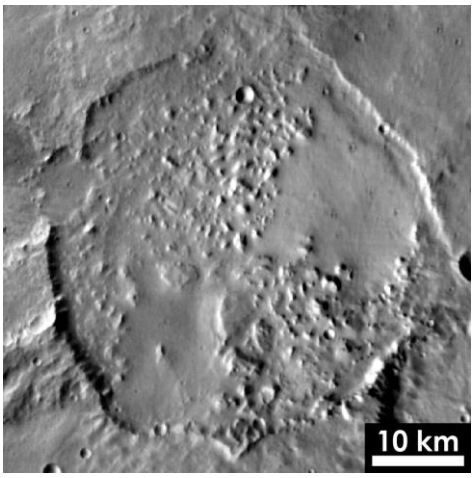

Figure 1. THEMIS daytime IR radiance image of an ICC unit located in eastern Terra Sabaea, with characteristic tilted blocks, mesas, and knob fields.

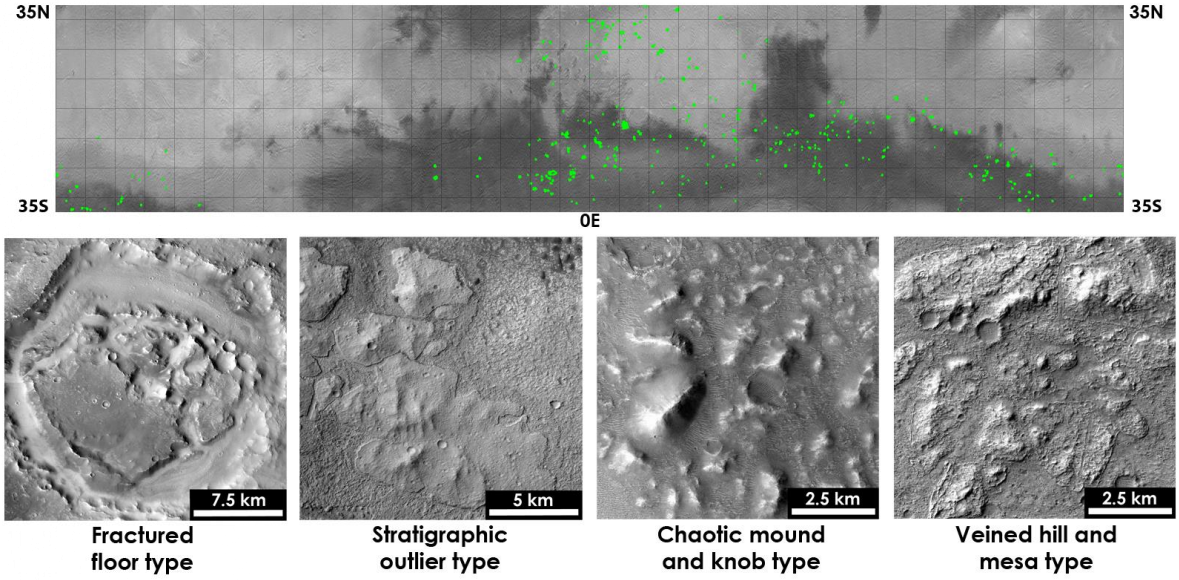

Figure 2. Global map of ICCs. Units are found throughout the cratered highlands region. Several subgroups of ICCs are present. A) Fractured floor ICCs consist of large mesas separated by a jigsaw-like network of deep fractures. B) Stratigraphic ICCs form low mounds that apparently conformably overlie basin materials. C) Chaotic mound and knob ICCs form fields of variably-sized knobs and mounds. D) Intercrater plains ICCs typically form isolated clusters of low, rugged hills within intercrater plains.

ance mosaic, we delineated ICC units within the cratered highlands equatorwards of 35° latitude. This constraint was chosen to reduce inclusion of periglacially-modified surfaces. We also avoided regions located along the global dichotomy boundary or previously characterized as chaotic terrain.

Classification: We found 394 ICCs in the cratered highlands (**Fig. 2**). Our morphological assessment of ICCs uses the Mars Reconnaissance Orbiter CTX camera (~6 m / px scale). Our assessment evaluates overall morphology (mesa-, mound-, or knob-forming); small-scale relief; qualitative crater retention; stratigraphic relationships to surrounding materials; and features such as layering, km-scale polygonal fracture networks, boxwork veins, and erosional moats. These features were used to identify major ICC subgroups (examples in **Fig. 2**). Several dozen ICCs cannot be confidently assigned to the groups described below and additional subgroups may be present within the unclassified ICCs.

Fractured floor type. ICCs in this subgroup form large mesas separated by a jigsaw-like network of deep fractures. Layering is observed in mesa walls in units not covered in a thick dust mantle, and appear to be large sub-horizontal blocks of crater fill materials. This subgroup may heavily overlap with fractured floor craters discussed in [9].

Stratigraphic outlier type. These units display clear planar (apparently conformable) contacts with the underlying plains, in contrast to other ICCs with obscured contacts or embayment relationships. These ICCs typically form low mounds with variable crater retention and are commonly bisected by kilometer-scale fracture networks. Clear internal layering is not always observed within these units.

Chaotic mound and knob type. Units in this subgroup typically form chaotic mound and knob fields. These units have a distinctive overall CTX morphology, including mottled tone, poor crater retention, and a smooth surface at CTX resolution. These ICCs are exclusively associated with heavily modified or obliterated basins, suggesting these units formed before intense erosion ceased in the highlands prior to the Noachian-Hesperian transition [10]. These units show a strong superficial similarity to the Eridania paleolake chaos terrains, and at least one unit shows R2240-R2540 (zeolite/sulfate) and D2300 (Fe/Mg phyllosilicate) CRISM FRT parameter detections (**Fig. 3**).

Veined hill and mesa type. These ICCs occur as isolated low hill clusters within intercrater plains and typically have rugged topography with vein-like ridge networks. Many of these units are surrounded by erosional moats, suggesting embayment by the surrounding plains materials. This relationship suggests a complex formation and modification history of these units.

References: [1] Cowart J.C. and Rogers A. D. (2017) *LPSC XLVIII* Abstract #1549 [2] Rogers A. D. et al. (2018) *GRL*, 45(4), 1767-1777 [3] Baker V.R. (2001) *Nature*, 412, 228-236 [4] Chapman M.G. and Tanaka K.L. (2002) *Icarus*, 155(2), 324-339 [5] Rodriguez J.A.P et al. (2005) *Icarus*, 175(1), 36-57 [6] Zegers T.G. et al. (2010), *GRL*, 297, 496-504 [9] Bamberg M. et al. (2014) *Planetary and Space Science*, 98, 146-162. [10] Howard, A.D. et al. (2005), *JGR-Planets*, 110, E12S14

Acknowledgement: This work was partially supported by NASA MDAP NNX14AM26G and 80NSSC19K0021.

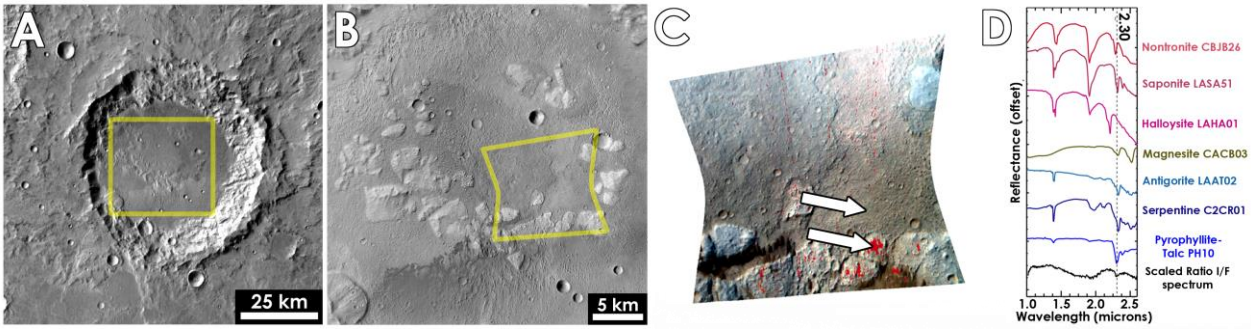

Figure 2. A) Regional context of an ICC unit located within Tyrrhena Terra. This unit is located in an intracrater plain forming the floor of a heavily-degraded crater. The yellow box shows the CTX mosaic footprint. **B)** CTX mosaic. This ICC unit consists of light toned mounds. MOLA measurements indicate these mounds stand up to 50 m higher than the surrounding plains. The yellow box shows the CRISM FRT footprint. **C)** CRISM FRT image of ICC mounds and the surrounding. Plains materials are primarily basaltic. The mounds show weak D2300 (Fe/Mg phyllosilicate) parameter detections. Arrows mark the sample locations of plains and ICC spectra. **D)** Ratio of plains and ICC spectra primarily reflects the basaltic plains materials, but contains a weak 2.3 µm feature and possible 1.4 µm feature. The lack of corresponding 1.9 µm and 2.5 µm features favor talc or serpentine as the dominant Fe/Mg phyllosilicate phase.