GEOLOGIC HISTORY AND CHANNELING EPISODES OF THE CHRYSE PLANITIA REGION OF MARS; **Susan L. Rotto and Kenneth L. Tanaka,** U.S. Geological Survey, Flagstaff, Ariz.

Introduction. Our investigation of the Chryse Planitia region of Mars is based on geologic mapping on a 1:5,000,000-scale shaded relief map base [1]. The map area includes Chryse and southern Acidalia Planitiae; the circum-Chryse channels and chaotic terrains; Xanthe, southern Tempe, and western Arabia Terrae; Lunae Planum; and northeastern Valles Marineris. The aim of the study is twofold: (1) to obtain relative ages of the outflow channels by performing and compiling detailed stratigraphic analyses, and (2) to correlate channeling episodes with causative mechanisms (such as volcanism and tectonism) and resulting effects (such as climate change). Preliminary mapping has been completed. It incorporates previous, broad-based work [2-4] and ongoing, high-resolution (1:500,000-scale) mapping by colleagues [e.g., 5]. The following geologic history, based on this mapping, includes the documentation of a previously unproposed channeling episode in the region as well as our presently favored hypotheses concerning the nature and origin of the channeling events.

(1) Early to Middle Noachian. Chryse and Aram basins, other large impact features, and heavily cratered terrain were formed during this period, when bombardment was intense. Ancient crater material makes up much of the highland plateaus and probably underlies most other areas covered by younger materials.

(2) Late Noachian to Early Hesperian. This period is marked by the development of several runoff and outflow channels and by degradation of older lowland materials. We propose that these events are correlative and demonstrate a common episode of activity. Runoff channels that include Nanedi and Bahram Valles cut the southwest exposed rim of Chryse basin, as well as the rim's buried trace. Other runoff channels southeast of the map area (including Nirgal, Parana, and Samara Valles) fed the Ladon-Ares outflow system (only the northern section is in the map area). This system is made up of discontinuous outflow channels (Uzboi, Ladon, and Ares Valles and an unnamed channel southeast of Margaritifer Chaos) linked by chaotic terrain (Margaritifer and Iani Chaos) and basin deposits (Ladon and Holden [6]). In Arabia Terra, the outflow channel Mawrth Vallis originates north of crater Trouvelot and near other large craters and winds down into southeastern Acidalia Planitia. Intercrater plains formed near many of the channels and thus may consist in part of flood-plain deposits. Below the mouths of the runoff and outflow channels, possible flood-plain deposits are buried by younger material. However, extensive fields of relatively small knobs of degraded Noachian materials are embayed by younger plains material in southern Acidalia Planitia. In places these fields grade into mesas and fractured highland materials. Many of the knobs form rings--the remnants of impact-crater rims. Thus the channels and knobs of this period appear to be the result of ground-water outbreak, sapping, and runoff from highland rocks onto lowland plains.

We suggest that tectonic movements and heat from intrusions generated the hydraulic gradients necessary to produce such hydrologic activity. North of Acidalia Planitia, Borealis basin lowered [7], while igneous activity and local uplift occurred at Syria Planum [8] and the Coprates rise [9]. (It is uncertain whether Valles Marineris was active at this time [10].) During the Early Hesperian, wrinkle ridges formed on possible lava and flood plains of that age that cover Lunae Planum and much of Chryse Planitia and Arabia Terra [2].

(3) Late Hesperian. The majority of outflow-channel systems in the map area formed during the Late Hesperian. They originate from large areas of chaotic and warped terrains, some of which connect with or occur in eastern canyons of Valles Marineris. The channels locally cut deeply into highland rocks and make shallower cuts in higher areas of Chryse Planitia. Some of these channel systems, such as Kasei Valles, show evidence for two or more episodes of erosion [11]. In lower Ares Valles (northwest of lat 11° N., long 27°), a resistant flow material (that we interpret to be lava) covered the earlier channel floor and was in turn eroded by flooding during this episode. In eastern Chryse Planitia (around lat 22° N., long 36°), a lobate deposit (probably more lava) was carved by flows from Ares, Tiu, and Simud Valles. Within deeper outflow channels (carved into highland rocks), lobate fields of knobs may be deposits of late-stage debris flows [12]. In Chryse and Acidalia Planitiae, neither clearly defined deposits nor paleoshorelines are recognized [13], and thus the mode and location of deposition of eroded materials and the fate of the released water are uncertain. However, wrinkle ridges in northern Chryse Planitia are subdued, perhaps due to embayment by sediments.

Most of the channel systems appear to consist of single channels originating from one or more areas of chaotic terrain. Shalbatana Vallis, however, is made of a series of channels that document progressive outbreak upslope. The youngest event was the largest and produced a narrow, deep canyon that originates from large depressions and chaotic terrain (in an impact crater) south of lat 1° N. (at 3,000-m elevation [14]). At lat 8° N. (0-m elevation), this canyon cuts a narrow but shallower canyon that in turn connects with a lower (and older), small area of chaotic terrain (at lat 12° N., -1,000-m elevation) from which extends a broad and shallow channel.

Chaotic and warped terrains are thought to form by liquefaction and removal of wet, subsurface material and collapse of near-surface, impermeable (ice-cemented?) material [15-17], which may lead to generation of debris flows. Retrogressive slope failure occurs in submarine environments on Earth as a consequence of evolving slope-stability conditions; Shalbatana Vallis also may have developed in a retrogressive sequence. Hydraulic conditions and quaking that could have led to such activity may have been produced by later episodes of Tharsis and Valles Marineris tectonism. In lower Kasei Valles, chaotic and fractured terrains associated with enlarged fractures suggest that outbreaks there may have occurred by hydrofracturing [18].

(4) Amazonian. The extent of channel activity during the Amazonian is as yet uncertain, pending further study. Landslides, however, occurred along high scarps in Valles Marineris and in some outflow channels, initiated by impacts and perhaps by seismic shaking as faulting continued at Valles Marineris. More wrinkle ridges formed in western Chryse Planitia and lower Kasei Valles [11], probably as a result of compression due to extensive erosion [19]. Extensive fields of lava flows were erupted from the Tharsis Montes region during this period; some of the flows buried upper reaches of Kasei Valles [3].

Conclusions. The geologic history of the Chryse region suggests that two major periods of tectonic activity resulted in two episodes of channeling in the highlands surrounding Chryse Planitia. The first channel episode was related to distant activity at the Syria and Coprates rises and downwarping of Borealis basin; erosion was shallow and relatively moderate, resulting in shallow channels, thin flood-plain deposits, and knobby lowland terrain. The second episode was primarily influenced by uplift and rifting at Valles Marineris and perhaps by Tharsis volcanotectonic activity. The formation of deep channels and chaotic terrains suggests liquefaction and transport of large volumes of wet debris.

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