

Layered outcrops on Mars give insights into the planet's glacial history

Evan Blanc^a, Susan J. Conway^a, Frances E. G. Butcher^b, Axel Noblet^c, Anna Grau Galofre^a,

Affiliation in format: ^aLaboratoire de Planétologie et Géosciences, Nantes, France susan.conway@univ-nantes.fr; ^bDepartment of Geography, University of Sheffield, UK; ^cUniversity of Western Ontario, London, Canada

Mars is thought to have been a hyperarid desert for at least the last one billion years of its history. Water is locked up in the two polar ice caps, ground ice, and widespread debris covered glaciers in the mid-latitudes. Layers expressed by the polar caps are thought to record the most recent climate cycles of Mars – up to a few tens of Ma (Becerra et al., 2017). The debris covered glaciers are thought to be tens to hundreds of millions of years old, and potentially record a deeper climate record (e.g., Hepburn et al., 2019). Here, we report on the widespread occurrence of layered outcrops intimately associated with ice deposits in the mid-latitudes. For the first time we map the global extent of these deposits previously only reported in patches (Baker and Head, 2015; Carr, 2001; Morgenstern et al., 2007; Soare et al., 2013). We explore the relationship between these layered outcrops, debris covered glaciers and more recent ice deposits by exploiting images and elevation data from the High Resolution Science Imaging Experiment (HiRISE) at 25 cm/pixel (McEwen et al., 2007), Context camera (CTX) at 6 m/pixel (Malin et al., 2007) and Colour and Stereo Imaging System (CaSSIS) at 4.5 m/pixel (Thomas et al., 2017). We use topographic data from HiRISE stereo-images to study their detailed geometry. We find that these layered outcrops are extremely widespread in the martian mid-latitudes and have similar morphology in both the northern and the southern hemisphere pointing to a globally relevant process. We find these layered outcrops are conformal to topography and on low slopes. We hypothesise that they are patchy remnants of the basal layers of past ice (or ice-rich) deposits. On Earth, basal layers within glaciers can be relatively lithic-rich compared to the bulk composition of overlying ice (Shaw, 2008). The layered outcrops on Mars could comprise mixtures of lithics and ice, though the ice-lithic ratio remains uncertain. In Hellas Basin the layered outcrops are continuous with layers expressed in the hosting icy units, whereas elsewhere on Mars they are surrounded by younger icy deposits. We infer that in Hellas Basin we are seeing a snapshot of how these outcrops were formed elsewhere on Mars, but due to Hellas' unusual setting/climate, it is only here that the outcrops are preserved within their host ice. We hypothesise that these layered deposits inform us about the former extent of mid-latitude ice caps or ice sheets on Mars. Therefore, these layered outcrops could give information of Mars climate beyond that obtainable by studying the polar caps and other well-studied mid-latitude ice deposits.

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