THERMAL INERTIA CHARACTERIZATION OF OLYMPIA UNDAE. T. N. Titus, United States Geological Survey, 2255 North Gemini Dr., Flagstaff, AZ 86004 (ttitus@usgs.gov)

Introduction: With the detection of a widespread water ice table in the Mars polar regions [1,2] and the impending landing of the Phoenix Polar Lander, it is important to understand the thermal inertia and hydration states of both the north polar ice table and the top layer of soil that covers the H$_2$O ice table (hereafter referred to as ice table).

The presence of hydrated minerals, most likely gypsum, has been identified within part of Olympia Undae by the Mars Express (MEX) near-infrared imaging spectrometer OMEGA [3]. The Mars Reconnaissance Orbiter (MRO) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) has also mapped gypsum, has been identified within part of Olympia Undae (referred to as ice table).

During the site-selection process for the Phoenix Polar Lander, several studies estimated the depth to the ice table at the proposed landing site to be ~1 to ~10 cm [5]. In one of these studies, Bandfield [6] used multiple Mars Odyssey Thermal Emission Imaging System (THEMIS) observations to estimate depths to the ice table at high spatial resolution (~100 m); this study found large variation of ice table depths at the 100 m scale.

Feldman et al. [7] have used both the Mars Odyssey Neutron Spectrometer (NS) and the Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) observations to further constrain the ice composition distribution of Olympia Undae.

In this study, we use MGS TES temperature observations immediately following the springtime disappearance of seasonal CO$_2$ to estimate the depth to the ice table and the thermal inertia of both the soil and ice table within the Olympia Undae and the region of Vastitas Borealis south of Olympia Undae. The methodology used in this study is similar to that used by Feldman et al. [7], except we include temperatures from both the day and night, as well as temperatures from the season immediately following the disappearance of CO$_2$ ice. Feldman et al. [7] excluded the temperatures from both the daytime and the earlier seasons to minimize systematic errors caused by variations in surface and atmospheric conditions, such as dust opacity and albedo. However, by including these additional observations, we can estimate the underlying ice table thermal inertia.

KRC Model and TES Data: We used the MGS TES thermal bolometer brightness temperatures and solar albedo observations to constrain the depth of the soil overburden covering the ice table. We use a thermal model originally written by Hugh Kieffer, KRC [8], to fit the rise in both the 2AM and 2PM brightness temperatures following sublimation of seasonal CO$_2$ frost. This approach has proven successful in detecting both the presence of exposed H$_2$O ice and estimating the overburden for buried H$_2$O ice [9].

Several thermal models are generated for a range of soil depth, soil thermal inertia, and ice table thermal inertia values. We then use a least-squares best-fit approach to match the brightness temperatures with the model that provides an estimate of both the depth and thermal inertia of the soil and the thermal inertia of the ice table.

Results: Estimates of the depth and composition of the soil and ice table derived from the diurnal and seasonal temperature trends are generally consistent with prior thermal and high-energy (neutrons and gamma rays) studies [10, 11, 12].

Thermal Edge of the Ice Table: Based on the results from the analysis of Phoenix Region B [12], the thermal edge of the ice table is approximately where the lower layer thermal inertia drops below 600 Jm$^{-2}$K$^{-1/2}$. Based on this criterion, the thermal edge of the ice table is ~67ºN latitude for the longitude range 140ºE-220ºE. Fig. 1c shows this effect for the longitude range 180ºE-220ºE.

Thermal Properties of Olympia Undae. The thermal inertia of the top layers of Olympia Undae appears to be similar to that of lower latitudes within Vastitas Borealis which is ~200 Jm$^{-2}$K$^{-1/2}$. The depth of this top layer is also similar to lower latitudes of Vastitas Borealis with a depth of ~5-7 mm. The difference between Olympia Undae at the lower latitudes (65N-70N) is the underlying layer, which has a thermal inertia consistent with ice. Near the same location that the NS observes a drop in Water Equivalent Hydrogen (WEH), the lower layer thermal inertia drops from ~1600 Jm$^{-2}$K$^{-1/2}$ to ~1100 Jm$^{-2}$K$^{-1/2}$, suggesting a significant drop in water ice content.

Future Work: The highest thermal inertia used for thermal models used in this study was ~1600 Jm$^{-2}$K$^{-1/2}$. Since pure CO$_2$ ice has a thermal inertia of ~2000 Jm$^{-2}$K$^{-1/2}$, additional analysis must be conducted using higher thermal inertia values for the ice table.

Figure 1: Results of Thermal Model Fits to 1°(Lat) x 2°(Lon) for the eastern part of Olympia Undae extending south into Vastitas Borealis. The maps are centered at longitude 200°E and extend from 180°E to 220°E, and from 65°N to 84°N. (A) Plot of top layer thermal inertia vs. latitude. (B) Regional distribution of the top layer thermal inertia. The majority of the top surface layer is between 150 Jm$^{-2}$K$^{-1}$s$^{-1/2}$ and 200 Jm$^{-2}$K$^{-1}$s$^{-1/2}$. (C) Plot of the bottom layer thermal inertia vs. latitude. (D) Regional distribution of the bottom layer thermal inertia. Red colors indicate a thermal inertia value ~ 1600 SI units. Because 1600 SI units was the highest thermal inertia used for the ice table, these thermal inertia values could actually be higher. (E) Plot of the thickness of the top layer (cm) vs. latitude. (F) Regional distribution of the top layer thickness.