SURFACE MORPHOLOGY OF VALLEY NETWORKS FORMED BY SAPPING

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Many investigators feel that groundwater sapping processes were responsible for the formation of numerous valley networks on Mars. Groundwater sapping on Mars has important implications for the interpretation of paleoclimates and paleohydrology on that planet. On Earth, sapping has been suggested as the process responsible for creating distinctive U-shaped valleys with theatre-like headward terminations on the Colorado Plateau (1,2,3), on the Hawaiian volcanoes (4,5), and at a smaller scale on beachfaces (6,7).

Experiments are underway in two sapping facilities to document the morphology of surface valley networks formed by groundwater sapping processes. Numerous runs have been made by allowing groundwater to flow through homogeneous unconsolidated sediments with a constant head. These experiments produced valley networks with the following commonalities with proposed sapping networks on Mars: 1) low drainage density with large areas of undissected terrain; 2) exceedingly acute junction angles compared to those characteristic of terrestrial valleys formed by runoff processes; and 3) wide channels with abrupt theatre-like heads (5).

Experimental runs have also been made using zones of increased permeability to simulate conduits such as joints and/or faults. In these cases sapping channels developed along these structural trends and evolved headwardly along paths controlled by the structure. Similar structurally-controlled valleys are common along valleys marginal to Valles Marineris on Mars (5,8).

Preliminary experiments show that sapping is a competetive process involving capture of local groundwater by the channel having the most rapid rate of headward extension. Unlike surface runoff systems, when capture occurs, the down-gradient tributaries become inactive because their source of groundwater replenishment has been intercepted and diverted into the more headward tributaries. As a result, sapping tributaries are uncommonly short and stubby like those in Nirgal Vallis on Mars. Headward extension is most rapid during early phases of channel evolution, followed by increased bifurcation in later phases.

Comparisons are currently being made using the same sediments and facilities of valley networks formed by surface runoff processes for comparisons on the same scale as the groundwater experiments. Additional experiments for the purposes of documenting valley morphology and observation of processes include: 1) release of water from confined aquifers; 2) additional structural and stratigraphic complexities; 3) cementation of sediments with salts to simulate bedrock; and 4) sapping and ground-ice interactions in frozen sediments.

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Aerial photographs and maps of channels dissecting the Hawaiian volcanoes on Hawaii and Maui are also being studied to compare morphometries of neighboring valleys which appear to have formed by sapping with those where runoff processes appear to have dominated. Multivariate analyses of morphometric indices indicate that valleys of probable sapping origin are morphometrically distinct from runoff valleys (9). Work is continuing toward building a suite of morphometric characteristics indicative of sapping that would be recognizable on the scale of Viking imagery of Mars.

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