MARS SURFACE PROCESSES THAT INFLUENCED ANCIENT RUNOFF PRODUCTION AND PRESERVATION OF DRAINAGE NETWORKS. R. P. Irwin III, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, PO Box 37012, MRC 315, Washington DC 20013-7012, irwinr@si.edu.

Introduction: Studies of Martian valley networks from the 1970s to the present have shown their immature development relative to Earth [e.g., 1–3]. The preservation of enclosed drainage from the early to late Noachian [e.g., 4,5] shows that the subsequent phases of lower aridity and increased runoff [6,7] did not fully dissect or integrate the Noachian landscape at any point in time. On low-gradient surfaces, sparse valley networks dissect Noachian pediments composed of impact ejecta and products of basalt weathering [8].

The extent to which the poorly dissected interfluvial pediments contributed runoff remains a major question regarding the late Noachian to early Hesperian valley networks. Here we discuss three considerations based on observations of study areas in equatorial Terra Cimmeria and Tyrrhena Terra: (1) Noachian modifications that facilitated runoff production from impact ejecta, (2) post-Noachian modifications of older runoff-generating surfaces, and (3) the effects of airfall mantling and deflation.

Noachian Modifications of Impact Ejecta: Mapping and modeling of cratered terrain have shown that Noachian impact ejecta blankets are largely intact but modified, such that local surface elevations increased rather than decreased between the early Noachian Hellas impact and the Noachian/Hesperian boundary [8,9]. Steep Noachian slopes retreated as escarpments, while significant aggradation (i.e., burial and embayment of Noachian degraded craters) was confined mainly to basin floor plains, and intercrater pediments were relatively stable.

In the latter setting, small craters (<~4–8 km) were preferentially lost while larger ones were degraded but not substantially buried. This ubiquitous observation requires Noachian sediment transport and deposition in local lows, while crater rim relief was preferentially attacked through scarp retreat and denudation [8,9]. This pattern of degradation is similar to younger volcanic plains at the Spirit and InSight landing sites [10,11], but at a much larger scale that requires higher ancient rates of weathering and sediment transport.

The transitions between escarpments, pediments, and plains in Noachian cratered terrain are commonly abrupt, without the alluvial fans that are common in the Great Basin and similar tectonic settings on Earth. This observation suggests that the transported sediment was mainly fine-grained products of weathering of the basaltic crust of Mars [8].

These observations indicating that a mainly fine-grained sediment load was preferentially deposited in topographic lows across a wide range of scale suggest that Noachian landscape evolution on intercrater pediments would have reduced the infiltration capacity of impact ejecta blankets over time. This trend is expected to facilitate runoff production under less arid conditions around the Noachian/Hesperian boundary.

Post-Noachian Modifications: Efficient (relative to fresh impact ejecta) runoff-generating surfaces from the Noachian/Hesperian boundary are not preserved. Although the topography of Noachian cratered terrain has changed little, resistant surfaces have been impact-gardened to rubble, and weakly consolidated deposits of fine-grained sediment have been somewhat deflated, such that the surface observed with the Context Camera (5 m/pixel) and higher-resolution imagers is a reworked expression of the ancient state. These surfaces do not preserve mappable tributaries well, such that much of the visible drainage network of Mars consists of reaches that substantially incised the Noachian ejecta substrate (Fig. 1).

Effects of Airfall Mantling and Deflation: In the present hyperarid climate, wind is the other major geologic process in equatorial cratered terrain. Thin aeolian mantles, deflated remnants, and bedforms are found cover much of the highland cratered terrain [12]. Most of the floor area of valley networks is presently aeolian. Although thick mantling that could eradicate valley networks tens of meters deep is localized, studies of crater modification on post-Noachian volcanic terrain [10,11] show that aeolian processes could remove small overland tributary channels.

Discussion: The foregoing observations show that Noachian landscape evolution may have facilitated runoff production from pediments but that the runoff-generating surfaces were not preserved, such that valley networks should be mappable today only where they were deeply incised.

Factors that favor incision on Earth include slope, reduction of base level, and increased sediment transport capacity relative to sediment load. Strong-over-weak stratigraphy that may result from duricrusts in impact ejecta [13] can support vertical knickpoints between shallowly incised and deeply incised reaches of rivers. Areas where the pre-existing Noachian surface was in disequilibrium with fluvial drainage (e.g., impact crater walls or other convexities in the

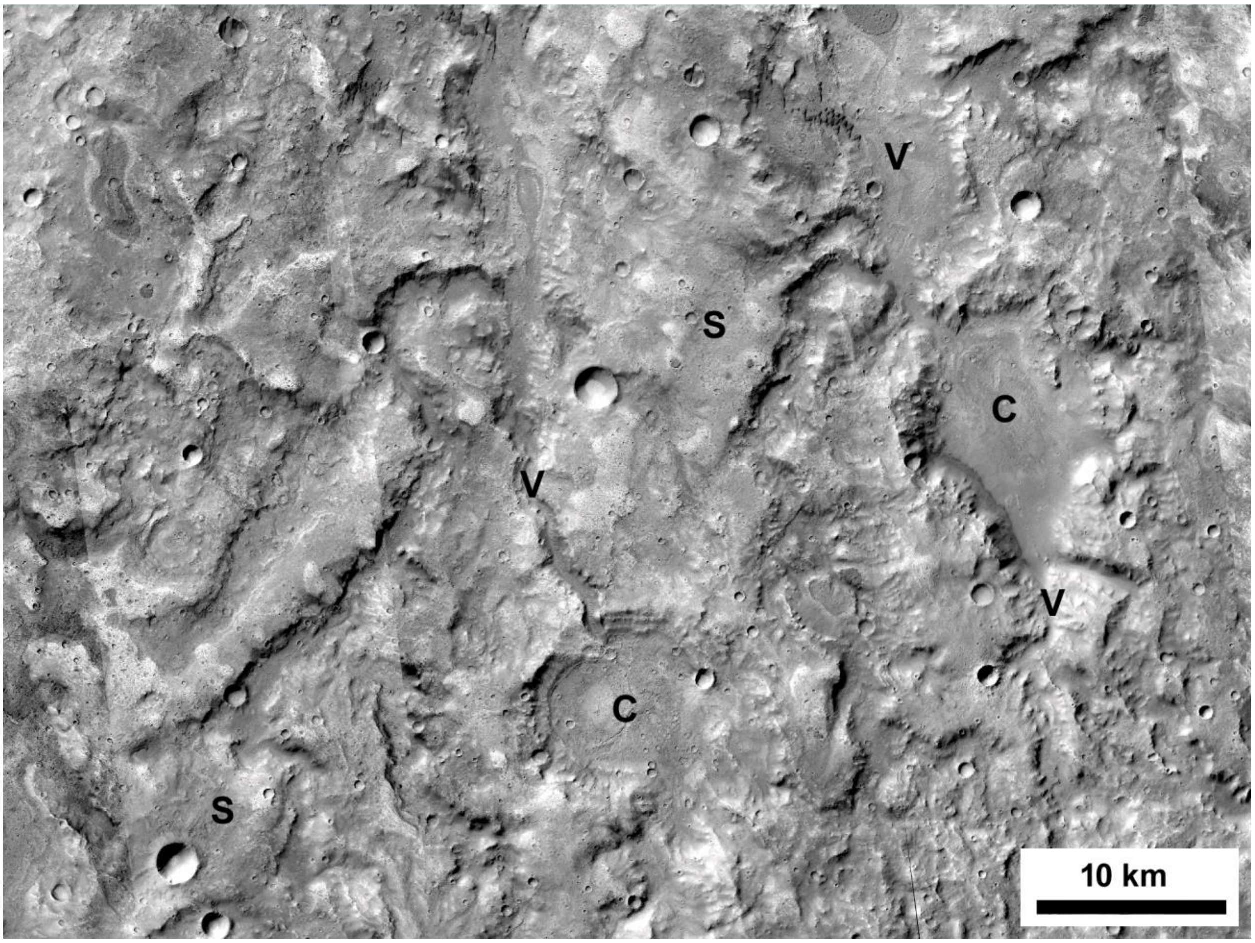

Fig. 1. Relatively densely dissected area of northern Terra Cimmeria, showing examples of valleys (V), craters crosscut by drainage (C), and poorly dissected interfluvial surfaces (S). Many valley walls are dissected. The geologic setting is Herschel crater ejecta sloping to the north with base level control by a 92 km crater floor to the northeast. Mosaic of Context Camera images centered at 10.13°S, 128.03°E.

longitudinal profile) would be preferentially attacked and could initiate the headward propagation of knickpoints. The overflow of low-relief topographic basins and the resulting sudden increase in stream power may have helped to establish some long valleys quickly [14]. On Mars, these factors are largely inherited from the Noachian landscape rather than reflections of the water source. Moderate meteorological floods, a fine-grained sediment load, and a semiarid paleoclimate may adequately explain the development of valley networks around the Noachian/Hesperian boundary.

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