Landforms inferred to have formed as a result of glaciation on Mars are common in the martian mid-latitudes, including lobate debris aprons, lobate valley fill, and concentric crater fill. We have completed new mapping of the spatial extent of these landforms in the northern mid-latitudes (30-50°N). From these data, we have derived new constraints on the timing and persistence of glaciation.

During this mapping, many synglacial craters were recognized, meaning they formed after ice was already present on the surface, but subsequent deposition of ice occurred in their interiors following formation. The sizable number of these features is an indicator that the glacial period during the Amazonian was long-lived. From this, we estimate that glaciation occurred for at least 600 My in the northern mid-latitudes. Glaciation need not have occurred continuously across this entire period, and may have varied in intensity spatially and temporally.

Fewer post-glacial craters, stratigraphically superposed on the remnant ice, were apparent. From the number of these features, we estimate that the period of widespread ice accumulation ended relatively recently, ∼100 Ma.

Since accumulation of ice and its survival at the surface are presently not favored in these locations, these observations indicated that during the Middle to Late Amazonian, Mars was commonly in a different climate state than it is today.

Examples of Glacial Features

- **Lobate Debris Aprons**
- **Valley Fill**
- **Crater Fill**

Postglacial craters: We interpret these craters as (1) forming after ice was already present on the surface based on interactions of their ejecta with ice-rich deposits, and (2) experiencing no substantial later accumulation of ice in their interiors. This suggests they post-date the era when accumulation was favored.

Synglacial craters: We interpret these craters as (1) forming after ice was already present on the surface based on interactions of their ejecta with ice-rich deposits, and (2) experiencing later accumulation of ice in their interiors. This implies they formed at some point after ice deposition had already occurred, and continued to occur (a glacial period).

Map of the (A) western and (B) eastern hemisphere of Mars in the northern mid-latitudes, showing glacial deposits (yellow), with the location of post-glacial (cyan) and synglacial craters (green) (not to scale). Basemap is a hillshade of Mars Laser Orbit Altimeter data, map is in Mercator projection.