MINERALOGY AND MORPHOLOGY OF LIGHT-TONED DEPOSITS IN NOCTIS LABYRINTHUS. C. M. Weitz[1] , J.L. Bishop[2], L. Roach[3], R.E. Milliken[4], and J.A. Rodriguez[1]. [1]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719 (weitz@psi.edu); [2]SETI/NASA AMES, 515 N. Whisman Rd., Mountain View, CA 94043. [3]Frontier Technology, 100 Cummings Center, Suite 450G, Beverly, MA 01915. [4]Jet Propulsion Laboratory, MS 183-301, 4800 Oak Grove Drive, Pasadena, CA 91109.

Introduction: We have used data acquired from the Mars Reconnaissance Orbiter (MRO), including HiRISE, CTX, and CRISM, to analyze ten light-toned deposits (LTDs) within pits and troughs of Noctis Labyrinthus. Noctis Labyrinthus consists of a network of intersecting linear troughs and pits that connect eastward to the continuous troughs of Valles Marineris. For this study, we refer to all locations as troughs although some depressions could also be termed pits. We have identified ten locations of well-exposed LTDs where we have focused our analyses (Figure 1). All ten LTDs exhibit hydration signatures in CRISM data.

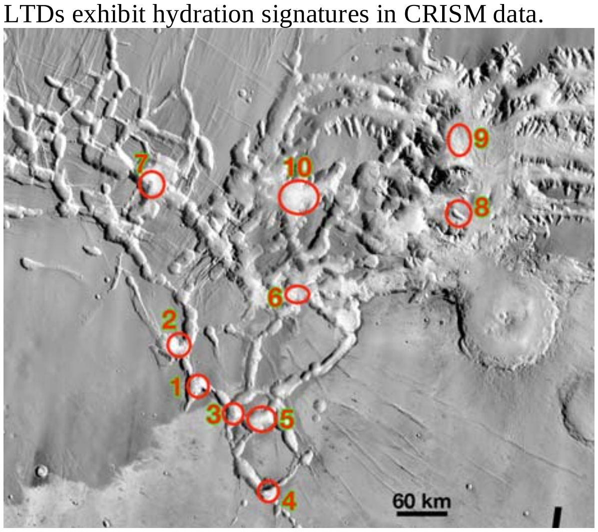

Figure 1. THEMIS daytime IR mosaic of Noctis Labyrinthus. Numbers identify troughs with LTDs analyzed in this study.

Observations: *Trough 1:* The LTD has dozens of beds that vary in thickness, brightness, color, and erosional morphology. These characteristics have also been observed in light-toned layered deposits along the plateaus of Valles Marineris and within a trough near Juventae Chasma [1]. Our CRISM analyses show at least two types of mineralogies in the LTD. Most of the beds within the LTD have spectra consistent with sulfates. Another bed within the LTD has a spectrum best matched to nontronite. Using a HiRISE stereo anaglyph, we have determined that the nontronite bed is within the thicker sulfate unit (Fig. 2) but located towards the lower portion of the exposed LTD strata. Our identification of sulfates and smectites within the LTD suggests that significant water once existed within this particular trough and that ph levels may have fluctuated between acidic and alkaline conditions.

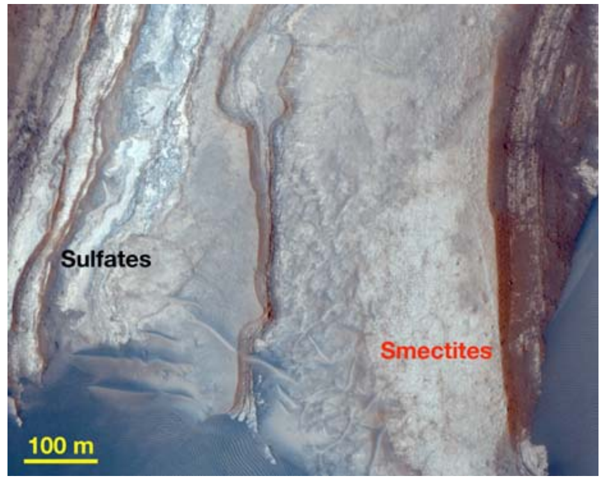

Figure 2. HiRISE false-color image of units in Trough 1.

Trough 2: This LTD also contains a diverse range of mineralogies. A similar nontronite and sulfate unit exists within this trough but the sulfate unit appears to represent only a few beds rather than the dozens of beds seen in Trough 1. Opal ($SiO_2 \cdot nH_2O$) occurs as a possible surficial debris in the northwest [2]. The mineral has also been identified along the plateaus outside of Valles Marineris [i.e., 1,3] and within Ius Chasma [4]. It can form as an alteration product or by aqueous precipitation of chemically weathered basaltic lava flows, ash or impact glass [3]. A bright bed in the northeast has a doublet absorption between 2.2-2.3 μm. This spectrum can be fit to either a leached smectite or mixtures of montmorillonite+jarosite or montmorillonite+ferromagnesium smectite [4] and is referred to as a hydrated silicate. A similar unit has also been identified within Ius and Melas Chasmata [4,5].

Trough 3: Numerous beds are visible near the bottom of the trough but they are spectrally bland. In contrast, flat-lying surfaces across the bottom of the trough have spectra consistent with opaline silica. The opal unit corresponds to surficial debris and could be volcanic ash or hydrated eolian debris.

Trough 4: The LTD is concentrated in topographic lows along the trough floor. Mass wasting debris flows and landslides have buried portions of the LTD. CRISM spectra taken from a half-resolution image of the LTD are consistent with opal but a full-resolution image will be needed to verify this interpretation. At least two units are visible in HiRISE images: a blocky, fractured, layered, medium-toned unit, and a lower brighter, massive unit.

Trough 5: The LTD is situated along the bottom of the trough and is partially obscured by mass wasting lobes. The deposit appears to embay and drape dark-toned units, suggesting it was emplaced after formation of the trough. The surface of the LTD is heavily fractured into meter-size polygons. CRISM spectra of the LTD have a doublet absorption between 2.2-2.3 μm, similar to that of the hydrated material in Trough 2.

Trough 6: Several locations of LTDs exist along the floor of this trough. One LTD (LTD1) is located to the east and two smaller LTDs (LTD2) are found in the west. LTD1 has numerous morphologies in the HiRISE image. The false-color HiRISE image of the deposit shows a gray smooth unit that embays a tan layered unit. CRISM observations confirm several units at this location, including the doublet absorption between 2.2-2.3 μm that varies in relative strength perhaps because of multiple phases present. A HiRISE stereo anaglyph of this deposit suggests the LTD post-dates formation of the trough.

The larger exposure of LTD2 is situated at the bottom of a small (~5 km across) pit within the larger trough. LTD2 does not show the diverse range of morphologies identified in LTD1. CRISM spectra have a strong absorption around 1.95 μm and a smaller feature at 2.28 μm that is similar to one of the units found in LTD1.

Trough 7: Exposures of LTD occur in the southwest portion of the trough. Small outcrops of LTD are seen where erosion has removed an overlying ridged plain. These LTDs have spectra consistent with an Al-smectite. Other LTDs are present about 10 kms to the south as <1 km exposures within a mass wasting deposit along the wallrock. Both gypsum and opal are possible matches to the CRISM spectra. There is a valley about 5 km to the east but it does not appear associated with any of the LTDs in the trough.

Trough 8: The LTD is located along the upper walls of a 20-km long elongated pit within the larger trough. The LTD occurs at several meters depth beneath eolian material and is only exposed within the pit's walls, indicating it is older than the pit. The unit has some layering although few color variations can be seen in the HiRISE false-color image of the strata. CRISM spectra taken from the LTD are best matched to jarosite, indicating relatively acidic conditions during formation of the deposit.

Trough 9: Small exposures of LTDs exist in the western portion of the trough. Many of the LTDs have a brecciated appearance, but it is difficult to discern if they could be material from an impact event or if their morphology is a result of limited exposure beneath an overlying layered dark mantle. CRISM spectra suggest mixtures of several phases, such as opal and smectites.

Trough 10: The LTDs are limited to thin rings around hills near the southeastern portion of the trough. Recent work has revealed that the LTDs drape pre-existing bedrock rather than erode out from the base of the hills [6]. CRISM spectra extracted from the LTDs are consistent with gypsum but other Ca-sulfates, such as bassanite, have also been proposed [7]. The light-toned bed could represent volcanic ash that was altered by snow or hydrothermal activity [7].

Discussion: The observation that the LTDs vary morphologically and mineralogically throughout Noctis suggests that there may be multiple processes with variable amounts of water that have emplaced and/or altered units in each trough. The processes operating in each trough are localized rather than affecting the entire Noctis Labyrinthus region. Interbedding of phyllosilicates and sulfates in Troughs 1 and 2 indicates fluctuations between alkaline and acidic conditions. The ages of the LTDs appear to span from the Late Noachian to the Amazonian. Groundwater infiltration from Tharsis volcanism could have sourced the water that partially filled or flowed through the troughs. The LTDs may have precipitated out from this water in a lacustrine environment. However, some of the LTDs may represent existing material, including lavas, volcanic ash, and eolian debris, that was altered by groundwater or hydrothermal activity.

Pit	Preliminary LTD Mineralogy from CRISM
1	Fe/Mg-smectite, Sulfate
2	Hydrated Silicate/Leached Smectite or Montmorillonite/Jarosite mixture, Sulfate, Fe/Mg-smectite, Hydrated silica
3	Hydrated silica
4	Hydrated silica
5	Hydrated Silicate/Leached Smectite/ Montmorillonite/Jarosite mixture
6	Mixtures of Leached Smectite, Phyllosilicates, Hydrated silica
7	Al-smectite, Gypsum, Hydrated silica
8	Jarosite
9	Mixtures of Phyllosilicates and Hydrated silica
10	Gypsum or other Ca-sulfates

References: [1] Weitz C.M. et al. (2009) *Icarus*, doi:10.1016/j.icarus.2009.04.01. [2] Milliken R.E. et al. (2008) *LPS XXXIX*, Abstract #2025. [3] Milliken R.E. et al. (2008) *Geology*, *36*, 847-850. [4] Roach L. et al. (2009) *Icarus*, in revision. [5] Weitz C.M. et al (2009) *LPS XXXX*, Abstract #1874. [6] Mangold N. et al. (2009) *Icarus*, in press.