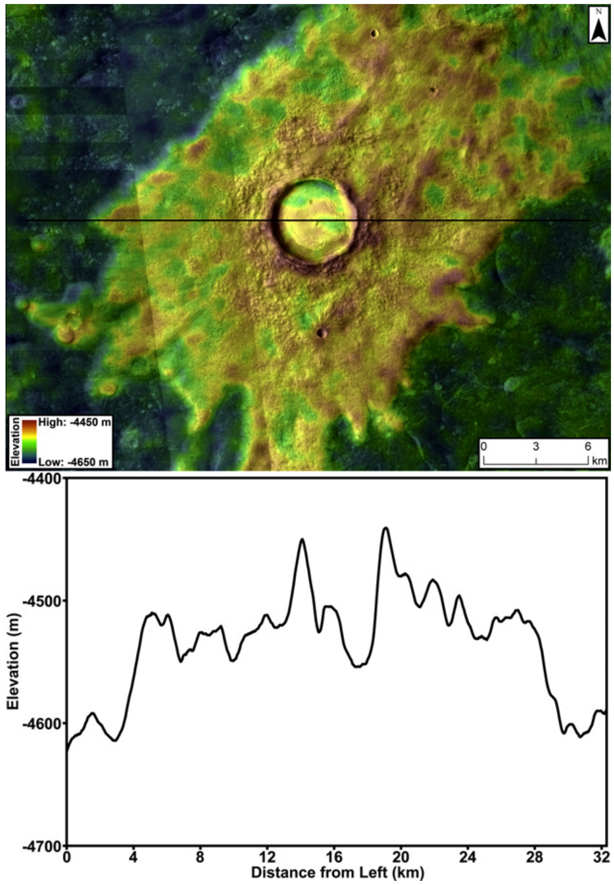

Fig. 4. A 4.8-km-diameter perched crater, shown as a CTX mosaic with HRSC HiRes DTM data. The black west–east trending line across the crater shows the path of the topographic profile, which has a vertical exaggeration of 73×. CCF has completely filled the crater interior, bringing the elevation of the crater basin level with the ejecta. The ejecta itself is DLE, with a rougher inner layer and a smoother outer layer that ends in a discontinuous rampart at its margin. Note that this ejecta is interacting with the ejecta of another crater to the northeast.

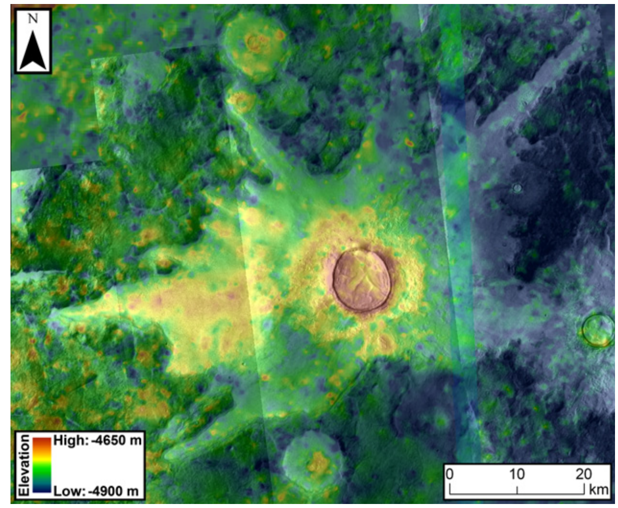

Fig. 5. A particularly interesting example of what could be classified as a heavily degraded 8.8-km-diameter perched crater, shown as a CTX mosaic with HRSC HiRes DTM data. The crater interior has undergone extensive infilling, and the fill material, which is heavily pitted, is now the highest part of the crater. Extensive sublimation/deflation of the ejecta is readily apparent, although both layers of the DLE can be identified, with slightly rougher texture on the inner layer. A moat-like pit, resembling scallops, extends around almost the entire margin of the outer ejecta, and is likely to be due to sublimation of the ice content of the ejecta. This sublimation and erosion is so advanced that, in some places where the plains have variable local topography, the ejecta is actually beneath the elevation of the plains. Other Pr/Pd are visible near the top and bottom of the image.

margins of the ejecta deposit usually slope gradually down to the elevation of the surrounding terrain, but do exhibit terminal ramparts in some cases. The material within the crater interiors is often concentric crater fill (Levy et al., 2010) (Figs. 3 and 4), but in some cases appears quite smooth with no evidence of cracks or flow. Additionally, the fill can be heavily pitted with depressions resembling scallops (Fig. 5), a feature interpreted to be due to sublimation (e.g. Lefort et al., 2009).

2.3. Pedestal craters

By definition, pedestal craters (Pd) are an impact morphology characterized by having the crater interior located near the center of a pedestal (mesa or plateau) that is surrounded by an outward-facing scarp (Barlow et al., 2000) (Figs. 6 and 7). The marginal scarp is generally located several crater diameters from the rim crest, which implies that the pedestal surface has a radial extent (Kadish et al., 2009) that exceeds that of a typical ejecta deposit (Barlow et al., 2000; Melosh, 1989). Some marginal scarps are marked by pits that represent loss of material from the pedestal; pit formation has been attributed to sublimation of the icy substrate below the protective veneer (Kadish et al., 2008) (Fig. 7).

Pd are generally small, with crater diameters less than 6 km (Fig. 6). The crater floors of mid-latitude Pd are usually but not always above the elevation of the surrounding terrain. In rare cases, the crater floor is above the elevation of the pedestal surface (Kadish et al., 2009) (Fig. 6A). Pedestals tend to be ∼20–110 m in height. Although evidence of ejecta is uncommon, the pedestal surface can sometimes be superposed by SLE, which never reaches the pedestal margins (Kadish et al., 2010). A global survey revealed that the highest Pd concentrations are in Utopia and Acidalia Planitia, and Malea Planum (Kadish et al., 2009). For a more detailed description of the physical attributes and geographic distribution of Pd, see Kadish et al. (2008, 2009, 2010, 2011).

3. Formation mechanisms

The fundamental commonality among these three crater types is the interpretation that each morphology is the result of an impact into ice-rich surface deposits (Black and Stewart, 2008; Kadish et al., 2009; Meresse et al., 2006) (Fig. 8). As discussed in detail by Kadish et al. (2009, 2010), these ice-rich deposits must be similar to, but thicker than, recent icy mantling units that have been repeatedly emplaced at mid latitudes during periods of higher obliquity in the last several million years (e.g. Head et al., 2003; Kreslavsky and Head, 2002; Mustard et al., 2001).

Climate model results (e.g. Levrard et al., 2004; Madeleine et al., 2009) show that the necessary thicker deposits can accumulate over geologically-short time periods given the proper orbital and atmospheric conditions. These include an equatorial source of ice, such as the Tharsis tropical mountain glaciers (e.g., Forget et al., 2006; Head and Marchant, 2003), a moderate obliquity (35°), and high dust opacity. Variations on these constraints do change the quantity and geographic distribution of ice deposited at mid latitudes. However, Madeleine et al. (2009) show that accumulation rates can readily exceed 10 mm/yr at the same locations in which we identify the highest populations of EE, Pr, and Pd. Furthermore, the predicted history of martian obliquity variations during the past tens to hundreds of Myr (Laskar et al., 2004) suggests that the ice-rich material that leads to the formation of these crater morphologies is likely to have been emplaced episodically. This scenario would lead to multiple generations of ice-rich layers