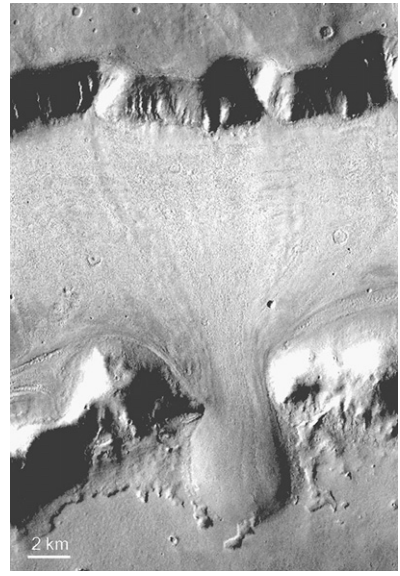

Figure 2.7 Ice-rich debris flow at 40° N, 25° E. Material shed from the cliff at the top of the image has flowed away from the cliff and through a gap in a barrier to the flow. Ground-penetrating radar indicates that the material is predominantly ice. Craters on the surface in various states of preservation suggest that the flow is tens to hundreds of millions of years old (THEMIS).

work that, if the debris flows are mixtures of rock and ice they must contain at least 28% ice. Lucchitta (1984) proposed that the ice was shed from the slopes at the head of the debris flows, which implies that the ground ice is pervasive in the 30°–55° latitude belts to depths of tens to hundreds of meters, consistent with flow of the near-surface materials to produce a general softening of the terrain (Squyres and Carr 1986). In contrast, Head et al. (2003, 2006) and Dickson et al. (2008) have emphasized the role of glaciation, suggesting that many of the features observed in these latitude belts could be the result of glaciation caused by precipitation of ice during periods of high obliquity (Figure 2.8). Counts of all craters, irrespective of preservation, indicate ages of several hundred million years, whereas counts of small fresh craters give ages of a few million years (Mangold et al., 2003). The counts indicate that the debris flows began forming at least several hundred million years ago and that the superimposed craters have been episodically or continually undergoing degradation by sublimation, shear, and other processes ever since. Degradation rates are such that small (<0.5 km) craters are preserved for millions of years.

Glaciers may have formed outside the 30°–55° latitude belts. On the northwest flanks of Olympus Mon and other large Tharsis volcanoes, several features, including lobate flows and fan-shaped formations with finely striated margins, strongly suggest that former glaciers modified the volcanic surfaces and left extensive moraines on the adjacent plains (Head and Marchant, 2003; Lucchitta, 1981; Shean et al., 2005). A glacial origin is supported by modeling studies of the atmosphere, which indicate that