GEOLOGIC MAP OF THE SOURCE REGION OF SHALBATANA VALLIS, MARS. Daniel C. Berman, Catherine M. Weitz, J. Alexis Palmero Rodriguez, and David A. Crown, Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719; bermandc@psi.edu.

Introduction: We are currently producing a 1:500,000-scale USGS geologic map of MTM quadrangles 00042 and 00047 in the Xanthe Terra region of Mars (2.5°S - 2.5°N, 310° - 320°E) (Fig. 1). The map region has been extensively modified by outflow channels and chaotic terrains and contains cratered plains deformed by subsidence [e.g., 1]. The overarching goal of this project is to document the sequence and types of hydrologic processes that developed as a consequence of the melting of subsurface ice, leading to subsidence and collapse. In particular, we examine the history of catastrophic floods in the region linked to these processes.

Geologic mapping is being conducted on a THEMIS IR daytime base mosaic, with CTX and HiRISE images as supplements where available. Geologic contacts, linear features, and surface features have been mapped, and geologic units have been defined (Fig. 1).

Geologic Units and Features: Types of geologic units include plains, crater, vallis, chaos, and surficial units. The boundaries of cratered plains units 1 (*cp1)* and crater plains 2 (*cp2)* are similar to those of Npl_1 and Npl_2 as in [2]. The plains units are smooth to mottled in appearance and are disrupted by secondary crater chains, wrinkle ridges, and areas of minor collapse. The ejecta blankets of the numerous large craters are partly eroded and in some cases entirely removed. Cratered plains 2 is similar to cratered plains 1, but with a dark signature in THEMIS day IR (bright in night IR) and some knobs. Crater counts give an age of ~3.8 Ga (Late Noachian) for both plains units, with a possible resurfacing event at ~3.6 Ga.

Crater units include crater material (*c*) and crater fill material (*cf*). Crater material includes ejecta blankets, rims, and floor materials for relatively unmodified bowl-shaped craters. The ejecta blanket of Orson Welles crater has been mantled and subdued by aeolian materials. Crater fill material consists of smooth or fractured infill deposits on flat crater floors.

Many of both the crater and vallis units are characterized by collapse and retreat. Shalbatana and Ravi Valles are characterized by smooth and chaotic floor units. Vallis units are divided into vallis floor material – upper smooth (*vfus*), vallis floor material – lower smooth (*vfls*), vallis floor material – etched (*vfe*) (which comprises the lower floor of Ravi Vallis), and vallis wall material (*vw*), comprised mainly of talus.

Chaos units include chaos material 1 (*ch1) and* chaos material 2 *(ch2).* Chaos material 1 occurs at higher elevations and contains larger, often flat-topped blocks, whereas chaos material 2 is at lower elevations and mostly comprised of knobby blocks.

Surficial units include dune material (*d*), found on the western floor of Orson Welles crater, landslide material (*l*), found along the retreating walls of Orson Welles crater and Shalbatana Vallis, lava flow material (*lf*), which extends to the southeast from Aromatum Chaos, and light-toned deposits (*lt*) found in several locations on the floors of subsided terrain (smooth floor material and chaos material 2) and craters.

Mapped linear features include crater rims, volcanic and fluvial channels, grooves, grabens, ridges, troughs, pit-crater chains, faults, and scarp crests. We have also mapped surface features including dark ejecta and secondary crater chains. All craters greater than 5 km in diameter have been mapped.

Geomorphic mapping of chaotic and subsided terrains is proceeding, along with related extensional faults south of Orson Welles crater, showing a zone of subsurface evacuation reaching to Ganges Chasma.

Geologic History: The impact that formed Orson Welles crater may have penetrated an aquifer or subsurface ice lens leading to initial outflow and incision of Shalbatana Vallis. Following impact, the plains units were resurfaced with weakly consolidated (potentially ice-rich) materials; Orson Welles and other large craters were infilled and their ejecta and rims were partially to completely removed. Melting of subsurface ice (perhaps by magmatic intrusion) led to the collapse of the infill material, resulting in chaos material 1 [e.g., 3]. The remaining infill material was swept away during resulting catastrophic flooding and outflow, incising Shalbatana Vallis and leaving behind chaos material 2 and smooth floor materials. Subsequent collapse and retreat of the crater walls led to talus deposits on the walls and landslides. Some of the blocks on the floor of chaos material 2 may also be from wall collapse. Dune material was the last to form.

Aromantum Chaos forms the source area of both a lava flow and an outflow channel. The lava flow likely erupted from a fissure parallel to the southern margin of the chaotic terrain that was subsequently destroyed during ongoing collapse and retreat of the canyon wall. Craters that impacted into the lava flow exhibit high thermal inertia ejecta blankets with large boulder deposits. Close examination of the southern wall of Aromatum Chaos in HiRISE images reveals evidence of a sequence of possible buried lava flows that form low-albedo bouldery outcrops. Episodic volcanic activity in the region could have provided high geothermal conditions conducive to groundwater outburst leading to catastrophic flooding [4].

Flooding in Ravi Vallis inundated plains surfaces above the margins of its grooved floor, where the floods deposited widespread smooth deposits, locally marked by small-scale streamlined landforms. These smooth floors flank the lower scoured sections and their origin might be related to earlier floods that were not topographically constrained within a channel and thus spread (and thinned out) over the intercrater plains, thereby rapidly losing velocity. This scenario indicates a possible transition from non-catastrophic floods (depositional) to catastrophic (erosional) floods.

Crater counts indicate that Ravi Valles and the lava flow both formed in the Early Hesperian, ~3.44 Ga for the channel and ~3.47 Ga for the lava flow, which would be consistent with the magmatic activity acting as a trigger for melting and outflow. The ejecta blanket of Dia Cau crater is bisected by Ravi Vallis, and we date its formation at ~3.61 Ga.

Light-toned deposits: CRISM analyses of the light-toned deposits show evidence for Fe/Mg-smectites and hydrated silica. Light-toned Fe/Mg-smectite deposits are also observed along the upper wall of one of the craters, indicating the deposits predate the impact. These results are consistent with melting of subsurface ice lenses, with water interacting with and altering subsurface layers to form smectites, which are later exposed due to either impact crater formation or subsidence and collapse.

Conclusions: Geologic mapping, combined with geomorphic and spectral analyses, show that subsurface ice in this region melted, leading to evacuation, collapse, and flooding, leaving behind cavities that have caused further deformation and collapse of surface units.

References: [1] K.L. Tanaka et al. (2014) USGS SIM-3292. [2] S. Rotto and K.L. Tanaka (1995) USGS SIM I-2441. [3] J.A.P. Rodriguez et al. (2015) Nature Scientific Reports, 5, 13404. [4] D.C. Berman et al. (2016) LPSC 47, #2674.

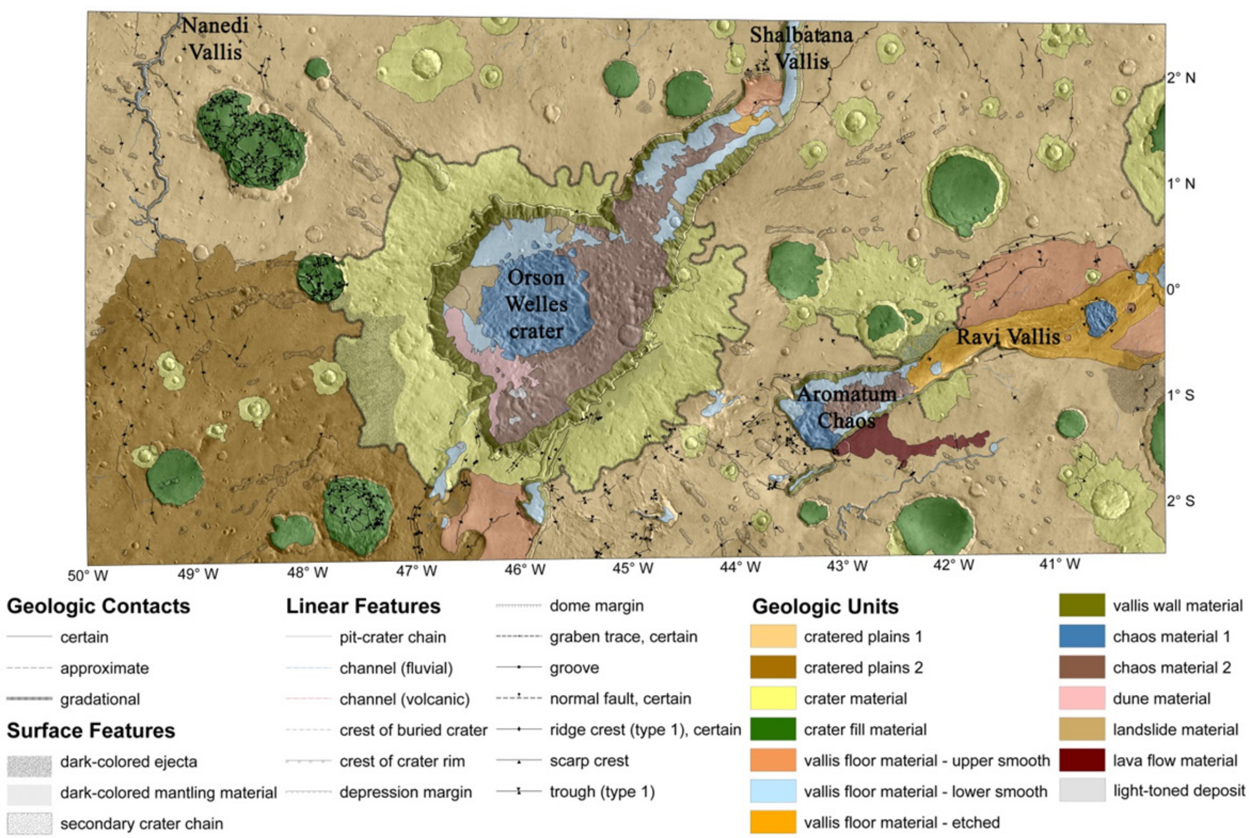

Figure 1. Geologic map of MTM Quadrangles 00042 and 00047 at 1:500,000 scale. THEMIS IR daytime base. Transverse Mercator projection. Map width is ~615 km.