STRATIGRAPHIC CONTEXT FOR INVERTED CHANNELS ON THE PLAINS NORTH OF JUVENTAE CHASMA: IMPLICATIONS FOR POST-NOACHIAN MARTIAN CLIMATE CHANGE. R. M. E. Williams[1] and C. M. Weitz[2], [1]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719, williams@psi.edu

Overview: Strata above Lunae Planum located north of Juventae Chasma record geologic events in the post-Noachian period. Near the base of the section are anastomosing sinuous ridges interpreted to be inverted channels [1]. These ridges are buried in places by coherent material. Negative relief channels are present near the top of the section. The sequence of events that formed this startigraphic section included discreet fluvial episodes separated by a period of nonfluvial activity. In the post-Noachian period clement climate conditions that enabled surface overland flow of fluids were episodic at this location.

Introduction: Since fluvial landforms were first recognized on in Mariner 9 data, the planetary science community has pondered various climate condition scenarios to enable the flow of liquid water across the Martian surface. A consensus, not adhered to by all, soon formed that early Mars had prevailing conditions that were both warm and wet that transitioned to the cold, dry conditions present today [e.g. 2, 3]. This scenario is consistent with the predominance of valley networks found on the ancient cratered highlands [4]. However, the nature of the climate transition, including causes and relative timing, remain unknown.

Layered material has been documented on the plains proximal to the canyons at several locations in the Valles Marineris region [e.g. 5, 6]. Many of these locations of light-toned layered material are spatially associated with sinuous ridges, the inferred remnants of stream courses preserved as inverted topography [1]. One of the most spectacular bifurcating ridge networks is located northwest of Juventae Chasma and has been reported on in prior studies [7, 8]. East of this site, new CTX and HiRISE images show a ~100 m thick layered rock section that superposes the Lunae Planum ridged plains and is the focus of this study.

The Lunae Planum ridged plains north of Juventae Chasma were mapped as a single geologic unit and interpreted as flood basalts based on the presence of mare-type ridges [9-11]. Based on the lower crater density on Lunae Planum relative to the ancient cratered highlands, this unit was defined as the global stratigraphic position of the Early Hesperian Epoch [10], which began around 3.7 Ga according to impact crater age dating techniques [12]. The layered rocks that superpose Lunae Planum are cut by the western wall of Juventae Chasma and indicate that these strata post-date heavy bombardment and pre-date the cessation of canyon formation in Juventae. Thus, the maximum age of these strata are Early Hesperian, but the minimum age is unconstrained.

Observations: We used CTX and HiRISE images to create a geomorphic map based on surficial features and landforms with common characteristics over the region from 3.5 to 4° S, 62.5 to 63° W. As a result of this effort, we identified a distinct ~100 m thick section of layered rock, a ‘formation’, that can be subdivided into characteristic units or ‘members’ that are described below. The layered rock unit is stratigraphically above the Lunae Planum ridged plains. At the decameter scale, the ridged plains are laterally traceable over a region of >1 x 10^6 km^2. At submeter resolution, the ridged plains exhibits a cracked pattern with polygons ranging from 10–50 m across.

At the base of the section is a thin (~1 m), smooth layer that exhibits a repetitive pattern with wavelengths of 30–45 m. This undulation may be the original depositional form or an erosional product that exploits regularly spaced hetereogeneties within the material.

Atop the smooth basal unit is a thinly bedded unit that has light and dark layers. Anastomosing ridges (5–15 m thick) aligned ~N-S consistent with regional gradient (Fig. 1), are inferred to be inverted channels that are a resistant capstone beneath which 5–10 layers can be identified in the ridge wall. These thin layers may be former fluvial deposits within an aggrading system, or they may be strata that is protected by the inverted channel capstone. The lower-most layers in this section extend laterally a few tens of meters from the ridge. The inverted channels within the study region have a branching and rejoining pattern that is distinct from the highly ordered, branching network ridges located to the west. Although both inverted channel locations (east and west of a ~9-km diameter crater at 4° S, 63° W) are stratigraphically just above the Lunae Planum ridged plains, it is uncertain if the two regions were active simultaneously.

The upper section of the ‘formation’, the bulk of the ~100 m thickness, is difficult to subdivide because of discontinuities, draping relationships, subsequent erosion and aeolian overprinting. Nevertheless, we have identified distinct attributes and relative stratigraphic positions of important features within this undivided section. A thick mantle unit conforms to pre-existing topography. In the southern portion of the study region, the mantle is extensive and buries the inverted channels (Fig. 1) while to the north the mantle is located between inverted channel ridges, is thinner (~10 m) than to the south, and has apparently near-vertical margins. Topograhic depressions (few m to 1 km size) within the mantle vary from circular to irregular in shape, reflecting heterogeneities within the material, and the larger depressions are covered in ripples.

Importantly, negative relief channels are incised into this mantle in the far eastern portion of the study region (Fig. 2). The channels are subparallel, aligned NE–SW, and form a low order network. The planimetric pattern of these channels is similar to immature terrestrial drainage networks and suggests that the fluvial system was short-lived, in contrast to the more persistent flow necessary to develop the higher ordered network patterns of the inverted channels to the west.

At the top of strata there are isolated outcrops of a thin layer with a megawave pattern that has a typical wavelength of 65 m and linear lengths of 1–2 km (Fig. 3). This undulating capping material superposes both the negative relief channels and the mantle. The megawave pattern appears to be a primary depositional feature, and likely formed by aeolian processes, although these landforms are larger than martian transverse aeolian ridges (average wavelength ~40 m) [14].

Discussion: The strata above Lunae Planum plains is a window into climatic conditions present during the post-Noachian period, and may record events that occurred during the climate transitional period. This rock formation records, at a minimum, the following sequence of events: 1) an early fluvial period, 2) widespread burial of material, 3) a late-stage, short-lived fluvial interval, 4) subsequent burial, possibly localized, and 5) exhumation that reached down to the ridged plains in the northern portion of the study region. Although determininination of timescales for each of these events is difficult to constrain, the entire section could be constructed in a mimimum timescale of centuries. Potential unconformities within the section would lead to a more complicated sequence of events. The hiatus in fluvial events recorded here indicates that the water source and/or clement climate conditions were episodic. Tharsis volcanism [e.g. 14-15] or impact events [e.g. 16] are two factors that may have contributed to temporary and potentially localized climate conditions suitable for surface overland flow of fluids.

References: [1] Williams R. M. E. and Edgett K. S. (2005) *LPSC XXXVI* Abs. #1099. [2] Mars Channel Working Group. (1983) *GSA Bull 94* 1035-54. [3] Carr M. H. (1996) Water on Mars. [4] Carr M. H. (1995) *JGR 100*, 7479-7507. [5] Malin M. C. and Edgett K. S. (2000) *Science 290*, 1927-1937. [6] Weitz C. M. et al. (2008) *GRL 35*, L19202. [7] R. M. E. et al. (2005) *LPSC XXXVI* Abs. #1173. [8] Mangold N. et al. (2008) *JGR 113*, E08009. [9] McCauley J. F. (1978) *USGS Map* I-897. [10] Scott D. H. and Tanaka. K. L. (1986) *USGS Map* I-1802-A. [11] Witbeck, N. E. et al. (1991) *USGS* Map I-2010. [12] Hartmann W. K. (2005) *Icarus 294* 294-320. [13] Wilson S. A. and Zimbelman J. R. (2004) *JGR 109*, E10003. [14] Phillips R. J. et al. (2001) *Science 291* 2587-2591. [15] Johnson, S. J. et al. (2008) *JGR 113*, E0800. [16] Segura T. L. et al. (2002) *Science 298*, 1977-1980.

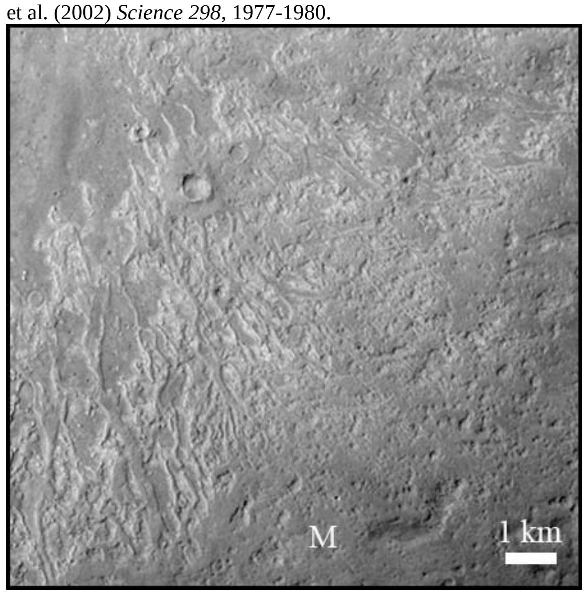

Fig. 1: Anastomosing sinuous ridges, inferred inverted channels with flow direction to the N/NW. Pitted mantle (M) buries ridges to the south. CTX subscene P03_2234_1761_XN_03S062W_07011.

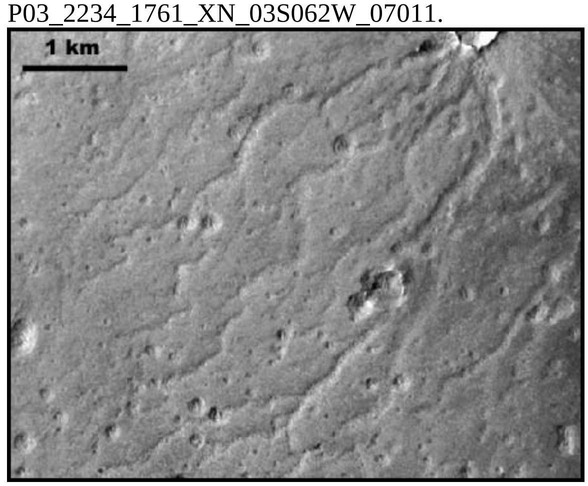

Fig. 2: Channels incised into mantle with flow direction to the NE. CTX P03_2234_1761_XN_03S062W_070117.

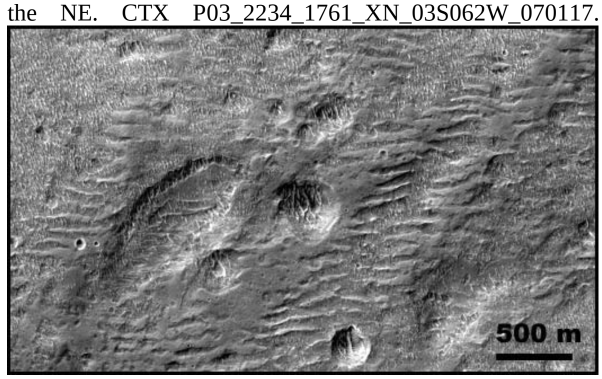

Fig. 3: Megawave pattern. HiRISE PSP_007627_1765.