POLYGENETIC ORIGIN OF HRAD VALLIS, MARS: R.A. De Hon, Department of Geosciences, Northeast Louisiana University, Monroe LA, 71209.

Introduction. The western and northern outer flanks of the Elysium Mons rise are characterized by valley systems that begin near the outer limits of the Elysium lavas and extend down slope radially away from the volcanic construct (1). Unlike the outflow channels that discharge into Chryse Planitia, these channels are confined systems that are carved by a prolonged discharge of water to the surface. One of these valleys northwest of Elysium Mons, Hrad Vallis, begins in a fissure of Galaxias Fossae near the edge of the lava flows and continues down the regional slope for nearly 800 km. The upper (southern) part of Hrad Vallis is characterized by a wide, flat-floored valley with an incised channel. The outer valley of Hrad terminates 250 km from the source, but the narrow channel turns to a more westerly course and continues another 500 km before disappearing in Utopia Planitia. The upper part of Hrad Vallis is similar to terrestrial valleys of late stage development, but flat-floored, terrestrial valleys with incised streams near the head of the valley are uncommon. The origin of the outer Hrad Vallis and the history of development of upper Hrad Vallis provides insights into surface materials and processes in this region of Mars.

Regional Setting. Hrad Vallis is located along the transition zone between the broad Elysium Mons rise to the southeast and Utopia Planitia to the northwest. The regional topography has a uniform, gentle slope to the northwest upon which is superimposed a moderately smooth to rugged surface consisting of lava plains in the south and a mixture of rolling plains, rugged badlands, and subdued knobby topography to the north (2). The regional trend of fissures, faults, and ridges is north-northwest parallel to the regional slope. Galaxias Fossa e consist of two distinct groups of fissures. The southern group, near the head of Hrad Vallis, consists of several large, open, north-northwest trending fissures cutting Elysium lavas. The northern fissures trend northwest and consist of a 350 km long fissure, a shorter parallel segment, and several cross-connecting northeast trending segments.

Geomorphic Elements of Hrad Vallis. The source of water that flowed through Hrad Vallis is an enlarged fissure of the Galaxias Fossae system along the northern edge of the Elysium lava flows. In the head region, the outer valley is marked by slumped walls and the floor of the valley is covered by chaotic terrain. The channel leading from the fissure was blocked but reopened by later discharge from the fissure. The channel in the head region bifurcates around several mid-channel islands and then continues north-northwestward as a single, well-developed channel.

Beyond the region of chaos, the outer valley is 25-50 km wide. The walls are steep and irregular, and the floor is flat and featureless. The valley trends north-northwest for 80 km and turns to a more northerly trend for 40 km. This valley segment connects through a narrow opening in the west wall to an adjacent, 25 km wide and 70 km long, valley segment with a northwest trend. One hundred ninety km from the head, the outer valley ends.

Beyond the zone of chaotic material of the source area, the low sinuosity channel (SI=1.03) stabilizes to a uniform width of 4 km. The channel is located along central axis of the southern outer valley segment, but at the junction with the northern segment it cuts across a narrow septum of upland terrain and follows the eastern wall of the northern valley segment. A short section of abandoned channel provides evidence that the channel made minor course adjustments during its development. The channel continues beyond the outer valley along a more westerly course. Near its termination the channel decreases in size as is characteristic of a losing stream.

Regional Elements of Morphology. A flat-floored valley east of Hrad Vallis provides an analog for comparison. This unnamed valley follows the same overall trend and has a similar configuration as Hrad Vallis. The valley walls stand above a flat, nearly featureless floor. The valley is composed of several valley segments that coalesce with adjacent valley segments or are joined by short, narrow channels.

Unlike Hrad Vallis, this valley lacks an incised channel. The southern reach of the valley is developed in polygonally-grooved terrain formed by the breakup of Elysium lavas. The valley in

this area is characterized by irregular valley walls with many re-entrants extending along polygonal grooves.

The valley head is composed of a steep-sided, roughly circular depression. The basin is 10 km in diameter, has a smooth, flat floor, and connects to the main valley through a breach in the northeast wall. Levee deposits at the breach attest to discharge from the basin into the connecting valley (3). Minor scour features, seen in the north where the northern-most basin narrows to a channel, show that water did accumulate and flow through the interconnected valleys.

Elsewhere within the region small, irregularly-shaped, closed-basins with steep walls, and flat, featureless floors are found. Small basins (10-20 km wide) have no preferred orientations. Larger basins (greater than 20 km long axis) tend to be elongate in a north-northwest direction parallel to the structural trend and the major valleys. These basins do not appear to be degraded impact craters, nor do they have parallel walls common to structural basins. They do appear to be fault controlled. Most of the basins occur along the trends of lineaments and faults.

Origin of Valley and History of Discharge. There are problems with any attempt to describe the valley system in terms of normal, sequential valley development by running water. Although sinuous, the Hrad channel is not meandering. The channel is not responsible for carving the valley. Rather, the outer valley was formed first, and the channel was cut at a later time.

Hrad Vallis and its neighboring valley are composite valleys made up of several interconnected segments. These valley segments formed as isolated basins much like the other flat-floored basins in the area. The depressions expanded along structural trends until they coalesced into elongate closed depressions. At some later time, the basins filled with water. Overflow spilled into the next downslope basin and cut connecting channels.

The pre-Hrad Vallis basin and other depressions in the area, have several features in common with both terrestrial Karst valleys and thermokarst valleys. Water circulating within fault zones resulted in removal of material and formation of the basin. The flat, concordant floors of the various basin segments suggest that a stratigraphic control limited their depth.

If circulating groundwater is responsible for the basins, then either the materials are soluble and the basins formed as pojles, or they formed as decaying permafrost depressions, alases or thermokarst valleys. Terrestrial Karst topography forms primarily in limestone terrains, but it may form in gypsum/anhydrite terrains, or any other soluble rock. Karst activity implies a rather thick section of soluble rock and freely circulating groundwater. Further, a thick soluble bedrock implies an extended period of marine or lacustrine deposition. Alternately, thermokarst activity implies a porous saturated rock. The material may be sedimentary or volcaniclastic. If the material is volcaniclastic, it cannot be dense, welded material. It must be porous, ice saturated and, lacking mechanical strength, to lose cohesion when interstitial ice melts. If the materials into which the valleys formed are thixotropic clays, then the basins may have formed in response to melting of ground-ice by circulating groundwater and by subsequent collapse of destabilized clay-rich materials.

Development of the neighboring valley was arrested when the various basin segments coalesced and water drained to the northwest. Water continued to discharge from the fissure at the head of Hrad Vallis, establishing a channel along the basin floor and beyond to the northwest. Unlike the short-lived outflows around the Chryse basin, the discharge must have been continuous over a sufficient length of time to allow a well-defined channel, but the flow did not last long enough to allow lateral migration of the channel to develop a true meandering pattern.

References:

(1) Greeley R. and J.E. Guest (1987) U.S. Geol. Surv. Misc. Inves. Map I-1802B.
(2) De Hon R.A. and P.J. Mouginis-Mark (1990) Lunar Planet. Sci. Conf. XXI, 268-269.
(3) Mouginis-Mark P.J. (1985) Icarus 54, 265-284.