THE ROLE OF HYDROTHERMAL CIRCULATION IN THE FORMATION OF FLUVIAL VALLEYS ON MARS; V.C. Gulick and V.R. Baker, Department of Geosciences, University of Arizona, Tucson, Arizona 85721

Fluvial runoff valleys which formed on the northern flank of Alba Patera required prolonged periods of surface flow at relatively low discharges in comparison to the outflow channels (1). Unlike the volcanoes Ceraunius Tholus and Hecates Tholus which also contain fluvial valleys, Alba Patera is thought to have formed well after the period of heavy bombardment (2,3) under climatic conditions similar to those of the present time. Past studies (4,5) have concluded that surface flows of relatively modest discharges could flow in ice-covered streams for hundreds of kilometers under present climatic conditions. Thus the problem in forming the valleys lies not in the stability of these streams but in the initiation and subsequent recharging of water flow (5). Recent studies have suggested the inevitable formation of hydrothermal systems as a consequence of the formation of volcanoes and impact craters (6) and the emplacement of igneous rocks as extensive sills (7). Additionally Squyres(8) suggested that the geothermal heat flux early in martian history may alone be sufficient to allow valley networks to form. In this paper, I present possible ways in which fluvial valleys could form both by sapping and runoff processes in the presence of an active hydrothermal system.

A hypothetical cross-section of an active hydrothermal system as might be produced by a magmatic intrusion associated with volcano formation on Mars is presented in Figure 1. Depending on the size of the intrusion, ground-ice within several tens of kilometers could be melted, providing groundwater. Heat transfer from the magma to the surrounding region would then produce perturbations in the subsurface flow field resulting in a net flow of water toward the surface. Water may reach the surface in the form of liquid or vapor or both. The time it takes for the water to re-enter the ground water system to repeat the process depends on the surface and near surface lithologic conditions. If the surface permeability is relatively low, water will flow on the surface and re-enter the subsurface at a given distance from the source. The path that this hydrothermally derived water takes has important implications for fluvial valley formation. On the left flank, the surface is composed of permeable basalt so water quickly infiltrates and recharges a near surface aquifer. The water again intersects the surface farther down the flank forming a seepage face. At this site, sapping processes (i.e., erosion by ground-water outflow) may eventually form a valley. On the right flank, the surface is mantled with ash. This ash, which is much less permeable than the underlying basalt, allows more water to flow on the surface. With continual surface flow, water will start to concentrate and downcut into the surface forming a runoff valley. If the seepage face intersects the surface environment at a cliff or steeply sloping landsurface, sapping valleys will form. If the seepage face intersects the surface environment on a very gently sloping landscape (< 5 degrees) and if the surface downslope of the seepage is such that the rate of runoff is greater than the rate of infiltration (i.e., ash mantled) runoff valleys may form (9).

In summary, whether hydrothermal systems alone could have provided the volume of water needed or whether water from other sources were involved in forming the valley systems is still uncertain and is a topic which will be considered in a future paper. What is clear is that hydrothermal

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circulation could provide a way of recycling water over the time periods needed to form the valley networks.

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