GEOLOGIC MAPPING IN SOUTHERN MARGARITIFER TERRA ON MARS: CONSTRAINING THE TIMING OF FLUVIAL ACTIVITY IN NIRGAL VALLIS. S. A. Wilson[1] and J. A. Grant[1], [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, 6th at Independence SW, Washington, DC (wilsons@si.edu).

Introduction: Geologic mapping in Mars Transverse Mercator (MTM) quadrangles -20037, -25037, -30037 and -30032 encompasses Uzboi Vallis and terrain west of Holden and Ladon basins in southern Margaritifer Terra (**Fig. 1A**). This region preserves a long record of aqueous activity, and mapping was undertaken to constrain the timing, source, duration and relative importance of aqueous versus other geomorphic processes (**Fig 1B**).

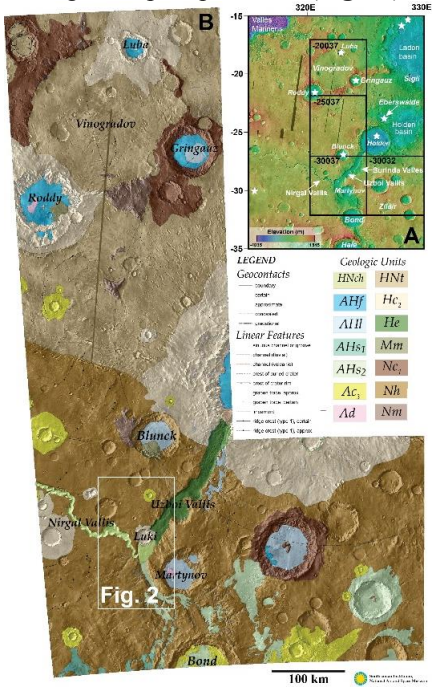

Fig. 1. A) Map quads cover 17.5°S-32.5°S, 320°E-325°E and 27.5°S-32.5°S, 325°E-330°E (black boxes). Stars mark craters with alluvial fans [1-2]. MOLA over THEMIS IR. **B**) Preliminary geologic map, 1:1M scale. Box shows location of Fig. 2A.

Background: The Noachian-Hesperian age [1] Uzboi-Ladon-Morava outflow system dominates the regional drainage from Argyre to the northern plains [3-7]. Holden crater formed in the mid to Late Hesperian [7] and blocked the northern end of Uzboi Vallis, creating an enclosed basin within Uzboi that flooded and formed a large paleolake [8]. Nirgal Vallis is a 670 km-long [9] east-west trending valley network that debouches into Uzboi along its western flank just south of crater Luki (**Figs. 1 and 2A**). Despite being Uzboi's largest tributary, one of the outstanding questions regarding the geologic history of this region is the age, timing and duration of fluvial activity within Nirgal Vallis [8]. Furthermore, it was unclear whether discharge from Nirgal contributed to the relatively short-lived lake in Uzboi or if fluvial activity in Nirgal terminated prior to the filling and draining of the Uzboi basin [8].

We characterized the deposit on the floor of Uzboi Vallis at the mouth of Nirgal Vallis [10] using topographic data (**Fig. 2**) and high resolution images (**Figs. 3-4**). The volume of this deposit at the confluence of Nirgal and Uzboi Valles was estimated and compared to the total volume of material eroded by Nirgal Vallis. This volume comparison provides insight into the evolution of Nirgal Vallis relative to Uzboi Vallis, helps constrain possible sources of water for Lake Uzboi [8], and furthers our understanding of the aqueous history of this region in the Late Hesperian.

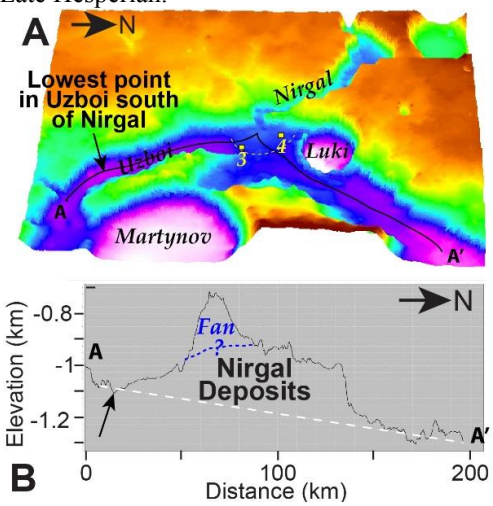

Fig 2. A) Perspective eastward-looking view of deposit in Uzboi at confluence of Nirgal Vallis (MOLA 8x VE, elevation in scene ranges from 1060 to -1764 m, see Fig. 1B for context). For scale, crater Luki is 20 km in diameter. Transect corresponds to profile in (B). Boxes indicate Figs. 3 and 4; dashed line indicates symmetric fan-shaped deposit at mouth of Nirgal. **B**) Profile on Uzboi floor in (A), arrow indicates low point in Uzboi south of Nirgal. Dashed line projects Uzboi floor beneath Nirgal deposits.

Methods: The volume of the deposit on the floor of Uzboi Vallis was estimated by multiplying the varying thickness of the deposit by the corresponding surface area [11]. The thickness was estimated from MOLA topography on Uzboi's valley floor between craters Bond and Holden (**Fig. 2A**), where thickness was equivalent to the difference in elevation between the surface of the deposit and the projected elevation of Uzboi's floor beneath the deposit (**Fig. 2B**).

The volume of material removed from Nirgal Vallis was calculated by comparing a "pre-Nirgal" surface digital elevation model (DEM) to the present day DEM. In ArcGIS, a reconstructed "pre-Nirgal" surface was created by clipping the gridded 128 pixel per degree MOLA data to encompass ~632 km of Nirgal Vallis. The DEM raster was converted to individual elevation points, and the points within Nirgal Vallis (plus a 1.5 km buffer) were removed. A triangular irregular network (TIN) was generated from the remaining elevations points, which connects straight lines across the removed data. The TIN was converted to a raster DEM with a cell size of 463 to correspond to the original resolution of the 128 pixel per degree gridded MOLA data using the nearest neighbor interpolation method. The Cut/Fill tool calculated the difference in volume between the "pre-Nirgal" DEM and the present day topography. This method provides an order of magnitude estimate as the actual valley profile (and resulting volume) is approximated using a DEM generated from coarsely spaced (~½ km) MOLA elevation shot points.

Results and Observations: The estimated volume of the deposit on the floor of Uzboi Vallis at the confluence of Nirgal is significantly smaller (~200-250 km^3) than the total volume of material removed by Nirgal Vallis (~1600 km^3). The surface of the deposit at the mouth of Nirgal Vallis is fan-shaped and fairly symmetric in planform (**Fig. 2A**) with gradients of ~0.01 m/km. The fan-shaped deposit near the mouth of Nirgal consists of light-toned material that tends to incorporate meter-scale blocks and lacks obvious fine-scale layering (**Fig. 3**). The fan surface ~15 km away from Nirgal exposes fine-grained, light toned, horizontal layers [10] **(Fig. 4**). The fan-shaped deposit (~40 km^3) appears to be stratigraphically on top of a larger mound of material (~200 km^3) that is offset downstream toward Holden crater. This lower-gradient surface is incised by a few shallow and poorly integrated channels [6].

Discussion: The net difference in volume between the Nirgal deposits in Uzboi relative to the volume of material eroded from Nirgal Vallis suggests that most of the material eroded by Nirgal debouched into Uzboi when there was active flow through the system, thereby resulting in much of the sediment being transported downstream. The bulk of the deposit that is offset downstream beneath the fan-shaped deposit (**Fig. 2**) suggests that the majority of the incision of Nirgal likely pre-dated deposition into Lake Uzboi. The roughly symmetrical fan-shaped deposit at the mouth of Nirgal Vallis today, however, suggests that the constituent material was deposited into standing water in Uzboi, a depositional environment consistent with the fine layers at its distal margin (**Fig. 4**). If correct, this implies that late fluvial activity in Nirgal was concurrent with Lake Uzboi and (or) was related to water draining out of Uzboi as the lake drained northward into Holden.

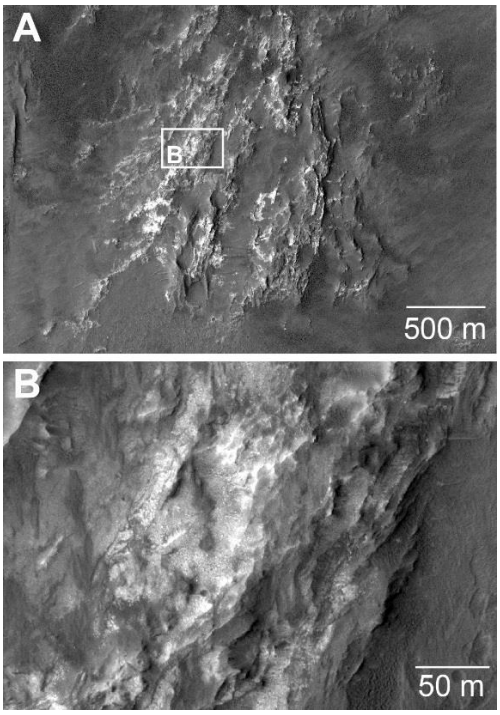

Fig. 3. Proximal surface of fan-shaped deposit is eroded (A) and consists of light-toned material that incorporates meter-scale blocks (B). See Fig. 2A for context. HiRISE PSP_003565_1495, 25.9 cm/pixel.

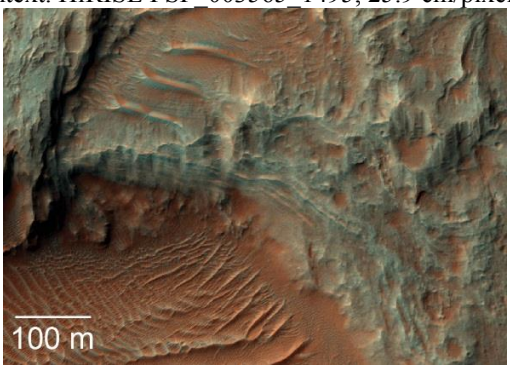

Fig. 4. Light-toned horizontal layers at distal end of fan-shaped deposit. See Fig. 2A for context. HiRISE ESP_04208 2_1495, 25.8 cm/pixel.

References: [**1**] Moore & Howard 2005 *JGR*, doi:10.1029/2005JE002352 **[2]** Wilson et al. 2013 *LPSC* Abst. 2710 [**3**] Grant 1987 NASA Memo 89871, 1-268 [**4**] Grant & Parker 2002 *JGR*, doi:10.1 029/2001JE001678 [**5**] Parker TJ 1985 Thesis, Cal. State [**6**] Saunders SR 1979 USGS Map I-1144 [**7**] Irwin & Grant 2013 USGS Map I-3209 [**8**] Grant et al. 2011 *Icarus*, doi:10.1016/j.icarus.20 10.11.024 [**9**] Reiss, D. et al. 2004 *JGR* doi:10.1029/2004JE002251 [**10**] Wilson & Grant 2016 *LPSC* Abst. 2505 [**11**] Morgan et al. 2014 *Icarus*, *229*, 131-156.