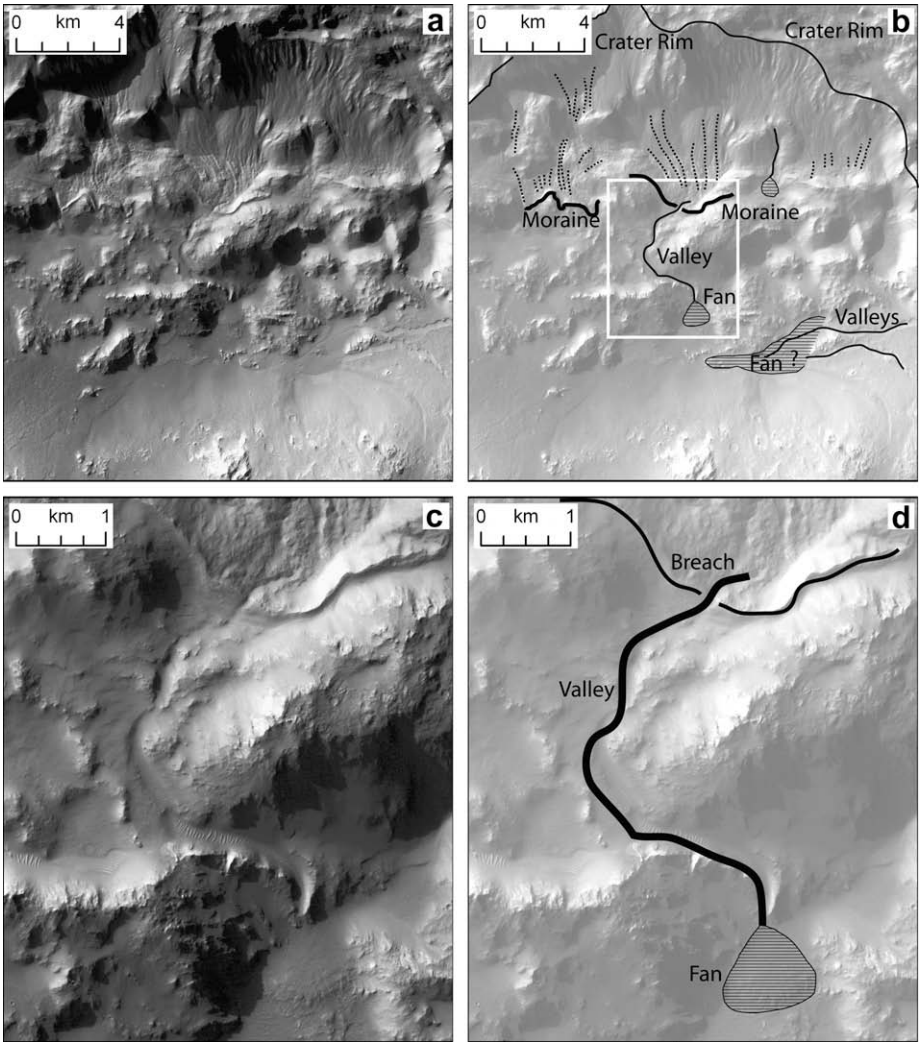

Fig. 5. (a and b) The interior northern wall of a ~75-km crater in the southern highlands (88°E, 27°S) where remains of a feature interpreted to be a debris-covered glacier are found, as well as a series of moraines, perched on material in the crater interior. CTX image P22_009797_1527. (c and d) A valley incises a portion of one moraine and continues downslope for ~6 km; at its terminus is a small sedimentary fan. There are other possible young valleys terminating in the crater center from the east.

either catastrophically, due to a flood triggered as a moraine-dammed lake overtops (e.g., Clague and Evans, 2000), or more gradually, as the moraine is eroded or undercut (e.g., Swanger et al., 2010). In this case, there are no signs of either a lake ever having existed or of a flood origin for the observed valley, suggesting that the second, more gradual scenario is likely. The valleys clearly incise the moraine as well as a part of the remnant glacial surface. These constraints require that the valley is associated with or post-dates the last period of major ice activity in the crater (interpreted as Amazonian). Moreover, the ejecta and secondary craters from the host crater are superposed on the Hesperian ridged plains, implying that the host itself is Hesperian-aged or younger. Thus, the best estimate for the age of valley formation in this crater is Amazonian, as the observed valley cannot be older than the Hesperian age for the crater itself.

2.1.4. Valleys in an ancient 45-km crater, 31.4°E, 31.7°S

At this locality, on the interior wall of a crater in the southern highlands, a series of small sinuous valleys are seen below small lobate-debris aprons (Fig. 6). The characteristics of these valleys are consistent with formation in direct association with glacial deposits. The valleys have nearly constant width (~500 m), high sinuosity, and headwaters just below the present margin of the deposits interpreted to be ice-related. Tributaries of the larger valleys are of particular interest at this location, as they coincide with the largest, furthest advanced lobes of material interpreted to be of glacial origin. Valleys descend approximately 600–750 m into the crater over lengths of 8–10 km, with average slopes of ~4°.

The constraints on the timing of these valleys are limited, since the host crater for these valleys is degraded and interpreted to be of Noachian age. However, the lobate features appear very fresh and similar in morphology and freshness to other Late Amazonian examples in this latitude range. In addition, the characteristics of these valleys are similar to others described in this paper that are found in association with lobate-debris aprons, and which are interpreted to be due to melting of ice, overland flow, and fluvial erosion. Thus, we hypothesize that these valleys are similar in age to the other examples we describe, despite the lack of direct constraints on the formation age for the observed valleys.

2.1.5. Valleys in 70-km crater, east of Hellas, 113°E, 39°S

The region east of Hellas is rich in ice-related landforms (Pierce and Crown, 2003; Head et al., 2005) and Forget et al. (2006) have proposed possible mechanisms for the region being an epicenter of accumulation related to ice mobilized from the south polar cap. Of particular interest are valleys found in association with