HIGH-RESOLUTION THERMOPHYSICAL MAPPING OF GLEN TORRIDON AND GALE CRATER, MARS. J. R. Christian[1], R. E. Arvidson[1], M. T. Mellon[2], A. R. Vasavada[3], and C. M. Weitz[4], [1]McDonnell Center for the Space Sciences, Dept. of Earth and Planetary Sciences, Washington University in St. Louis (jchristian@wustl.edu), [2]Cornell University, [3]Jet Propulsion Laboratory, California Institute of Technology, [4]Planetary Science Institute.

Introduction: Thermal inertia (TI), the square root of the product of heat capacity, density, and thermal conductivity, is a useful summary property for distinguishing surface materials from orbit. In dry conditions, the primary control on TI is thermal conductivity. As such, large variations in TI can be used primarily to distinguish unconsolidated sediment (low conductivity, so low TI) from bedrock (high conductivity, so high TI). Smaller TI variations can be used to distinguish different properties within those materials, such as grain size or degree of cementation.

Recent processing improvements [1] have established a method to estimate TI from hyperspectral measurements from the CRISM instrument on MRO [2]. This method involves DISORT-based radiative transport modeling [3], a neural network-based approach to separate the thermal and reflected solar components of the observed spectrum [4], and a thermal model incorporating atmospheric radiative transfer through atmospheric dust and aerosols to estimate TI based on temperature and albedo [5,6]. When applied to a CRISM along-track oversampled observation, this process results in a single-point TI retrieval at a resolution of 12 meters per pixel, substantially better than available from any other orbital data set. CRISM scene FRT00021C92 is used to derive TI estimates over the Glen Torridon region in Gale Crater (figure 1); as an oversampled scene, it can be reliably processed to high resolution. It was acquired at 14.78 LTST and at Ls=40.6, resulting in ground temperatures warm enough to produce a detectable thermal signature.

Here we compare thermal inertia estimates derived from CRISM data with those derived from the REMS GTS onboard Curiosity that employed the full diurnal curve [7]. A single-point method cannot simultaneously estimate TI and albedo from thermal data; therefore, we use DISORT to model Lambert albedo from the same CRISM scene and use it as an independent constraint on thermal models. Likewise, a single-point method cannot separate multi-material surfaces (like bedrock partially covered with sand); instead, a single material with the same temperature at 14.78 LTST is assumed, and the model estimates what we term apparent TI (ATI) of that material. In this abstract we correlate ATI variations with geomorphic features observed by the Curiosity rover, especially in sand fields where ATI variations indicate changes in the sand grain size distribution.

Bagnold Dunes: The Bagnold dunes (figure 2) are a low-albedo active aeolian dune field investigated by the Curiosity rover [8]. They are also the best place to compare quantitative ATI estimates between CRISM and GTS data sets, due to the spatial homogeneity of the deposits between the northern stop of Curiosity (with GTS analysis available) and the southern regions within the field of view of FRT00021C92.

From CRISM data, we estimate that the Bagnold dunes Mount Desert Island area has an ATI of 178 ± 9. ATI estimates derived from GTS have similar values, regardless of thermal model used [5,9]. When processed with the same model as used for CRISM data, the resulting ATI estimate is 180 [5]. When switching instead to the KRC thermal model [10], the ATI estimate from GTS is in the range 170-200 [9]. The consistency between these results indicates we can use CRISM data to estimate ATI reliably.

Sand Fields: There are two large sand fields with ATI estimates that can be derived from FRT00021C92: the Bagnold dunes (at the Mount Desert Island location) and the Sands of Forvie. Between these, the Bagnold dunes have a lower ATI at 178 ± 9, and the Sands of Forvie have a higher ATI of 229 ± 13. The Rigg field (a smaller sand deposit in Glen Torridon, figure 1) has similar ATI to the Sands of Forvie.

Curiosity images show a difference in grain size among these three sand deposits. The Bagnold dunes (figure 2) appear to be relatively finer grained compared to the Sands of Forvie (figure 3) and Rigg ripple fields (figure 4). This grain size difference also matches the ATI difference between the Bagnold dunes and the other two deposits; the lower ATI of the Bagnold dunes suggests they are composed of finer-grained sediment [11].

Bedrock Outcrops: ATI values much higher than those over sand fields map well to bedrock outcrops. The top of the Vera Rubin Ridge has an ATI of 385 ± 70, much higher than the average of the entire CRISM scene. As observed by Curiosity, this area is mostly bedrock with little sand cover, consistent with the higher ATI value (figure 5).

Further to the east is an exposure of the smooth fractured unit (SFU), interpreted as potentially a basal outcrop of the sulfate-bearing unit above Glen Torridon (figure 1) [12]. This exposure maps as significantly higher ATI than the rest of the scene, high enough that the center of the outcrop is too cold for a reliable detection. The edges of the outcrop are a bit warmer, suggesting the SFU has an ATI of 500+, so is likely solid or lightly weathered bedrock without a thick cover of sand or regolith. This is expected to be confirmed in the near future when Curiosity reaches that outcrop.

Discussion: CRISM observations stretching to 3.8 μm can yield higher resolution ATI estimates than available from other sources. These ATI estimates align well to those derived in situ, indicating that these estimates are reliable.

Variations in ATI between different units correspond well to geomorphologic differences among them. Large differences in ATI can tell apart bedrock exposures (Vera Rubin Ridge, SFU) from sand fields. Within the sand fields, ATI variations can be used as a tool to understand spatial variations in sand properties.

References: [1] Christian, J. et al., 2020, AGU abs. P069-0013. [2] Murchie, S. et al., 2007, *JGR Planets*, 10.1029/2006JE002682. [3] Stamnes, K. et al., 1988, *Appl. Opt.* 10.1364/AO.27.002502. [4] He, L. et al., 2019, LPSC abs. 2094. [5] Vasavada, A. et al., 2017, *Icarus*, 10.1016/j.icarus.2016.11.035. [6] Vasavada, A. et al., 2012, *Space Sci. Rev.*, 10.1007/s11214-012-9911-3. [7] Gómez-Elvira, J. et al., 2012, *Space Sci. Rev.*, 10.1007/s11214-012-9921-1. [8] Bridges, N. and B. Ehlmann, 2017, *JGR Planets*, 10.1002/2017JE005401. [9] Edwards, C. et al., 2018, *JGR Planets*, 10.1029/2017JE005501. [10] Kieffer, H., 2013, *JGR Planets*, 10.1029/2012JE004164. [11] Huetter, E. et al., 2008, *JGR Planets*, 10.1029/2008JE003085. [12] Hughes, M. and R. Arvidson, 2020, AGU abs. P069-0012.

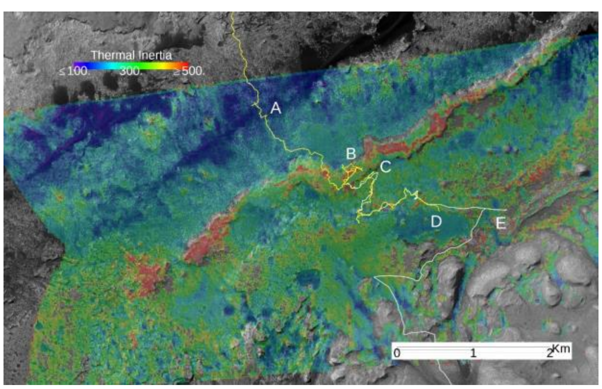

Figure 1 Estimated ATI for CRISM scene FRT00021C92 over Glen Torridon, showing Curiosity's recent traverse (yellow, through sol 2979) and strategic path (white, MSAR 10). Labeled features are A) Mount Desert Island (Bagnold dunes), B) Vera Rubin Ridge, C) Rigg ripple field, D) Sands of Forvie, E) smooth fractured unit outcrop.

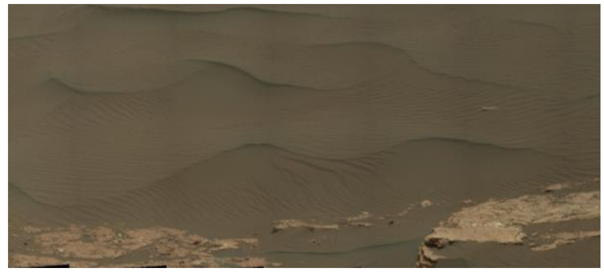

Figure 2 Mastcam mosaic from sol 1647 showing the Mount Desert Island feature within the Bagnold dunes (figure 1, point A). These dunes have some of the lowest ATI observed in the CRISM scene, indicative of the fine-grained sands.

Figure 3 Mastcam mosaic from sol 2979 showing the Sands of Forvie ripple field within Glen Torridon (figure 1, point D). These sands have a higher ATI than the Bagnold dunes, indicating that they consist of coarser-grained sediment.

Figure 4 Mastcam mosaic from sol 2412 showing the Rigg ripple field abutting the Vera Rubin Ridge within Glen Torridon (figure 1, point C). These sands have a similar TI to the Sands of Forvie (figure 3), indicating their grain size is closer to that of the Sands of Forvie than that of the Bagnold dunes.

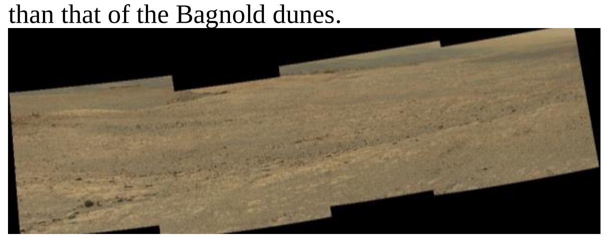

Figure 5 Mastcam mosaic from sol 1998 showing the upper surface of the Vera Rubin Ridge (figure 1, point B). This surface consists primarily of bedrock, matching the much higher TI observed here than within the rest of the CRISM scene.