The Berlin Mars near Surface Thermal model (BMST) – Surveying the stability of ground water ice in selected areas on Mars. J. Helbert[1], J. Head[2], J. Benkhoff[1,3], and D. Marchant[4] [1]Institute for Planetary Research, German Aerospace Center DLR, (Rutherfordstr. 2, Berlin-Adlershof, Germany, joern.helbert@dlr.de); [2]Dept. of Geol. Sci., Brown Univ., Providence, RI 02912 USA; [3]Research and Scientific Support Department, ESTEC, (Keplerlaan1, 2201AZ Noordwijk ZH, The Netherlands); [4] Boston University, Dept. of Earth Sciences, Boston, MA 02215.

Introduction: Morphological studies of Mars show mounting evidence for the widespread existence of near surface ground ice deposits even at low latitudes. The unique images provided by the HRSC camera on Mars Express has provided us with a wealth of morphological detail on these deposits [1]. Some of them are found on the flanks of volcanic edifices. These include very young deposits, for example on the flanks of Hecates Tholus [2]. We have studied this deposit and found a high likelihood that it is still ice cored [3]. Building on our studies dedicated to selected sites on Mars we have started a systematic survey of potentially ice-rich deposits on Mars. In this survey we are focusing more on a general understanding of the link between morphological and physical properties to interpret ice-related landforms on Mars. Therefore, the survey covers typical examples of different landforms associated with ice-rich environments and deposits on Mars. For each of these we are performing parameter studies using the Berlin Mars near Surface Thermal model (BMST).

This modeling is accompanied by supporting laboratory studies on the detectability of hydration features especially in the mid infrared range as it is for example observed by PFS on Mars Express.

The BMST: Over the last five years we have developed the Berlin Mars near Surface Thermal model (BMST) that allows investigation of the detailed evolution of an ice-rich deposit. The main features of the BMST [3, 4] are 1) a high vertical resolution (down to the centimeter range), 2) a realistic treatment of the thermal properties of ice-rock mixtures, and 3) a detailed treatment of gas flux within the subsurface. The thermophysical parameters, such as thermal conductivity (Fig 1), and the porosity of the matrix for each layer are recalculated in every time step. All parameters, including water vapor transport, ice distribution (Fig 2) and changes in the porosity can be monitored. The model evaluates the diffusion based on the matrix properties (including porosity, pore size and tortuosity) and traces the actual movement of volatiles within the matrix. This dynamic approach allows us to study also the behavior of subsurface ice on a timescale where the soil has not yet reached thermodynamical equilibrium. This approach allows studying “young” ice-related deposits which might form in response to climate variations on short timescales as well as “old” persistent deposits. There are observational evidences showing at least two climatic cycles on Mars. There is a long term cycle on the order of 5-10 Ma as shown by evidence of glaciation in equatorial regions [5] and a medium term cycle in the order of 100-300 ka as shown for example by the layering in the polar caps [6].

Recent studies: We have performed over recent years several studies assessing the likelihood of the presence of localized ground-ice deposits on Mars. This includes studies for the planned Beagle 2 landing site in Isidis Planitia [7], showing that ground-ice deposits would not be expected within the reach of the MOLE instrument. We have also shown, using the BMST model, that a morphologically identified glacial deposit on the northwestern flanks of Hecates Tholus [2] very likely still contains a stagnant ice core. There are several units on Mars, especially on the flanks of volcanic edifices, which based on morphological evidence, may be glacial deposits and which possibly are still ice-cored [2, 5]. We are working on a more detailed analysis of the deposits on the flank of Arsia Mons, one of the Tharsis volcanoes [8].

Ongoing survey: For the currently ongoing survey we have selected five candidate ice-rich geological environments and deposits that are intimately linked to our understanding of the climatic evolution of Mars.

The candidate landing areas for the NASA Phoenix mission have been selected as a typical example for latitude-dependent mantling [9]. Apart from the morphological evidence, the observations by the neutron and gamma-ray spectrometers on Mars Odyssey [10] have shown that these deposits are very ice-rich below a thin desiccated mantle. The MARSIS radar on Mars Express has shown an extensive subsurface layering in this area. As a comparison, the Dorsa Argentea Formation [11] is part of the survey. For this southern circumpolar deposit, MARSIS has detected layering similar to the polar layered deposits [12].

Our survey includes several examples of candidate locations for young debris covered glaciers, similar to the ones we have already studied at Hecates Tholus. These include several structures on the western scarp of Olympus Mons [1, 13] as well as structure in the Thaumasia Region [14].

The Arsia Mons deposit is being studied in more detail as a typical example of tropical mountain glaciers and their sub-environments [15]. The Arsia Mons deposit exhibits three facies; ridged, knobby and smooth. These facies are related to the evolution of the deposit and may indicate different degrees of preservation of ground-ice deposits [16, 1].

Finally, the survey addresses the modification of the dichotomy boundary by glacial and periglacial processes. Typical examples of morphological structures associated with this modification are northern mid-latitude lineated valley fill and lobate debris aprons [17, 18].

We have defined examples for all regions of our survey and are currently working on modeling each of these areas. Existing modeling, as performed for Arsia Mons [8], Thaumasia [14] and Hecates Tholus [3] is being updated and integrated into the survey. Where necessary for this survey, the BMST is being updated, as recently done for surface-atmosphere interactions.

For some of the different areas our knowledge of the thermophysical parameters necessary for the modeling is very limited. To address this issue we perform parameter studies with the BMST. In these studies the parameters are varied within reasonable limits; some limits can be derived based on remote sensing data, as for example the thermal inertia from TES observations [18]. The range for other parameters as for example, subsurface structure or porosity, can only be defined by assumptions based on analog sites [e.g., 19, 20] or inferred from morphological studies.

Summary: The aim of this survey is to link morphological interpretations with physical modeling to study potentially ice-rich deposits on Mars. We will present the current status of our survey and preliminary conclusions concerning the persistence of ground ice deposits at mid-to-low latitudes on Mars, highlighting recent results [21-23].

Apart from advancing our understanding of the ice and water inventory of Mars and its evolution over the geological history of Mars, this work is aimed at supporting upcoming and proposed missions to Mars, for example ExoMars [24], MSL or ARES.

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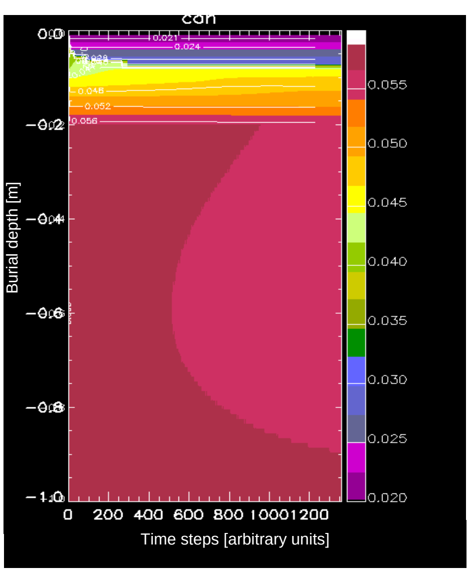

Figure 1 Example for the evolution of the thermal conductivity over time in a BMST run

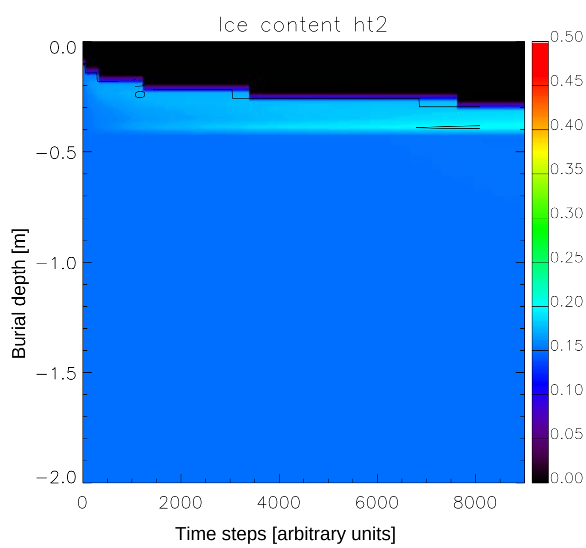

Figure 2 Formation of an ice lens structure in a model run for a "Hectates Tholus"-like deposit [3]