CHARACTERISTICS AND REGIONAL DISTRIBUTION OF INTRACRATER LAYERED DEPOSITS IN ARABIA TERRA, MARS. F. C. Chuang[1] and C. M. Weitz[1], [1]Planetary Science Institute, 1700 E. Fort Lowell Rd., Suite 106, Tucson, AZ 85719 (e-mail: chuang@psi.edu).

Introduction: Exposures of layered materials on Mars are of significant interest because of their potential for yielding information on past geologic processes and environments [1-12]. Arabia Terra, an extensive region of cratered ancient highlands, has an abundance of light-toned layered deposits that are both intracrater and intercrater in nature [6,7]. Analysis of the western and southwestern portions of this region have shown that these two groups are unrelated and may have formed under different geological processes [7]. Recent work on some intracrater layered deposits in Arabia Terra have shown that repeated sets of layers may be related to orbital climate cyclicity [8]. Using several datasets from the Mars Reconnaissance Orbiter mission, we are assessing the morphology and other characteristics of intracrater layered deposits with regard to their regional distribution in Arabia Terra.

Study Region and Datasets: A 60x30 degree area (330-30 E, 0-30 N) was selected for studying the intracrater layered deposits. The region includes many prominent impact craters including Becquerel, Crommelin, Vernal, Capen, Trouvelot, and Henry. THEMIS IR, CTX, MOC, HiRISE, and CRISM datasets were used to assess crater and layer morphologies. Select CRISM spectral browse products in the visible-to-near-infrared and infrared spectrum were used for compositional information. In addition to these datasets, global gridded MOLA topography and thermal inertia (TI) [13] were used to determine heights and relative dustiness of the deposits. All of the data were imported into ArcGIS and co-registered for viewing and analysis.

A total of 46 impact craters were initially identified to have possible deposits based on THEMIS images and previous studies [9-10]. Of these 46 craters, 34 had sufficient image coverage by CTX, MOC, HiRISE, or some combination of the three to identify deposit morphologies and possible layering. Of these 34 craters, 29 had deposits with exposed layers that could be confidently identified. Other ancillary information regarding crater size and deposit features were also gathered.

Layered Deposit Characteristics: The following describes the deposit forms, layer styles, and layer abundance observed in Arabia Terra.

Deposit forms. Intracrater deposits generally have 4 forms: floor mound, isolated mound, floor, and buttes. Floor mounds are deposits with sloped sides that cover most, if not all of the crater floor with some parts abutting the crater wall, creating an “attached” appearance. Isolated mounds are singular deposits on crater floors that do not abut crater walls with downward sloping sides. Floor and buttes are remnant deposits in various parts of the crater floor that are not in mounded form.

Layer styles and abundance. Deposit layers generally have 4 morphologic styles: stair-step 1, stair-step 2, ridgeforms, and whorls (Fig. 1). Stair-step 1 layers have well-developed flat, bench-like surfaces with a steep edge down to the next layer. The edges of layered deposits have either straight, sinuous or cusp-like forms, or some combination of the three that transition from one type to another. Stair-step 2 layers also exhibit bench-like surfaces but have highly sinuous edges that can be traced for some distance before completely thinning or merging with another layer, similar in fashion to terrestrial exfoliation surfaces. Ridgeforms and whorls do not have clear layered appearances, but are ridge-like and semi-circular ribbon-like remnants of layered materials. Where layers are present, the number of layers are defined as abundant or moderate with the former having 10 or more consecutive layers and the latter with 10 or less consecutive layers. This definition is not related to bundles of layers that have been documented by [8].

Results of Deposit Characteristics: Most of the deposits are in mounded form: 41% floor mounds (12/29), 34% isolated mounds (10/29), 24% floor (7/29), and 34% some combination of floor mounds, isolated mounds, and buttes (10/29). In terms of layer styles, 90% have stair-step 1 (26/29), 7% have stair-step 2 (2/29), and 17% have ridgeforms or whorls (5/29). Within the stair-step 1 style, 85% have only stair-steps (22/26) and 15% have stair-steps with one of the other styles (4/26). In terms of layer abundance, 62% have abundant layering (18/29) and 38% have moderate layering (11/29). Overall, when considering deposit form, layer style, and layer abundance together, slightly over half of the deposits (52%; 15/29) are mounded with abundant stair-stepped layers. Mounded deposits with estimated heights of 0.05-2 km, generally increase in height with increasing crater depth and diameter.

The impact craters have a diameter range of ~27-180 km and a depth range of ~1.2-3.7 km. 86% of craters have some portion of their rim intact (25/29) and 34% of craters have discernable ejecta deposits (10/29). 65% of intracrater deposits (19/29) have had their surfaces modified by eolian activity, producing yardangs, windtails, or other wind-sculpted forms. Of the deposits with abundant layering, 78% have eolian-modified features (14/18). Deposit surfaces in the study region have an overall TI range of ~40-590 $Jm^{-2} K^{-1}s^{-0.5}$ in which the eastern half have dustier surfaces (~200-400 mean TI values) and the western half have less dusty surfaces (≤ ~100 mean TI values), which roughly correlates with a high to low trend in elevation from east to west.

One of the stronger correlations in deposit characteristics is between crater morphometry and layer abundance. Of the 10 largest diameter craters with layered deposits, 9 have abundant layering. Of the 10 craters with layered deposits that have the greatest depth, 9 have abundant layering. This result is not unexpected as larger craters should contain more material (by volume) than smaller craters; thus preserving more of the deposits, leading to more well-developed and abundant layering with all other factors being equal. There does not appear to be any strong transition in deposit form, layer style, or abundance from one part of the region to another.

CRISM Results: A total of 12 deposits were all or partially covered by CRISM data. Of these 12, 8 have sufficient spectral quality to identify iron-rich dust or coatings, olivine, pyroxenes, and phyllosilicates and hydroxylated phyllosilicate minerals. Of these 8 deposits, 6 have a combination of iron-rich, olivine, and pyroxene signatures including 4 in prominent craters (Henry, Becquerel, Capen, and Vernal). Their locations are not clustered and are spread out both latitudinally and longitudinally. Only 1 deposit had hydroxylated minerals. Based on the limited CRISM coverage thus far, layered deposits, along with most deposit outcrops, do not appear to be spectrally diverse and are often covered or coated by iron-rich dust.

Deposit Distribution: Because the center locations of intracrater layered deposits have been recorded in GIS, their geographic distribution can be assessed using statistical tests of point locations to determine their pattern (e.g., uniform, clustered) with inference to their homogenous, isotropic, or random nature [14].

For the entire 60ºx30º study area, we performed an initial chi-squared test (a.k.a. Pearson chi-squared test) to determine if the distribution was random. Using 3ºx3º, 4ºx4º, 5ºx5º, and 6ºx6º grids of squares and selecting the points within, chi-squared statistical values for 46 and 34 deposits were calculated to determine if they were less than 95% of all randomly obtained chi-squared values, indicating true randomness. The 2 smaller grids produced values consistent with a random distribution, but the low number of point classes for 34 deposits resulted in unreliable chi-squared values. The 2 larger grids produced values greater than 95% of all randomly obtained values, favoring a uniform or clustered distribution for both 46 and 34 deposits. To test for uniformity, a second chi-squared test was applied to a 24ºx12º area centered at the prime meridian where the majority of deposits are located. Statistical values from 2ºx2º, 3ºx3º, 4ºx4º, and 6ºx6º grids for both 46 and 34 deposits were all less than 95% randomly obtained chi-squared values, confirming a uniform distribution.

The positive chi-squared test results for uniformity and the clear non-clustered distribution of the deposits (by observation) indicate a mostly homogenous and isotropic process of material deposition in Arabia Terra. Although these tests may appear more related to actual impact crater distribution rather than deposit distribution, they are not mutually exclusive. The preservation and now exposure of the deposits would not be possible without the craters having been present beforehand.

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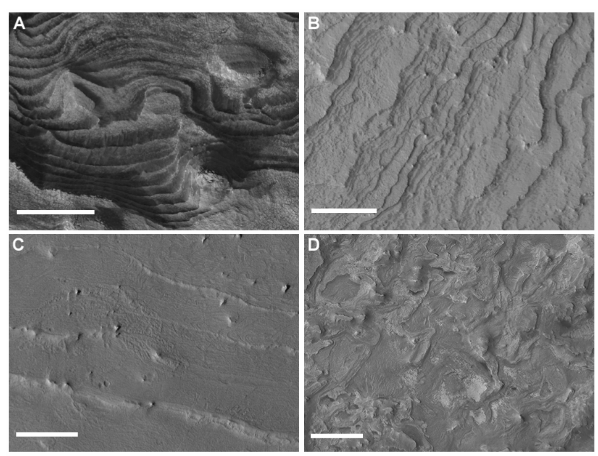

Figure 1. Type examples of layered deposit morphologic styles: a) stair-step 1, b) stair-step 2, c) ridgeforms, and d) whorls. Portions of HiRISE images (in order of a-d; scale bar lengths in parentheses) PSP_003656_2015 (100 m), PSP_003734_1905 (100 m), PSP_002574_1860 (300 m), and PSP_002390_1840 (200 m).