**NATURE OF HESPERIAN RESURFACING IN THE SCANDIA-NORTH POLAR REGION OF MARS.** K. L. Tanaka[1], J. A. P. Rodriguez[2], C. M. Fortezzo[1], R. K. Hayward[1], and J.A. Skinner, Jr.[1] [1]U. S. Geological Survey, Flagstaff, AZ 86001 (ktanaka@usgs.gov), [2]Planetary Science Institute, Tucson, AZ (alexis@psi.edu).

**Introduction:** We have begun a four-year project to produce a geologic map of the Scandia region of Mars at 1:3,000,000 scale for publication in the USGS Scientific Investigations Map series. The primary objective of the map is to analyze and reconstruct the resurfacing history of this region in much greater detail than achieved by the previous northern plains-wide mapping effort [1-2]. This region includes (1) a broad swath of the Vastitas Borealis plains that includes various Scandia landforms and the Phoenix lander site; (2) part of the margin of the north polar plateau, Planum Boreum; and (3) the northern margin of the immense Alba Patera volcanic shield. We rely mostly on Mars Orbiter Laser Altimeter (MOLA) digital elevation models and Thermal Emission Imaging Spectrometer infrared and visual range and Context Camera images for mapping and topographic analysis.

**Background:** Resurfacing within the study region is thought to have involved collapse, erosion, mud volcanism, and sedimentary diapirism of fluvial-lacustrine deposits originating from outflow-channel discharges from the Martian highlands into the northern plains [1-2]. Landforms interpreted as having resulted from these processes include Scandia Colles (knobs), Scandia Tholi (low rounded plateaus), and Scandia Cavi (broad, irregular depressions surrounded by rises). Furthermore, basal materials exposed along the margin of Planum Boreum may source from eroded Scandia materials [3].

**Mapping results:** Geologic units thus far mapped include: (1) Alba Patera shield lavas and channelized flows, (2) Vastitas Borealis materials, (3) Scandia materials, (4) the Planum Boreum rupēs and layered deposit units [4-5], and (5) circum-polar dune material (Fig. 1). The crater densities for unit areas already mapped (Fig. 1) register Hesperian surface ages (Table 1).

**Table 1. Cumulative densities of craters* for Scandia region units (from [1, 6]).**

| *Unit* | *N(2)* | *N(5)* |
|---|---|---|
| Northern Alba Patera | --- | 77±9 |
| Vastitas Borealis interior | 295±18 | 87±10 |
| Scandia region | 336±51 | 122±31 |
| Planum Boreum rupēs | 476±107 | 143±58 |

*N(X) = no. craters > X km diameter per $10^6$ km$^2$.

We are mapping a variety of structures and landforms. Linear features include classes of ridges, most of which form the wrinkle ridges of Arcadia Dorsa become which become more subdued toward lower parts of the Scandia region. Another set of subtle, linear ridges trend N in the SE corner of the map region. Some ridges trend down slope and may be degraded flows. Narrow grabens trending NNE make up Alba and Tantalus Fossae and dissect NE Alba Patera. North-facing scarps of irregular form generally trend E-W across the middle of the map, defining a low topographic scarp along which the Scandia Colles knob field occurs. The Phoenix lander site is just below this scarp. North of the scarp, the plains are marked variously by ridges, mesas, and irregularly shaped, nested depressions. The two lowest parts of the northern plains occur immediately south of Planum Boreum. The western part includes the broad, circular domes of Scandia Tholi and the irregular depressions surrounded by rises that form Scandia Cavi. The eastern low is partly included along the NE margin of the map region and includes the conical features known as Abalos Colles. Each of these low regions includes plains that are cut by networks of troughs that bound polygons several to ~20 km across.

We also have mapped all 17,472 knobs in the region that can be defined by at least two enclosed 20-m-interval elevation contours. They are distributed throughout the map region and are particularly concentrated in Scandia Colles, Tholi, and Cavi and around Milankovič and Korolev craters. Impact crater morphologic types and significant albedo boundaries, including one locally defining the boundary of Vastitas Borealis units, are also being mapped.

**Formational hypotheses:** Geologic mapping provides a basis to assess the spatial, temporal, and geologic relationships that enable creation and testing of hypothetical reconstructions of the process history and events that shaped the landscape. Based on our initial mapping results for the Scandia region, we are formulating working hypotheses that may account for the major aspects of geologic activity recorded during the Hesperian for the map region. Here are a few intriguing hypotheses based on our preliminary observations that we plan to further develop and test (see also [7-8]):

*(1)* The major endogenic geologic materials, structures, and landforms of Hesperian age in the map region may have developed in an integrated, regional basin environment that includes the lowest part the northern plains. The major components were: (1) Alba Patera magmatism, which drove tectonic deformation, heating, and hydrothermal groundwater circulation in the Scandia region; and (2) northern plains outflow-channel sediments that included an ice-rich, impermeable upper permafrost zone underlain by water-saturated material and

thus were subject to hydrogeologic, tectonic, and periglacial processes.

*(2)* Crustal rocks bounded by thrust faults underlying wrinkle ridges N and NW of Alba Patera could be zones of groundwater collection, aquifer development, and elevated fluid pore pressure (especially within topographically lower zones of aquifers) [9-10]. In addition, upward groundwater and ice flow may have been enhanced along such buried faults. Such flow could have lead to diapirism and the formation of cavi and tholi, especially with the development of superlithostatic fluid pore pressure and/or intense seismic shaking associated with large impact events. Buried salt deposits might also participate in similar activity [cf. 11].

*(3)* NE of Alba Patera, resurfacing was relatively moderate and may relate to a cluster of grabens that cut the shield. The grabens may define a zone of enhanced crustal cooling due to heat dispersion through hydrothermal convection along deep-seated fractures, resulting in downward propagation of a cooling front. As a result, thickening of the cryosphere along fractures underneath this terrain could have reduced aquifer connectivity and hydraulic head.

Knobs, pedestal craters, albedo variations, and mantles in the map region record additional aspects of the geologic history that remain poorly understood, but we are making some advances [e.g., 7-8]. As with the other features in our study, we will consider how they fit into the regional geologic context.

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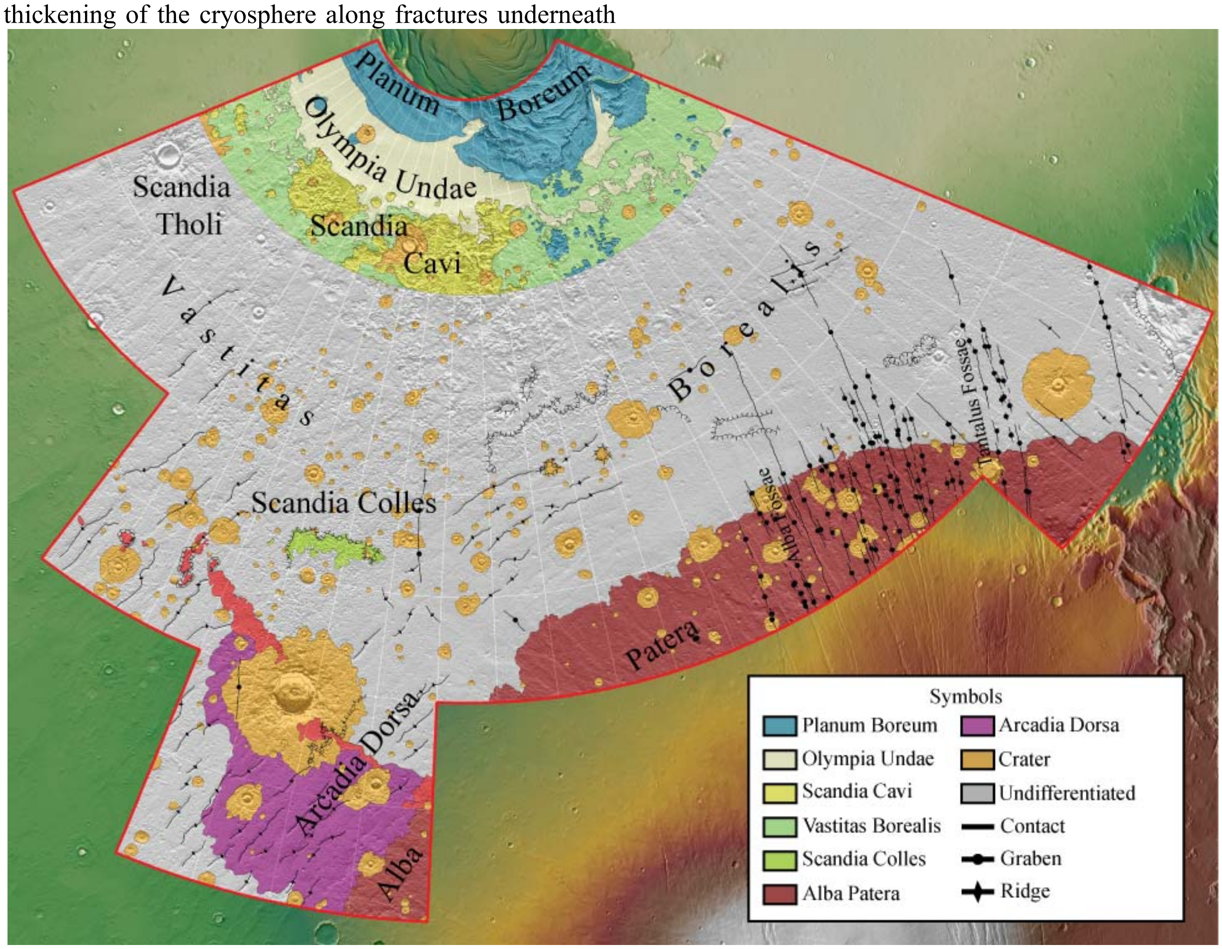


**Fig. 1.** Preliminary geologic map of the Scandia region of Mars showing map units, wrinkle ridges, scarps, grabens, unfinished contacts, and major geographic features; uncolored region remains largely unmapped. Background image is MOLA shaded relief view in Polar Stereographic projection (45-85° N., 160-295° E.); scale varies with latitude (5° grid spacing, ~295 km spacing between parallels).