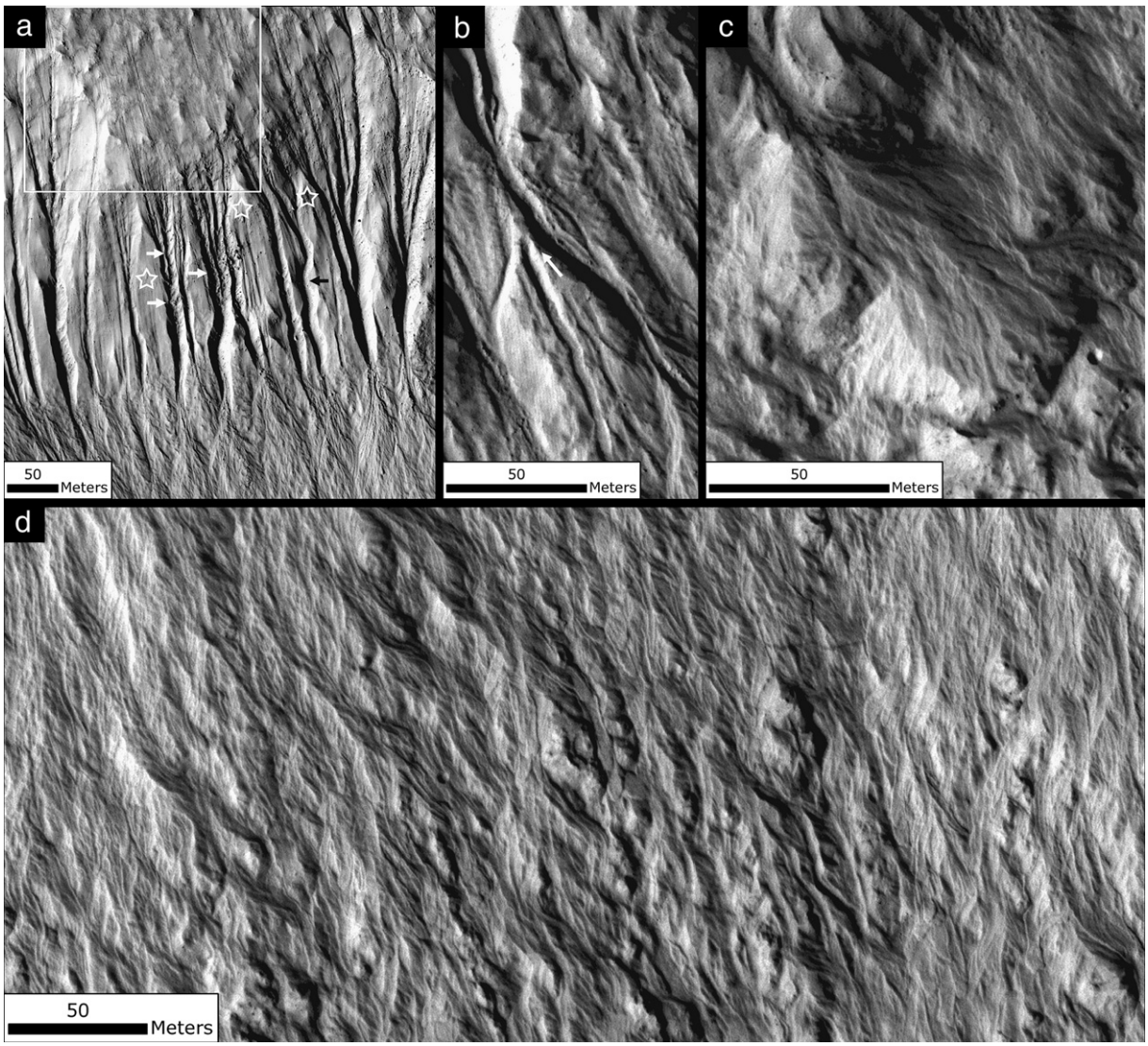

Fig. 5. The morphology of Protonilus Mensae study site gullies. a) Gully channels dissect latitude-dependent mantle related pasted-on terrain (thick exposures of pasted-on terrain are marked with stars). Channels reach their highest point as faint, narrow, and shallow furrows high on the mesa (shown in box). Some gully channels have periodic sinuosity on several meter length-scales (white arrows) while other channels are sinuous on tens of meter length scales (black arrow). b) Multiple cut-off, cross-cutting channels (arrow). c) Gully fan composed of multiple depositional surfaces. Note fresh crater to right. d) Detail of complexly fluted, sculpted, and channeled gully fan texture. Note transitions between fan texture and lobate fronts. All images excerpted from PSP_007148_2245, with north towards image top, down-slope towards image bottom, and illumination from the lower left.

present in the lobes, nor are detachment surfaces or crown-scarps typical of landslides (Johnson and Rodine, 1984) present upslope of the lobes.

The lobes have a complex stratigraphy. Some lobes are present in incised channels (Figs. 4 and 7); other lobes emanate from incised channels (Fig. 8). Lobes commonly overlap and multiple lobe fronts are present in some channels (Fig. 7). Lobes commonly have a stacked (lobes cross-cutting other lobes) or pulsed (variable widths in a continuous lobe) appearance (Fig. 7). Channels containing lobes, or from which lobes emanate, can be traced clearly to the foot of many gully fans, where they are lost in the complex fan texture. In some cases, lobe-filled channels can be traced onto fan surfaces. In rare cases channels containing lobes can be traced to gully fan apices and into gully channels (Fig. 8). Small lobes (<10 m wide, <25 m long) are present on some gully fan surfaces (Fig. 5d).

The lobes are superposed on two pre-existing units, 1) a mounded and pitted "brain terrain" patterned lobate debris apron (Head et al., 2003; Levy et al., 2009c) and 2) a polygonally-patterned mantle surface (Levy et al., 2009a). The lobes are diverted around topographic highs, and follow local slopes into depressions (Figs. 4 and 7). Lobe deposits commonly bank up on topographic features (e.g., "brain terrain" knobs) forming marginal deposits that remain topographically high and that may represent levees (Fig. 7a). Shadow measurements indicate that the distal lobes average ~1.5 m in thickness at their snouts (range: 0.6–2.8 m, $N=20$). Lobes average ~11 m in width (range: 4–50 m, $\sigma=6$ m, $N=100$) and ~50 m in length (range: 10–200 m, $\sigma=40$ m, $N=100$).

Lobes commonly have higher blue-green channel I/F values in HiRISE color data than the surrounding brain terrain and mantle textures, typical of gully channel deposits (McEwen et al., 2007) and unlike features interpreted as potential dry, granular flows (which are typically red-toned in HiRISE color data) (Kolb et al., 2008; Pelletier et al., 2008). Lobes are also observed on an adjacent mesa, but are not observed in HiRISE images surrounding the study site. Lobes cannot be clearly distinguished in HRSC or CTX images of the study site.

3. Slope relationships

We use high-resolution (100 m gridded) HRSC stereo topography to analyze slopes on which gullies and lobes are observed (Gwinner etal.,