Modeling the Surface Temperatures of Asteroid 16 Psyche. Carver J. Bierson[1], L. T. Elkins-Tanton[1], and J. G. O'Rourke[1], [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, 85287, (CBierson@asu.edu),

Introduction: The asteroid 16 Psyche is the target of the upcoming Psyche mission. 16 Psyche (hereafter called Psyche) is thought to have a metal rich bulk composition from its relatively high bulk density and surface properties [1].

Among these surface properties are two mutually exclusive thermal inertia measurements of 125 ± 50 J m^{-2} $s^{-1/2}$ K^{-1} [2] and 25 ± 10 J m^{-2} $s^{-1/2}$ K^{-1} [3]. This wide discrepancy leads to a large uncertainty in derived quantities like the thermal conductivity and skin depth. Accounting for a range of possible densities, these thermal inertia measurements imply a diurnal skin depth on the order of millimeters to centimeter and annual skin depths of tens of centimeters to a meter.

In this work we present a new thermal model targeted at characterizing Psyche's surface temperatures. This model will be used in the interpretation of surface temperature measurements in addition to making predictions for how thermal stresses may be expressed in the observations returned by the Psyche mission.

Model Description: We have developed a new thermal model to determine Psyche's surface temperatures. This model can use in an arbitrary shape allowing us to compare predictions based on published shapefiles [4-6]. The solar incidence at each point on the surface is calculated using the JPL SPICE package [7]. Surface temperatures are determined by accounting for the incident solar flux, black-body radiation, and near surface geothermal heat flux.

This model solves the vertical thermal diffusion equation using a 1D backwards Euler implicit solver. This allows the vertical grid to be significantly higher resolution in the near surface to efficiently resolve both diurnal and seasonal thermal cycles. Variable physical properties (caused by near surface porosity compaction) with depth can also be included. We assume no heat flux from below the model domain and no lateral heat transfer.

The initial results presented here use a surface albedo of 0.12 and thermal emissivity of 0.9. We assume the bulk density to be 3800 kg/m^3 and the specific heat is 500 J kg^{-1} K^{-1}. To match the estimated thermal inertia we use a thermal conductivity of 0.01 W m^{-1} K^{-1}.

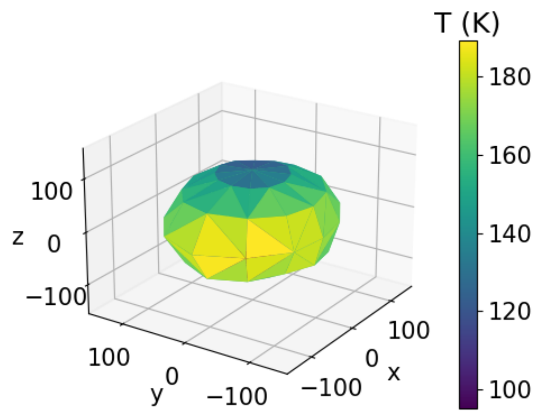

Figure 1: Example expected temperature distribution of Psyche near equinox.

Initial Results: Psyche's large obliquity (95 degrees) leads to extreme seasonal temperature swings. These swings are so large that the seasonal cycle must be included to accurately capture even equatorial surface temperatures. Initial runs suggest diurnal temperature variations in the equatorial region of more than 30 K and seasonal variations of up to 60 K

Future work: Going forward we will use this model to constrain the different surface conditions as a function of surface composition. This will include assessing thermal stresses (which play an important role on Bennu and Ryugu [8]). We will also be comparing our model results to ground based observations to better constrain Psyche's surface properties.

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References: [1] Elkins-Tanton, L. T. et al. (2020) *JGR:Planets* 125 [2] Matter, A. et al. (2013) *Icarus* 226 [3] Landsman, Z. A. et al. (2018) *Icarus* 304 [4] Shepard, M. K. et al. (2017) *Icarus* 281 [5] Viikinkoski, M. et al. (2018) *A&A* 613 [6] Drummond, J. D. et al. (2018) *Icarus* 305 [7] Acton, C. et al. (2017) *PSS* 150 [8] Molaro, J. L. et al. (2020) *JGR:Planets* 125