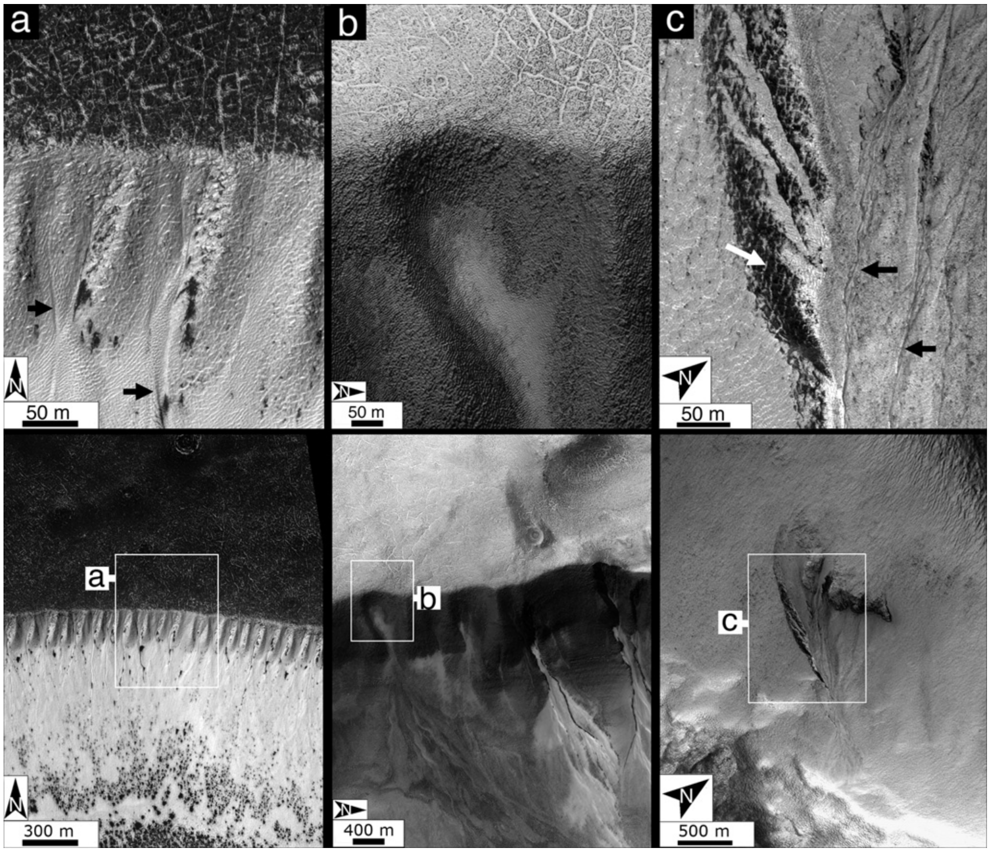

Fig. 7. Bright material present in polygon troughs (white arrow) in proximity to alcoves and channels (black arrows). Images were taken during winter/spring in all cases, suggesting bright material is frost, ice, or snow. Downslope is towards image bottom in all images. (a) Portion of PSP_003920_1095, located at 70° S, 2° E. Ls = 246.8°: southern spring. Illumination from left. (b) Portion of PSP_3511_1115, located at 69° S, 1° E. Ls = 226.7°: southern spring. Illumination from above. (c) Portion of PSP_002165_1270, located at 53° S, 28° E. Ls = 165.3°: southern winter. Illumination from left.

by gully flow (e.g., Lyons et al., 2005; Levy et al., 2008b), such as concentration of boulders at the surface (heaving), sorting of sediments through cryoturbation (which might be detectable as changes in surface brightness or texture), or the formation of ice-wedge polygons with upturned shoulders. These observations suggest that water involved in the transport and deposition of fan sediments rapidly froze-on to the ice-cement table within the fan and/or sublimated until local equilibrium conditions were met for water stability.

In summary, we interpret these overprinting and cross-cutting relationships to indicate the following formational sequence. Small-scale gully fans formed by deposition of sediments over previously existing polygonally-patterned ground (consistent with MOC observations, e.g., Malin and Edgett, 2000; Heldmann et al., 2007), and crack expansion continued throughout and after fan deposition, dissecting gully fans from beneath. This implies the continuous presence of ice-cemented permafrost beneath gully fans during their development and aggradation of permafrost concurrent with the growth of gully fans. Larger fans formed from the emplacement of sediment at a rate that resulted in the burial of previously extant polygon networks, resulting in polygon development limited to fine-scale networks that are discontinuous with the surrounding polygonal network.

4.4. *Slope orientation*

Although preliminary reports conflicted on the presence or absence of orientation preferences for gullies at the hemisphere scale (e.g., Malin and Edgett, 2000; Edgett et al., 2003), binning of gully orientations by latitude by Heldmann and Mellon (2004) discovered a latitude-dependence for the orientation of gullies in the southern hemisphere. Gullies between 30–44° S predominantly face polewards and gullies between 45–60° S generally face equatorwards (Heldmann and Mellon, 2004). This observation was verified in the Newton Crater region by Berman et al. (2005). Dickson et al. (2007a) further confirm these observations, finding that ∼86% of gullies in the 30–45° S latitude band occur on pole-facing slopes, and noting that the few gullies mapped on equator-facing slopes are confined to above ∼40° S. One interpretation of the orientation data is that gullies form on protected slopes where snow/ice, if available, would tend to accumulate (Hecht, 2002; Dickson et al., 2007a; Head and Marchant, 2008; Head et al., 2008), and where protected ice reservoirs could be rapidly exposed to peak insolation, leading to melting. Hecht (2002) demonstrated that peak insolation sufficient to cause melting can be achieved on either pole- or equator-facing slopes on Mars, depending on latitude and slope inclination.

In some HiRISE images gullies on polygonally-patterned surfaces can be observed on both pole-facing and equator-facing slopes (Fig. 11). “Pole-facing” and “equator-facing” are qualitative measurements of orientation, indicating that gully–polygon systems were present on slopes oriented within ∼30° of north or south. These occur most commonly on interior crater walls. Only HiRISE images in which gully–polygon systems are present on near-diametrically opposite slopes (> ∼150° angular separation) were included in orientation analyses.

The morphology of gullies and polygons on Mars differs with slope orientation (Fig. 11). Gullies on pole-facing slopes generally have sharply-defined channels and fans, and polygons on pole-facing slopes are crisply delineated. On equator-facing slopes (imaged at the same resolution) gullies and polygons have subdued