MAIN TOPOGRAPHIC AND MORPHOLOGIC CHARACTERISTICS AND CHRONOLOGY OF THE UZBOI-LADON FLUVIAL SYSTEM ON MARS, M.A. Ivanov[1], H. Hiesinger[2]

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Introduction: Uzboi and Ladon Valles are often considered as parts of a single system of outflow channels (Uzboi-Ladon-Morava, ULM) that extends northward from the main rim of Argyre basin for ~2000 km and enters Margaritifer Chaos [1-4]. It was proposed that the ULM system formed by massive water flows from the Argyre basin that was completely filled by water and overspilled [5,6]. Evidence was presented, however, that the overflow from Argyre is poorly consistent with the actual topographic configuration of the region [7]. Because of this controversy, we investigated the southern portion of the ULM system (SULM) that includes: (1) a trough-like feature that begins at the main rim of the Argyre basin, the southern trough, (2) Bond crater, (3) Uzboi Vallis, (4) Holden crater, and (5) the upper stretches of Ladon Valles in order to assess their topographic and morphologic characteristics and to establish (by the CSFD measurements) the general sequence of events in the region of the SULM. Our study was based on the topographic data (MOLA topographic map, 1/128 degree resolution), images provided by the THEMIS spectrometer (100 m/px resolution), and the global mosaic of the CTX images (6 m/px resolution). At the current stage of our investigation, we did not consider the contribution of Nirgal Vallis to the evolution of the SULM.

Topographic configuration of components of the Uzboi-Ladon system: ***(1) The southern trough*** is an elongated topographic depression ~40 km wide that extends from the main rim of Argyre northward for ~100 km. The trough has a U-shaped cross-section and its floor is sloped northward, toward Bond crater. The depth of the trough is several hundred meters at the southern end near the Argyre rim and becomes larger (~1 km) as the trough approaches the Bond rim. This implies that the ejecta from Bond are missing within the trough. No features indicative of a catastrophic water outflow and resistant to later modification (e.g., tear-drop islands, overflow channels) are seen within the trough.

(2) Bond crater (~120 km diameter): its flat floor is at an elevation of ~-1.5 km and the mean elevation of the rim is ~0.68 km (±0.39 km, 1σ); the mean depth of the crater is ~2.2 km and its volume is estimated to be ~20-25*10^3 km^3. The northern half of the Bond rim, which is closer to Uzboi Vallis, has smaller topographic variations than the southern half and shows no evidence for a breach(es) that could connect Bond with the upper portions of Uzboi Vallis. In contrast, the southern rim of the crater has a deep (~1 km) and broad (40-50 km) gap in the place where the southern trough approaches the crater. The presence of the gap in combination with the lack of the Bond ejecta in the southern trough suggests that the southern trough is younger than Bond crater.

(3) Uzboi Vallis: the uppermost portion of Uzboi Vallis is characterized by a circular topographic depression (~65 km diameter and ~0.9 km deep, i.e., the head depression), which is adjacent to the northern rim of Bond crater. The southern part of the depression cuts the northern rim of the crater and represents a cliff-like feature ~0.6 km high. Thus, either the formation of the head depression, or its modification, or both postdate the formation of Bond crater.

The topographic profile along the thalweg of Uzboi Vallis and the imagery data show four distinct features of Uzboi. (a) The upper reach of Uzboi Vallis begins at the breach of the head depression and extends for ~36 km northward at relatively steady general slope of ~0.28 degrees. (b) A mound-like feature [8] occupies the middle portion of the Uzboi depression and extends for ~120 km. The highest portion of the mound occurs at the mouth of Nirgal Vallis. (c) The lower reach of Uzboi begins after the mound, extends for ~130 km and is about horizontal (mean slope is ~0.03 degrees northward). The northernmost edge of the lower reach closely approaches the rim of Holden crater (~10-15 km) and represents a U-shaped topographic depression that is ~35 km wide and ~1.5-2 km deep. The lower reach of Uzboi does not change its depth approaching Holden crater. This means that the topographic depression of Uzboi Vallis postdates Holden, otherwise it would be partly filled by Holden ejecta and become shallower near the crater. (d) A V-shaped and narrow (a few kilometers wide) terminal channel incises the floor of the northernmost portion of Uzboi Vallis and cuts through the Holden rim. The mean slope of the channel on the Uzboi floor is ~0.09 degrees and increases up to ~1.5 degrees as the channel crosses the Holden rim.

The total volume of Uzboi Vallis including its head depression is ~4.5*10^3 km^3. As in the case of the southern trough, entire Uzboi Vallis shows no features indicative of catastrophic flooding.

(4) Holden crater (~160 km diameter) has a flat floor, the main portion of which is at ~-2 km elevation. The rim of the crater shows large topographic variations and its mean elevation is ~-0.12 km (±0.58 km, 1σ). The SW portion of the rim has a prominent gap in the place where Uzboi Vallis approaches the crater. This gap is ~40 km wide and ~0.8 km deep (excluding a deep and narrow cleft cut by the terminal channel). The eastern portion of the Holden rim is lower than the rest of the rim and has the mean elevation of ~-0.78 km (±0.36 km, 1σ). The total volume of Holden crater (below the eastern lowering) is estimated to be ~18.5*10^3 km^3.

(5) Ladon Valles: the main channel of this system begins as a full-sized feature (~10-12 km wide) near the deepest, central potion, of the ancient Holden basin [9]. This portion of the basin represents a broad (~65-70 km across) and shallow (0.2-0.3 km deep) topographic

depression with a knobby surface [4,10]. In sharp contrast to all other parts of the SULM, several large (15-20 km long) tear-drop shaped islands and broad (6-7 km wide) overflow channels occur on the left bank of the Ladon main channel. These features suggest a rapid (catastrophic?) release of water from the Ladon source area. Neither morphologic nor topographic evidence exists for a continuation of Ladon Valles southward of the Ladon source area.

Chronology of the SULM: In order to reconstruct the general sequence of events of the Uzboi-Ladon system, we have performed crater size-frequency distribution (CSFD) measurements in four key areas of the SULM: (1) in the Bond crater (its northern floor and walls unaffected by ejecta from the Hale crater), (2) on the floor of Uzboi Vallis (both southward and northward of the Nirgal mouth), (3) in the central massif of the Holden crater, and (4) on the floor of the main channel of Ladon Valles. The CSFD measurements show the following absolute model ages (AMAs): (1) Bond, two AMAs, 3.74+0.04/-0.06 Ga and 3.58±0.02 Ga; (2) Uzboi, a single AMA of 3.48+0.03/-0.04 Ga, (3) Holden, two AMAs, 3.87+0.03/-0.04 Ga and 3.63±0.02 Ga, (4) Ladon, two AMAs, 3.71+0.07/-0.13 Ga and 3.31±0.04 Ga. These AMAs indicate the following general sequence of events in the study region. (1) Formation of Bond and Holden craters (Late Noachian), (2) formation of Ladon Valles (Late Noachian-Early Hesperian transition), (3) formation of Uzboi Vallis and resurfacing events in the Bond and Holden craters (Late Hesperian / Early Amazonian), (4) resurfacing events at Ladon Valles (Early Amazonian).

Conclusions: The topographic and morphologic characteristics, and the AMAs of the major parts of the SULM yield the following conclusions.

(1) Uzboi and Ladon Valles are not pieces of a larger, single outflow system (ULM) [5,6, 11,12] but represent individual fluvial features with independent histories.

(2) The modes of formation of Uzboi and Ladon Valles were different. Complete lack of features indicative of a catastrophic flooding in association with Uzboi Vallis suggests that its topographic depression (if it did not exist previously) was formed by a slow, glacier-like flow(s) that gradually removed material from the Uzboi trough and redeposited it on the floor of Holden crater. The total volume of Holden crater is able to accommodate all materials removed from Uzboi Vallis. In contrast, the tear-drop shaped islands and overflow channels at the upper stretches of Ladon Valles suggest that this system was related to a sudden and powerful release of large amounts of water from the source area near the center of the Holden basin.

(3) Neither Bond nor Holden craters have divided the originally contiguous system (ULM). The rims of these craters represented major dams on the way of flows during the formation of Uzboi Vallis.

(4) The formation or/and modification of the Uzboi Vallis head depression postdated Bond crater whose northern rim in not breached. Thus, even if the crater could be full of water, it did not serve as a source for the formation of Uzboi Vallis.

(5) The Uzboi head depression is ~250 km northward of the main rim of Argyre basin and was formed/modified by water/ice flows from local sources that were not connected directly with the basin. This requires an abundant water sources on the northern rim of Argyre during the Late Hesperian/Early Amazonian. The absence of prominent topographic basins that could accommodate liquid water on the Argyre northern rim suggests that this region could have been a site of massive glaciation at the Hesperian-Amazonian transition.

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