

## ***Interactive comment on “Glacier-like forms on Mars” by B. Hubbard et al.***

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Received and published: 31 July 2014

Viscous flow features in Martian permafrost

Comments by Wilfried Haeberli and Sarah M. Springman

In their paper about “glacier-like forms on Mars”, Hubbard et al. (2014) describe landforms which, in their opinion, are “strikingly similar in planform appearance to terrestrial valley glaciers”. The well-organized surface structure of these flow features, however, has little in common with the mostly chaotic surface structure observed for debris-covered valley glaciers on Earth. Much more striking is the resemblance with landforms created by cumulative creep deformation of ice-debris mixtures in terrestrial permafrost, often called rock glaciers (cf., for instance, Figure 2 in Haeberli, 2013, and Arenson et al., 2007 or the remark by referee Kuhn). Concerning crevasses, Fig 6c in the paper by Hubbard et al. looks like features in creeping terrestrial permafrost

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described by Roer et al. (2008) or Buchli et al. (2014), and Figure 8c may represent common features of volume loss and subsidence, due to thawing of subsurface ice in terrestrial permafrost.

With average temperatures around  $-60^{\circ}\text{C}$ , permafrost exists at all latitudes on Mars and its thicknesses most likely range from 3.5 km at the equator to approximately 8 km in the polar regions (Anderson 1985). By definition therefore, the subsurface ice related to the flow features described by Hubbard et al. (2014) is part of Martian permafrost and its viscous flow is akin to permafrost creep on Earth.

There is considerable research into creep deformation of terrestrial permafrost and sophisticated technologies are being applied (cf., for instance, Springman et al., 2012). In 2006, an expert group of the International Permafrost Association (IPA) and the former International Commission on Snow and Ice (ICSI; today the International Association of Cryospheric Sciences IACS) had published a task force report on permafrost creep and rock glacier dynamics (Haeberli et al. 2006), which explicitly states that “the planetary science community has also become increasingly interested in diverse features visible on Mars that resemble rock glaciers or are suggestive of deformation of subsurface ice”.

Clarification of the surface temperatures on Mars, careful consideration of the corresponding subsurface thermal conditions and full use of the rich knowledge basis related to creep deformation of subsurface ice/debris mixtures in terrestrial permafrost may help to come closer to understanding the observed viscous flow features on Mars.

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