meters to tens of meters wide, hundreds of meters long, and are common on steep slopes in the 30–60 latitude belts, particularly in the south. They have a slight preference for pole-facing slopes, at least at midlatitudes (Balme et al., 2006; Bridges and Lackner, 2006). Their origin is controversial. Although initially attributed to groundwater seeps, this origin now seems unlikely given the probable thick cryosphere during most of the Amazonian and the common presence of gullies at locations where groundwater is unlikely, as on slopes around mesas and central peaks and at crater rim crests. Dry mass-wasting may contribute to their formation but this also seems to be an unlikely primary cause since many of the gullies cut through bedrock ledges. Erosion by wind or ice appears ruled out by their morphology, and erosion by liquid or gaseous CO_2 appears ruled out by stability relations (Stewart and Nimmo 2002). All the morphologic attributes are consistent with water erosion, and the broad consensus is that that is their cause.

In the southern highlands at midlatitudes, where most of the gullies occur, average daily summer temperatures are in the 220–230 K range and surface pressures are below the triple point of water. While small amounts of liquid water might temporarily exist today under such conditions, particularly in the presence of salts, accumulation of sufficient liquid to erode gullies is unlikely, and although newly formed light-toned slope streaks starting at gullies have been attributed to liquid water (Malin et al., 2006), spectral data and closer examination have failed to find evidence that the recent bright deposits were deposited by water (McEwen et al., 2007). They may simply be dust avalanches. A plausible possibility is that the gullies result from the temporary presence of water produced by the melting of snow and ice deposited at midlatitudes during periods of high obliquity (Christensen, 2003; Costard et al., 2002; Lee et al., 2001). Such an origin is supported by modeling studies (Costard et al., 2002) and by observations of gullies emerging from beneath what appear to be ice deposits on steep slopes (Christensen, 2003). The age of the gullies cannot be accurately determined but they probably have been forming episodically, when obliquities were high throughout the 3-billion-year length of the Amazonian, and possibly longer (Schon et al., 2009). They appear fresh because of the extremely low erosion rates, but are unlikely to have been forming continuously since there is little evidence that they have caused significant backwearing of crater walls and filling of the craters despite the long times over which they probably have been forming. Thus, fluvial activity during the last 3 billion years of Mars' history has been minor and restricted mainly to rare groundwater eruptions, very rare valley network formation of unknown causes, and the gullying of steep slopes, probably from melting of ice during high obliquities.

2.6.4 Poles

The finely layered deposits at the poles provide the most complete record of geologically recent events on the planet. The deposits in the north form a mound roughly centered on the pole and reaching up to 3 km above the surrounding plains of Vastitas Borealis. Crater counts indicate that the average age of the surface is of the order of 10^5 years (Herkenhoff and Plaut, 2000). The deposits can be divided into two distinct units: (i) a basal, platey, low-albedo unit, up to 1 km thick, that rests directly on the