SURFACE DRAINAGE ON MARS. W. B. Banerdt[1] and A. Vidal[2], [1]Jet Propulsion Laboratory (M.S. 183-501, 4800 Oak Grove Dr., Pasadena, CA 91109, bruce.banerdt@jpl.nasa.gov), [2]California State University, Northridge.

Introduction: The role of water on the surface of Mars is a central question bearing on investigations crossing a wide range of disciplines, including geomorphology, geochemistry, and biology. A basic component of this history involves the patterns of transport and accumulation of water on the surface. Although it is not possible to confidently reconstruct the surface of Mars as it was during the Noachian (when liquid water may have existed in equilibrium at the surface), we can investigate the current potential hydrology. In other words, we can calculate what the behavior of water would be if it existed on the surface today. Several lines of evidence suggest that very little large-scale vertical distortion has occurred in the last several Gy [e.g., 1-3]. To the extent that the surface levels have remained unchanged, especially at the broadest scales, this exercise can illuminate the possible hydrologic patterns during the wetter eras of Martian history, and can be used to investigate the importance of wide-scale erosion by flowing water.

Method: We have calculated the potential flow patterns using high-precision MOLA topographic data. The aeroid-referenced grid used here has a resolution of 1/8 degree (about 7.4 km at the equator). At this grid spacing over 95% of the bins are populated with data; the remaining grid points are interpolated. The RMS of the crossover residuals for this data set is less than a few meters. The method used involves tracing a "stream" by following the maximum downhill gradient among nearest neighbors from each point on the grid until a closed depression is encountered. All points whose streams end at the same point constitute a "drainage basin". In this way 78,765 closed drainage basins are delineated on Mars today. The second step involves determining the overflow point for each basin (the lowest point on its rim). The elevation of this point determines the ”flooding level” of the basin, from which the depth, volume, and area of the "floodable basin" (defined by points within the closed contour at the elevation of the overflow point; on the Earth we would call this a lake) can be determined.

From this point the basins are allowed to coalesce in order of increasing volume (on the assumption that the smaller the amount of water the basin can hold, the more easily it would overflow), with new basin areas, overflow points and volumes calculated at each step. This process was stopped with eight remaining basins (Figure 1). The boundaries between these basins are comparable to continental divides on the Earth. Figure 2 shows what a very wet Mars might look like, with all basins filled to overflowing, similar to the situation over most of the Earth.

Results: The eight basins shown in Figure 1 correspond to major physiographic provinces: the Northern Plains and the four largest impact structures on Mars (Hellas, Utopia, Argyre, and Isidis), as well as three additional basins of comparable size that are not immediately obvious without a topographic analysis (Solis Planum, Sirenum Terra, and Cimmeria Terra). The three largest basins, the Northern Plains, Hellas, and Argyre, clearly dwarf the others (Utopia, with its small volume and low overflow elevation, is quickly absorbed by the Northern Plains). These three basins define the major planetary drainage divides. The area of the planet which drains into the Northern Plains is immense, comprising over 3/4 of the surface. However, any surface water south of about 45˚ (including, of course, the southern cap) will end up in either Hellas or Argyre. Although much smaller in area, Hellas volumetrically dominates the surface water budget (27 million km^3, compared to 14 million km^3 for the northern plains below Contact 2 of Parker et al. [4,5]). Its large volume to drainage area ratio implies that it would be an ultimate sink for surface water in its basin. Argyre, on the other hand, has a very small holding volume (2 million km^3) relative to its drainage area. Thus it could possibly be overfilled, spilling in turn into the Northern Plains [6].

Several attributes of the drainage patterns shown in Figure 2 indicate that Mars was not subjected to significant erosion by flowing water over any extended period of time since the end of heavy bombardment. First, there is little evidence for mature tributary patterns, which might be expected to survive as a subtle topographic signature. And second, the high density of closed basins argues that erosional breaching and filling of basins, which is generally very efficient on the Earth, has been relatively unimportant in shaping the surface of Mars over the past several billion years.

References: [1] Head et al. (1999) Science **286**, 2134; [2] Williams and Phillips (1999) GSA Abs., A-133; [3] Banerdt and Golombek (2000) abs# 2038, LPSC XXXI; [4] Parker et al. (1989) Icarus 82, 111; [5] Parker et al. (1993) JGR 98, 11061; [6] Parker et al. (2000) abs# 2033 LPSC XXXI.

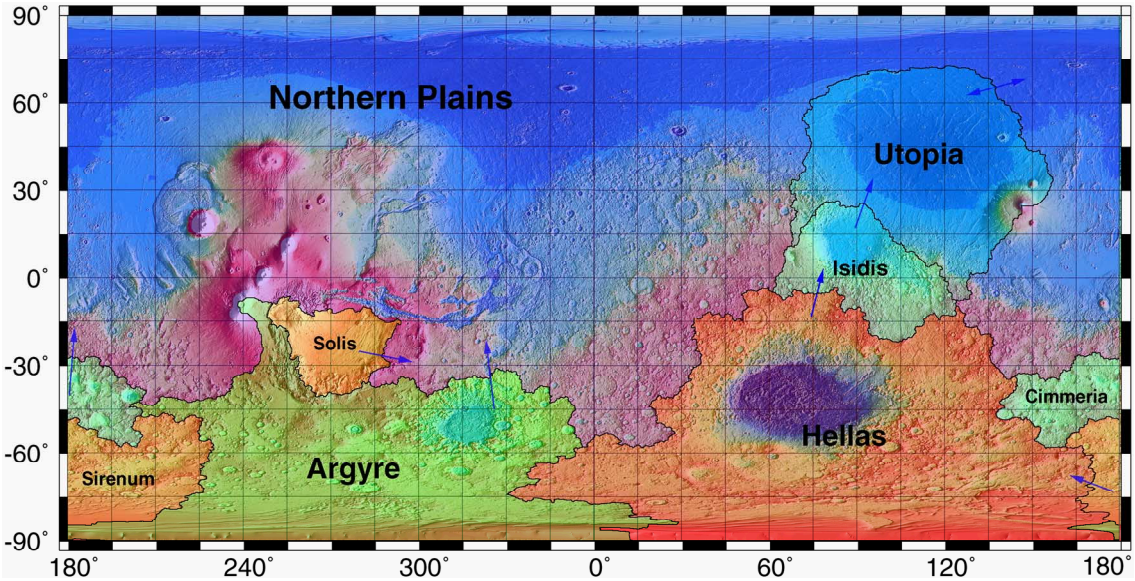

Figure 1. The eight largest closed drainage basins on Mars, calculated from the flow patterns induced by current topography, are plotted in color over a MOLA topographic map. Boundaries are equivalent to continental divides on the Earth. Blue arrows denote the overflow points for each basin.

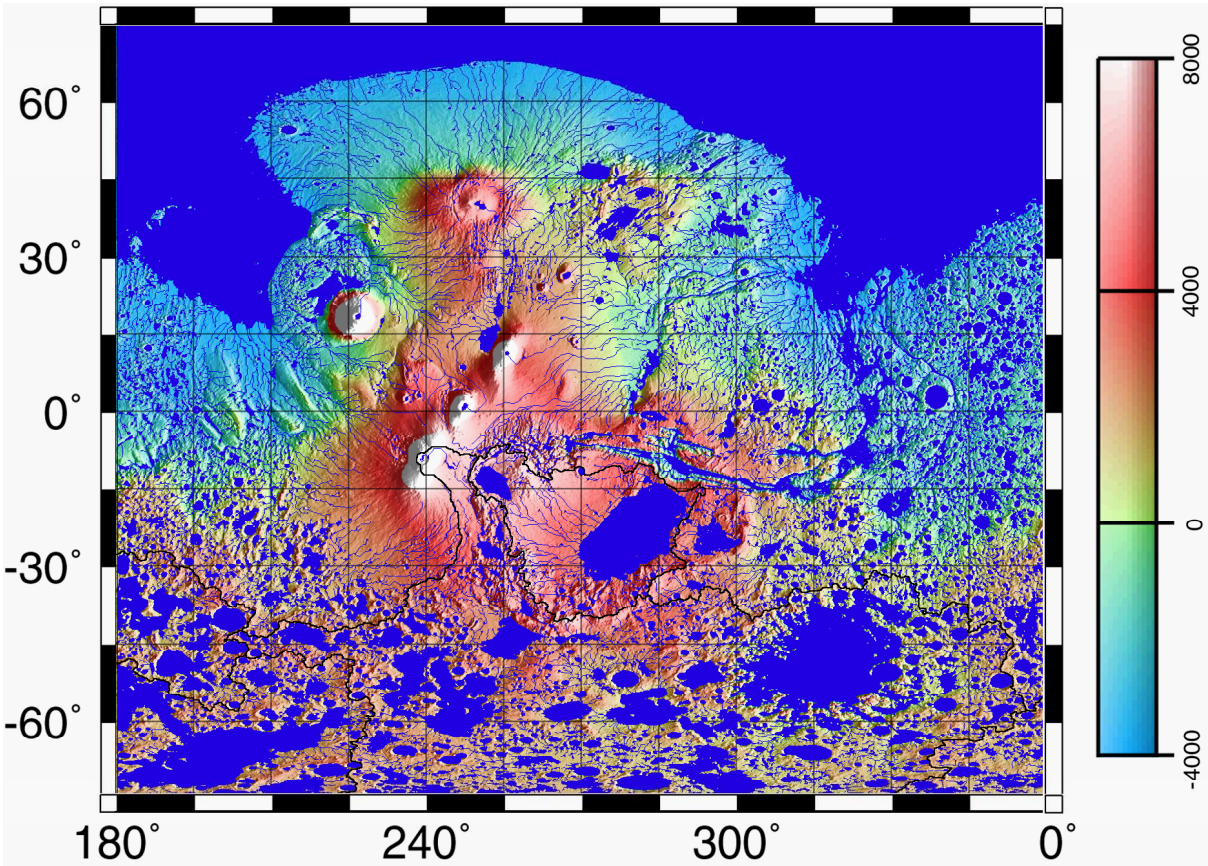

Figure 2. This figure shows what the western hemisphere of Mars would look like today with enough water to fill all closed depressions, overflow, and eventually reach the lowest possible elevation. The fill of each basin is determined by its overflow point except for the lowest one, the Northern Plains basin, which is arbitrary. For this figure a level of –3750 m was chosen, which corresponds to the elevation of the "contact 2" putative shoreline of Parker et al. [5-6]. Overflow stream traces are also shown.