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The North Polar Layered Deposits on Mars: The Internal Layering of Gemina Lingula and Implications for Ice Flow

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The North Polar Layered Deposits (NPLD) is one of the largest reservoirs of surface water on Mars and, via an active exchange of water vapour with the atmosphere, it plays an important role in the Martian climate. The impact of ice flow on the overall shape of the NPLD is still widely debated. A study by Winebrenner et al. (2008) found evidence for relict flow lines in the southernmost part of the NPLD called Gemina Lingula (GL). Other studies have concluded that the upper part of the NPLD shows no evidence of flow (Fishbaugh and Hvidberg, 2006) and that surface mass balance alone can produce the topography (Greve et al., 2004 and Greve and Mahajan, 2005) .

This paper presents results from an analysis of radar data from the SHARAD (SHallow RADar) instrument on board NASA's Mars Reconnaissance Orbiter. The SHARAD instrument operates with a 20MHz centre frequency and a 10MHz bandwidth and one of its primary mission goals is to map the state and distribution of water on Mars. For more details on the SHARAD instrument please refer to Seu et al. (2007).

In the SHARAD data we identified and mapped six internal horizons from over 80 radar lines retrieved over GL. All horizons were easily identifiable in the majority of the data and were on average present in over 80% of the radar data considered. The observed layers were then compared to modelled layers from a 3D ice flow model. The model uses a smoothed surface topography, where troughs and scarps have been filled in, and assumes that the shape and the mass balance of the NPLD are constant in time. The shape of the internal layers are then calculated as they would appear in a flowing ice cap given those parameters. More information on the model can be found in Hindmarsh et al. (2009).

The overall fit between modelled and observed layers is reasonably good, but the goodness of the fit varies both between the different horizons and the different regions of GL. Horizons in the upper part of the ice fit less well than horizons in the lower part. The upper horizons also generally achieve a better fit in the western part of GL while the fit for the lower horizons has a less distinct geographical variation. These differences could indicate a time gap in the deposition of the layers and may be explained by the existence of an angular unconformity previously identified within GL (Holt and Safaeinili, 2009). It is possible that the lower layers experienced a significantly different history than the upper, and/or that the geometry of the upper layers is primarily the result of draping the unconformity surface which is an elongated dome.

Only taking into account individual layer geometry, our comparison between modelled and observed internal layering indicates that it is possible that ice flow has influenced the shape of NPLD. However, if this is the case GL must have extended farther to the southeast, or alternatively the accumulation pattern must have been significantly different to what is assumed in the model.

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