FIRE AND ICE: VOLCANIC DOMES AND REMNANT ICE IN WESTERN ARCADIA PLANITIA. J. W. Rice, Jr.[1], W. H. Farrand[2]. [1]Planetary Science Institute, Tucson, AZ, [2]Space Science Institute, 4750 Walnut St., #205, Boulder, CO 80301, farrand@spacescience.org,

Introduction: It was suggested in [1] that an ice sheet was deposited in Arcadia Planitia at over 20 Ma and that it was protected by a lag deposit. The study area in [1] extended east of 180° E and between 35 and 65° N. In this abstract, we describe domes and associated ice deposits further to the west, roughly from 167 to 180° E and 34 to 46° N. This dome field has been described previously by [2 and 3]. The former suggested the domes were comparable to terrestrial silicic lava domes while the latter used CRISM visible/near infrared to short-wave infrared (VNIR-SWIR) reflectance spectra to describe the presence of mafic minerals including high-Ca pyroxene and olivine, suggesting a more mafic composition. Also described in [3] were exposures of "brain terrain" near the domes. Similar crenulated surface textures were identified by [4] as being ice-rich. We have performed additional work on this dome field and have found further evidence of ice occurring in association with the domes as well as spectroscopic evidence from CRISM for high-Ca pyroxene, olivine, and glass mixtures as well as some occurrences of a 1.25 μm band consistent with Fe-bearing plagioclase.

Dome Features: The western Arcadia domes have several defining characteristics (**Fig. 1**). They consist of a central core, often in a hemispherical dome shape, and sometimes with tongue-like extensions (**Fig. 2**) interpreted by [2] as viscous lava flows. The domes are generally 1 to 2 km in diameter. Surrounding the domes are shallowly sloping dark-toned aprons. The domes and aprons are often in the center of a bullseye-like pattern surrounded by light- and dark-toned rings or aureoles. There are also light-toned domes in the region as well as mounds that appear only as positive relief features on the plains. In nighttime THEMIS data, the domes are bright relative to the plains, aprons are variable (nighttime THEMIS IR data numbers ranging from commensurate with the plains to sometimes lower and sometimes higher). The light-toned aureoles are dark relative to the plains and the dark-toned aureoles are modestly brighter relative to the plains in nighttime THEMIS data.

Spectral Features from CRISM: In [3] it was observed that the domes and especially flanks of the domes have elevated 1000 nm band depths in both the CRISM S (VNIR) and L (SWIR) detector data and also flanks of some domes have elevated OLINDEX3 and HCPINDEX summary product [5] values. Examination of spectra from the flanks of several domes covered by CRISM "full range targeted" (FRT) observations, using spectral parameter plots detailed in [6] for assessing ferrous silicate mineral mixtures (**Fig. 3**) suggest that the flanks of these domes consist of a mixture of high-Ca pyroxene, basaltic glass, and olivine. On and around several of the domes there are also elevated values of the BD1300 spectral parameter, which is sensitive to the 1.25 to 1.3 μm band in Fe-bearing plagioclase. An averaged spectrum from the overlapping FRT00009700 and FRT00009A7D scenes is shown in **Fig. 4** and also shows the presence of a band near 2.2 μm that is attributable to either hydrated silica or an Al-OH bond such as in montmorillonite. These are the only scenes in which this 2.2 μm absorption is seen; however, we note that CRISM coverage over these domes is sparse. Additionally, a parameter indicating the possible presence of zeolites or sulfates, the difference of reflectance of 2240 nm less 2540 nm (R2240-R2540), is elevated in association with some of the aprons. Also, the BD3000 parameter is elevated in association with light-toned aureoles. As was noted in [3], HiRISE imagery of the light-toned aureoles show morphology nearly identical to the "brain terrain" described by [4] for ice-filled craters; thus ice is inferred as being a component of the light-toned aureoles.

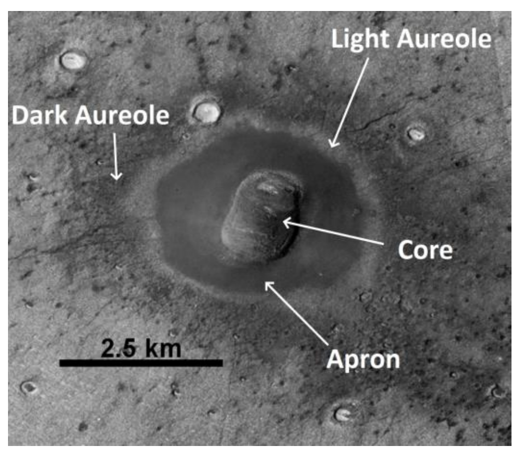

Fig. 1. CTX imagery of dome centered at 39.07°N, 172.41°E with major features labeled.

New Observations from HiRISE and CTX: A CTX mosaic was assembled for much of this region based on its nomination as a human exploration zone by [7]. Also, additional HiRISE scenes have been collected since the work carried out by [3]. The presence of “brain terrain” - like deposits in the light-toned aureoles was noted above. In the CTX mosaic we find multiple examples of domes with light-toned arcs immediately adjacent to the northern flanks of the domes. While there is no HiRISE coverage over these north-facing light-toned arcs, the CTX imagery partially resolves what looks like “brain terrain” composing these arcs; thus, again suggesting the presence of ice. With ice-rich material on both the proximal and distal portions of the aprons, we conclude that the aprons are likely similar in nature to (albeit smaller in scale than) lobate debris aprons (LDAs) observed in multiple locations elsewhere on Mars [e.g., 8-10].

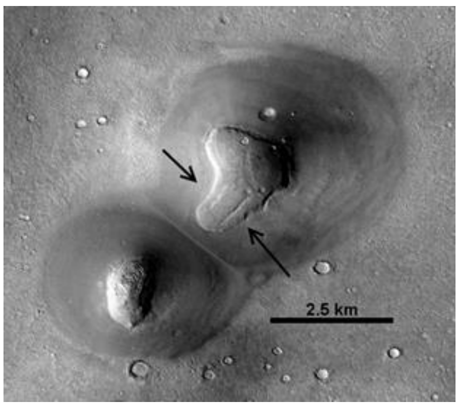

Fig. 2. CTX imagery of dome showing a tongue-like extension (noted by arrows) resembling a viscous lava flow.

Conclusions: In CTX and HiRISE data we find multiple examples supporting the morphologic evidence described by [2] in which these domes display features consistent with terrestrial lava domes formed from viscous magmas. The presence of mafic minerals plus plagioclase in association with the domes suggests a largely mafic composition for these features although the possibility exists that they could be slightly more silica-rich than basalt- e.g., andesites or basaltic andesites. THEMIS spatial resolution is insufficient to make any confident conclusions regarding how silica-rich these domes are. As noted in [3], crystal-rich basaltic magmas are viscous and this could be why domes formed rather than lava flows.

We have suggested that the aprons surrounding the domes are similar in nature to LDAs. As described by [10], LDAs could have formed through the collapse of regional ice sheets. Given the evidence in [1] for a regional ice sheet to the east of the dome field, we suggest that this ice sheet, or outliers of it, also covered the dome field. Collapse of the ice sheet and dark-toned mantling material is hypothesized here as forming the aprons and their dark mantles (dark mantles extend over the tops of many domes as well).

Several more polygonally shaped hills in the region are interpreted as being erosional remnants; however, the domes are interpreted here, as by [2] and [3], as lava domes.

References: [1] Viola D. et al. (2015) Icarus, 248, 190-204. [2] Rampey, M.L. et al. (2007) J. Geophys. Res. 112, E06011, 10.1029/2006JE002750. [3] Farrand, W.H. et al. (2011) *Icarus*, *211*, 139-156. [4] Levy, J.S. et al. (2009) *Icarus*, *202*, 462-476. [5] Viviano-Beck, C.E., et al. (2014) *J. Geophys. Res*., 119, 1403–1431, 10.1002/2014JE004627. [6] Horgan B.H. et al. (2014) *Icarus*, *234*, 132-154. [7] Barker et al. (2015) Human Mars Missions Workshop, #1002. [8] Squyres S.W. (1979) *JGR*, *84*, 8087–8096. [9] Plaut J.J. et al. (2009) *GRL*, *36*, 10.1029 /2008GL036379. [10] Fastook J.L. et al. (2014) *Icarus*, *228*, 54-63.

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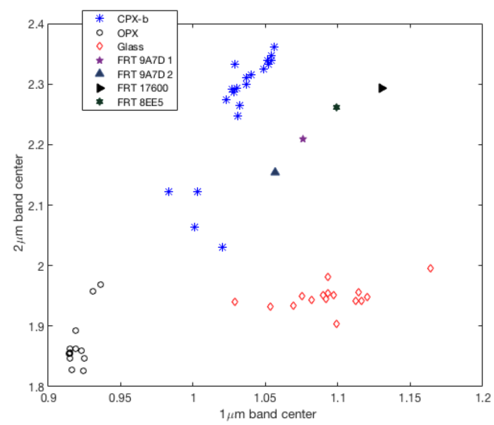

Fig. 3. 2 μm vs. 1 μm band centers for the library mineral spectra and dome flank spectral averages. In this plot, the spectral averages from the flanks of the domes plot between the CPX and glass fields.

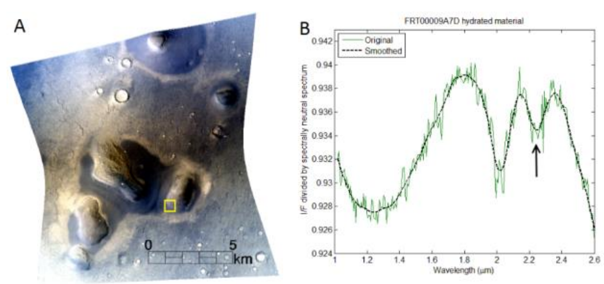

Fig. 4. A. Composite of 2.5, 1.5 and 1.07 μm CRISM bands of CRISM scene FRT00009A7D with box indicating area of spectra extraction. **B**. Original and smoothed region of interest average showing 1.25 μm band attributable to plagioclase and a 2.225 μm caused by either a Si-OH or Al-OH overtone.