weathering, seemingly common in the Noachian, were rare in the Hesperian. Thus, while the main era of local lake formation that accompanied formation of the valley networks was over by the start of the Hesperian, the main era of flooding and consequent formation of very large bodies of water was in the Hesperian.

Hesperian volcanism is evident mainly in the form of ridged plains. In the western hemisphere Hesperian lava plains occur mainly around the eastern periphery of Tharsis. In the eastern hemisphere, they form Hesperia Planum, Syrtis Major Planum, Male Planum, and part of the floor of Hellas. Hesperian ridged plains, present in local lows throughout the cratered uplands of both hemispheres, may also have a significant volcanic component. Partly buried craters and subdued ridges in Vastitas Borealis suggest that the northern plains are underlain by Hesperian volcanics that are continuous with the volcanic ridged plains further south (Head et al., 2002) and Hesperian plains almost certainly underlie the younger Amazonian plains of central Tharsis and Elysium. The large Tharsis shields, including Olympus Mons, probably started to accumulate in the Hesperian, or even earlier despite the young ages of the present surfaces. Thus volcanism was widespread in the Hesperian, continuing at a rate of $\sim 1\ \mathrm{km}^3\ \mathrm{year}^{-1}$, comparable to the Noachian (Greeley and Schneid, 1991). It resulted in resurfacing roughly 30% of the planet, if we assume that in central Tharsis and Elysium Hesperian volcanics underlie the younger Amazonian (Tanaka et al., 1986).

### *2.5.1 Valleys and Channels*

The rate of formation of valley networks declined precipitously at the end of the Noachian. Despite the decline, there are examples of Hesperian, and even Amazonian valley networks, particularly on volcanoes (e.g., Alba Patera and Ceraunius Tholus). A rare example of a heavily dissected Hesperian plain is that adjacent to southern Echus Chasma (Mangold et al., 2004). Within the uplands are numerous examples of valleys cutting, or having deposited sediments, upon what appears to be Hesperian plains in local lows. Thus, although a change in conditions resulted in the dramatic drop-off in valley formation at the end of the Noachian, conditions were occasionally such that fluvial erosion to form small valleys was enabled, at least locally.

In contrast, most of the large outflow channels formed in the Hesperian, particularly the upper Hesperian (Tanaka et al., 2005). The most important question concerning outflow channels is whether or not they were carved by liquid water. Some outflow channels have features in common with lunar and venusian rilles, including abrupt beginnings, streamlined islands, inner channels, anastomosing reaches, and terraces (Leverington et al., 2004). Lava flows are clearly visible in some outflow channels (e.g., Marte Vallis, Athabasca Valles), and the source of some outflow channels (e.g., Cerberus Fosssae) are also sources of lava flows. Boulders, omnipresent in the low-lying northern plains at the ends of the large Chryse channels, suggest lava flows at the surface rather than fluvial sediments (McEwen et al., 2007). Despite these observations, a fluvial origin for most of the large outflow channels seems secure. The lunar and venusian rilles are only a few kilometers across as compared with tens of kilometer widths of Kasei, Ares, Mangala, and others. Most of the rilles are simple in form and lack the rich array of landforms that are common to both the