THE ORIGIN OF ERIDANIA LAKE AND MA'ADIM VALLIS: AN INVESTIGATION OF CLOSED CHAOS BASINS, HESPERIAN RIDGED PLAINS, AND TECTONIC CONSTRUCTS ON THE FLOOR OF A LARGE HYPOTHESIZED PALEOLAKE ON MARS. D. M. Baker[1] and J. W. Head[1]; [1]Dept. Geological Sciences, Brown Univ., Box 1846, Providence, RI 02912 (david_baker@brown.edu).

Introduction: The varied geomophological characteristics of Ma'adim Vallis on Mars have resulted in a variety of explanations for its formation [1-4]. Among these is a hypothesis [4] suggesting that Ma'adim Vallis was formed by a catastrophic flooding event that occurred near the Noachian/Hesperian boundary. Under this scenario, the incision of Ma'adim Vallis was initiated by the overflow of a large ~3,000,000 km^2 Noachian lake (Eridania Lake) spanning the Eridania and Phaethontis quadrangles and approximately delimited by the 1100 m contour line. Upon examining the parameters of the hypothesis, we find that while such an origin for Ma'adim Vallis may seem plausible, there are several issues that still remain unresolved. Among these is the nature and significance of several features on the Eridania Lake floor, including: 1) five major knob fields and the bowl-shaped craters they occupy; 2) widespread ridged plains units of Early Hesperian age; 3) concentric lobate and wrinkle-type ridges; and 4) a large, through-going ridge system. Another issue is the mechanism by which such a large lake would have been filled. Although precipitation is suggested as an input [4], the modest sizes of valley networks entering the lake's catchment area do not appear sufficient to account for the ~500,000 km^3 of water necessary to maintain such a large lake. Recent analyses of open basin lakes on Mars [5] also suggest that groundwater must have contributed to the development of large lakes in the Martian highlands, including Eridania Lake. Here, we look closely at the features listed above in an attempt to construct a history of the Eridania Lake floor and to assess alternative explanations to filling mechanisms for Eridania Lake.

Nature of closed chaos basins (knob fields and deepened craters): Early geological maps [6,7] have identified five major knob fields in the Eridania and Phaenthontis quadrangles (Fig. 1). Four of these knob fields (including Ariadnes Colles, Altlantis Chaos, and Gorgonum Chaos) are labeled chaotic terrain units (Hcht), with one (southeast of Ariadnes) labeled as knobby plains material (Apk) [6,7]. THEMIS, MOC, and MOLA data reveal that the knob fields have similar characteristics. Individual knobs are highly degraded, exhibiting pitted textures at THEMIS VIS scale (Fig. 2) with dark capping units and bright flanks where the capping unit has been removed. Larger knobs are mesa-like and tend to occupy the lowest points within the craters, while the smaller knobs are more rounded and are typically found along the perimeter of the craters. Most of the knobs are completely enclosed by the 500 m contour and extend down to the lowest points within the craters they occupy (Fig. 3). The knob fields have been modified by superposed craters and are also covered by later resurfacing events (e.g., Hesperian ridged plains), resulting in non-uniform distribution within the craters. Many knobs are also separated by linearly intersecting fracture patterns (Fig. 2), suggestive of fracturing of a once continuous surface layer. The knob fields occupy the floors of five very degraded craters with original diameters likely ranging from ~100 to 130 km. The bowl-like profiles of the craters (Fig. 3) are unlike most degraded craters on Mars [4], exhibiting in-

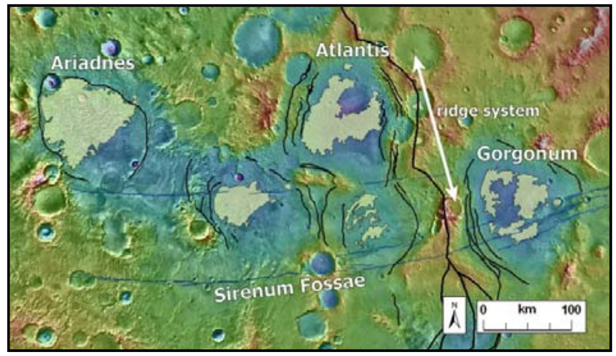

Fig. 1. MOLA gridded topography of five major knob fields (yellow) and their corresponding bowl-shaped craters (centered at 36.5ºS, 178.5ºW). Concentric ridges (black lines), a through-going ridge structure (thick black line), and E-W trending Sirenum Fossae graben (blue) are delineated.

ward sloping sides and large internal relief, with floors extending down to at least the -200 m contour. Other characteristics, including lava flow resurfacing, concentric ridges, and elongated shapes, also suggest that the craters have been highly modified since their formation.

Ridged plains units: Surrounding at least two of the knob-containing craters are mapped ridged plains units (Hr) [6]. Hr has been interpreted as volcanic in origin [7], and the presence of exhumed dikes [8] are evidence that Hr was emplaced in conjunction with regional dike-emplacement events. Hr has also been mapped on the majority of the Eridania Lake floor. Where present, it tends to produce flat regional-scale topography with polygonally connected ridges that occasionally take the shapes of buried crater rims. Units surrounding three of the craters are mapped as either a subdued cratered unit (Npl_2) or a smooth plains unit (Hpl_3), interpreted to be interbedded lava flows and eolian deposits that bury underlying rock [6,7].

Examination of the above plains units (Hr, Npl_2, Hpl_3), indicate that most of the exposed bedrock is continuous with the ridged plains unit, suggesting a common origin. Embayment relationships suggest that, despite resurfacing by younger airfall deposits [4,9], underlying rock post-dates all of the enclosed knob fields. If the underlying rock represents Early Hesperian lava flows [7], the embayment relationship places the formation of the knob fields prior to this, probably in the Late Noachian. Another characteristic of the ridged plains in this region is its tilted nature within the closed chaos basins. Profiles of the Eridania floor reveal that Hr plains and adjacent highstanding, Hr-filled craters slope toward the bowl-shaped craters typically with slopes of ~0.3-0.6° (Fig. 3).

Compressional and extensional features: Outlining the five craters are a series of concentric ridges (Fig. 1) which have topographic profiles closely resembling lobate ridges and wrinkle ridges [10]. These ridges result from compressional stresses in Hr and highland materials and may be related to subsidence induced by crustal cooling and volume reduction, loading by Hr, or both [10].

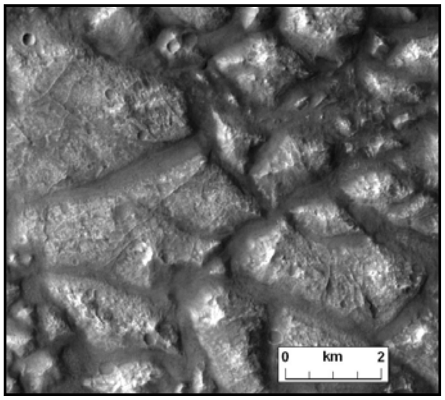

Fig. 2. Structural fracturing of knobs in the Atlantis basin knob field (THEMIS VIS image V01330003).

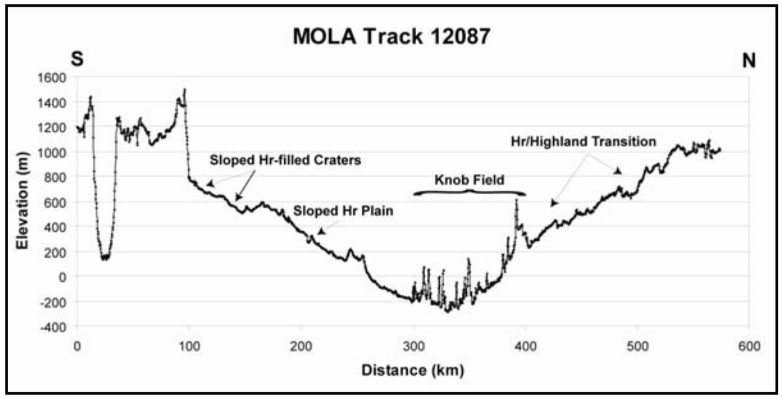

Fig. 3. MOLA altimetric profile of Ariadnes basin (Fig. 1), depicting its bowl-like shape, knob field distribution, and adjacent tilted Hr-filled craters and Hr plains.

Ridges also occur outside the craters and Hr units and are continuous with a large through-going ridge system on the Eridania basin floor (Fig. 1). The stress field associated with ridge formation may have elongated the northernmost knob-forming crater and produced smaller lobate ridges in the adjacent highlands.

Also on the Eridania Lake floor are the Sirenum Fossae, a set of long graben that originate from the Tharsis rise and radially traverse the basin floor to about ~171°E longitude. Modeling [11] has proposed that these graben are the surface manifestation of radial dikes that were emplaced during the formation of the Tharsis rise. Images show that the graben clearly cross-cut all major units on the Eridania Lake floor, indicating that their formation post-dates both development of the knob fields and the emplacement of Hr.

Chaotic terrains and the outflow of water: Chaotic terrains are interpreted to be the source regions for many outflow channels on Mars [2,12]. The development of these terrains has been associated with a process involving: 1) build-up of near-lithostatic pore-pressures in an aquifer confined by a cryosphere layer, 2) rupturing of the cryosphere layer, 3) release of confined groundwater to incise the associated outflow channel, and 4) collapse of the surrounding terrain to form the chaos [12]. Although the interpretation of chaotic terrain in the enclosed basins is less understood, the regional context of the craters on the Eridania floor and the structural break-up of the enclosed knob-forming material suggest that a processes similar to the one outlined above may have occurred. The craters that enclose the five knob fields represent several of the lowest points in the cratered highlands. With the Tharsis rise as a possible recharge zone [13], up to 7 km of hydrostatic head and near-lithostatic pore pressures may have been available at the knob-forming locations [12]. A cryosphere-cracking mechanism can only be speculated, but cross-cutting relationships suggest that it cannot involve the Sirenum Fossae graben.

Hr-induced subsidence: If the above chaos formation and outflow events did occur, the bottoms of the craters would have experienced fracturing and loss of lithostatic support from outflow-related removal of subsurface material [12]. Once Eridania Lake was emptied, the knob fields would have represented anomalously weak, porous zones on the Eridania Lake floor. Closely following, lava flow emplacement (i.e. Hr) is likely to have loaded the lake floor, producing localized stresses on the weakened knobby terrains. Such loads may have caused subsidence [10], both deepening the craters and tilting the adjacent surface. The observed concentric ridges in the bowl-shaped craters are not unlike crater-shaped ridges found in adjacent Hr plains and may be indicative of subsidence events. Such a subsidence scenario explains why the crater floors are not presently flat and also why the craters have such unusual bowl-shaped profiles.

Summary and conclusion: The Eridania Lake floor experienced much modification before and after the hypothesized lake occupied its interior. Close examination of floor features reveal that outflow events, rather than pluvial activity may have been the source of water for Eridania Lake and that later emplacement of Hr in the area may have resulted in localized subsidence around the knob-containing craters. Further investigation of the morphology and the distribution of the knob fields and of surrounding volcanic and tectonic features using new datasets, and the development of outflow models will help to construct a history of the Eridania Lake floor that is more completely consistent with the observations.

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