amounts of water into the atmosphere that could precipitate out over decades to form the valleys. They estimate, for example, that formation of 600, 1000, and 2500 km craters would result, respectively, in global precipitation of 2, 9, and 16 m of water. Some possible difficulties with the model are (i) the modest amounts of precipitation that result from these very large impacts, which are few in number; (ii) all the Noachian craters with the above sizes are highly eroded and must be much older than the valley networks that we observe, particularly the more pristine ones; and (iii) the two best preserved impact basins, the 200 km diameter Lowell and the 220 km diameter Lyot, are only minimally dissected by valley networks. Thus, while the mineralogic and geomorphic evidence for warm conditions near the end of the Noachian are convincing, how such conditions were achieved remains obscure. This discrepancy is one of the most puzzling aspects of Mars' evolution.

2.5 Hesperian era

The Hesperian era was initially invoked to distinguish old post-Noachian plains such as Hesperia Planum and Lunae Planum from younger plains such as those in Tharsis and Amazonis (Scott and Carr 1978). It was subsequently defined more quantitatively according to the number of superimposed craters (Scott and Tanaka 1986). The crater densities suggest that the period extends from the end of heavy bombardment around 3.7 Gyr ago to around 3 Gyr ago (Hartmann and Neukum, 2001), roughly coinciding with the lower Archean on Earth. The main characteristics of the Hesperian era are continued possibly episodic volcanism to form extensive lava plains, low rates of valley formation compared with the Noachian, formation of the canyons, formation of the largest outflow channels and their terminal lakes or seas, extremely low rates of erosion, a steep decline and possibly cessation of rock alteration to form phyllosilicates, and accumulation locally of sulfate-rich deposits, particularly in the western hemisphere (Figure 2.5). The steep decline in rates of erosion, weathering, and valley formation strongly suggests that surface conditions favorable to aqueous erosion and

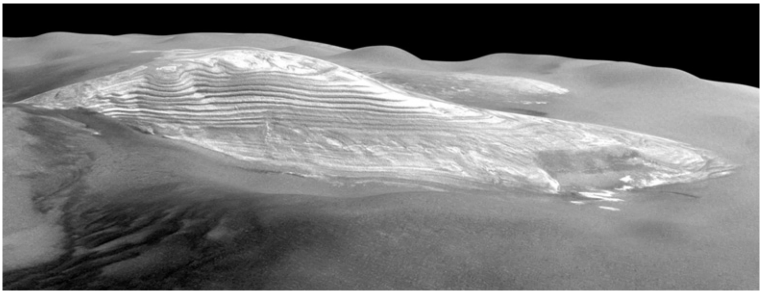

Figure 2.5 Sulfate-rich layered deposits — gypsum ($CaSO_4.2H_2O$) overlying Kieserite ($MgSO_4.H_2O$) — in Juventae Chasma at 3° S, 297° E. Their origin is controversial. Alternate suggestions are that they are remains of the materials into which the canyon is cut, or that they were deposited by water or wind on the canyon floor after the canyon formed (HRSC).