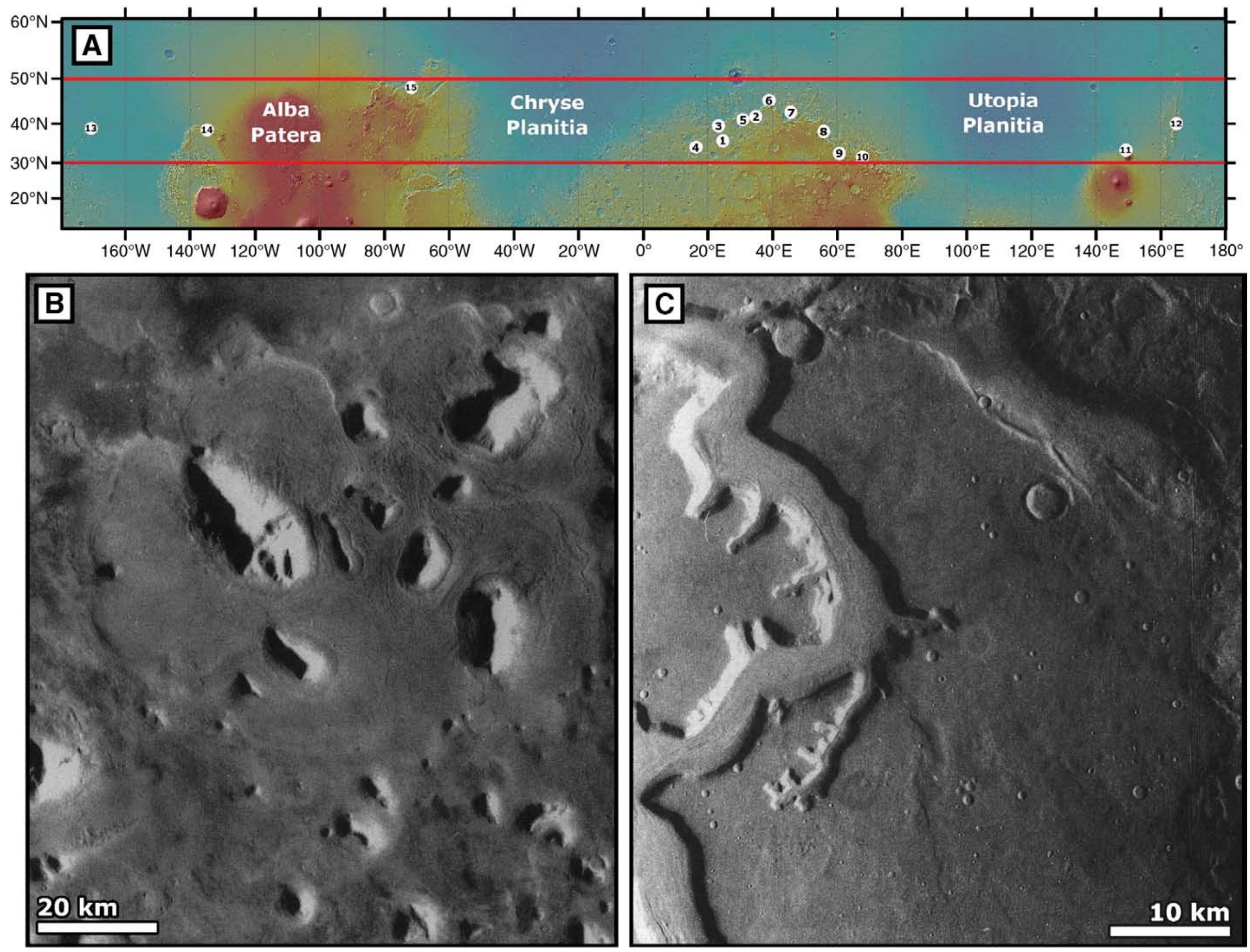

Fig. 1. A. Locations of areas discussed in this study showing lobate debris aprons (LDA) and lineated valley fill (LVF) and evidence of glaciation. Red lines show 30°–50° N latitude band in which they occur. Numbers refer to specific localities discussed in the text. B. Viking image of typical lobate debris aprons (Squyres, 1978, 1979) (46° N, 311° W; Viking Orbiter frame 338S31). C. Viking image of typical lineated valley fill (Squyres, 1978, 1979) (32° N, 341° W; Viking Orbiter frame 205S18).

surfaces, extend from massifs and escarpments outward to distance up to ~20 km. Squyres (1978, 1979) interpreted the aprons to have resulted from mass-wasted debris caused to flow by interstitial ice; he envisioned that during periods of climate change, atmospheric water vapor would diffuse into talus piles formed at the base of steep topography, and the resulting interstitial ice would cause mobilization and flow of the talus to produce lobes around isolated massifs. Longitudinal striae (ridges and grooves in surface debris) seen on the floors of the fretted valleys (LVF) were interpreted to be formed by ice-assisted debris aprons flowing from valley wall talus slopes and converging in the middle of the valley floor (Squyres, 1978, 1979). In the late 1970s a number of workers noted that some LVF in the Nilosyrtis region appeared consistent with down-valley flow (as reviewed by Baker (1982), p. 96–98). Following earlier ideas by Kochel and Baker (1981), Kochel and Peake (1984) provided detailed descriptions of geomorphological relationships and interpreted some debris aprons as formed by processes similar to those of terrestrial ice-cored or ice-cemented rock glaciers. Kochel and Peake (1984) further noted a transition from flow-parallel to flow-transverse ridge-and-furrow topography. Lucchitta (1984) interpreted the LDA and LVF as flow of debris with interstitial ice and showed evidence of local down-valley flow of LVF, likening some examples to flow patterns in glacial ice in Antarctica. Carr (1996; p. 116–120) urged caution in the general interpretation of a range of landforms as being due to glaciation (see Kargel and Strom, 1992; Kargel, 2004), on the basis of 1) the fact that the glacial hypotheses requires major climate change late in Mars history (e.g., Baker et al., 1991) for which he found little supporting evidence, and 2) that the low erosion rates in the Amazonian argues against any major climate excursions accompanied by precipitation, as envisioned by Baker (2001).

Pierce and Crown (2003) used new image and altimetry data to examine LDA in the Hellas region and found evidence for a wide range of possible ice content, interpreting the evidence to be consistent with multiple models of apron formation (e.g., rock glacier ice-assisted creep of talus, ice-rich landslides, debris-covered glaciers), with typical LDA resulting from flow of debris that was enriched in ground ice. Mangold (2003) presented evidence that ice content in LDA may exceed pore space, and Li et al. (2005) measured LDA MOLA profiles and compared these to simple plastic and viscous power law models for ice-rock mixtures; they concluded that LDA were ice-rich rock mixtures with some perhaps >40% ice by volume. Chuang and Crown (2005) documented the detailed character of sixty-five LDA in the Tempe Terra/Mareotis Fossae region and concluded that they consisted of mixtures of debris and ice, but that it was “difficult to constrain the internal distribution of ice or the method of debris apron initiation from the current datasets.” In summary, all workers agree