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Exploring the origin of ice-filled craters in the north polar region of Mars

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We investigate the origins of enigmatic ice-filled craters in the north polar region of Mars. We test several explanations for their origin, namely: (1) as polar cap remnants [1] (2) accumulation independently of the polar cap, and (3) upwelling of subsurface water, analogous to either aufice or pingo formation on Earth. Each of these hypotheses has a significant impact on our understanding of Mars' recent geological and climatic history and the behaviour of water and water ice at high latitudes.

We used several lines of evidence to assess the most likely formation mechanism. We first performed a crater survey based on THEMIS visual data and MOLA elevation data to identify any craters that had domal central mounds which were different from normal central peaks. From this survey we identified 17 craters for further study. These include Louth, Korolev, Dokka and other unnamed craters. Using data from orbiting spectrometers; OMEGA on ESA's Mars Express and CRISM on NASA's Mars Reconnaissance Orbiter; we verified that the composition of the exposed central domes was predominantly water ice.

We found the domes fell into three groups: (1) those completely covered by dunes, (2) those partially covered by dunes and (3) those with no dunes. We investigated the morphology and the relative position of the domes using MOLA elevation data. We found that the domes are always asymmetrically placed within the craters. However, this asymmetry could not easily be linked to wind directions as revealed by dune slip-faces [2]. The domes often have a moat-like structure and in some cases do not cover the entire crater floor, e.g.

Louth Crater. From image data, we identified six craters which possessed internal stratigraphy, in the form of regularly spaced layers, and of these we have inspected three in detail. We found that the layers possess both strong sinuosity and high angle unconformities.

We interpret the internal stratigraphy as representing a sequence of regular cyclic accumulations, which produced the layers, followed by asymmetric ablation and subsequent resumption of accumulation, to produce the unconformities. Hence, the present-day shape of the domes indicates that they are in a phase of ablation [3]. We attribute the colour contrasts between layers to different levels of dust, or particulate content. This could form a source for the dunes, which are often located on the summits of these domes. We find that this sequence is best explained by a model of atmospheric condensation. Our measurements of internal layer spacing and observations of layer stratigraphy argues that these deposits are not linked directly to a former, more extensive polar cap.

References: [1] Garvin J. B. et al. (2000) *Icarus*, 144, 329-352. [2] Tanaka K. L. and Hayward R. K. (2008) *Planetary Dunes Workshop*, no. 1403, p.69-70. [3] Russell P. S. et al. (2004) *Lunar Planet. Sci. Conf.* 35, no. 2007.