THE MARS GLOBAL DIGITAL DUNE DATABASE: EXPLORING DUNE FIELD MINERAL COMPOSITION. H. R. Charles[1,2], T. N. Titus[1], R. K. Hayward[1], U.S.G.S Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ 86001, [2]Northern Arizona University, Flagstaff, AZ 86001.

Introduction: The Mars Global Digital Dune Database (MGD^3) is a comprehensive compilation of the properties of Martian dune fields. Key fields in the database include the locations, sizes, dune types, and approximate volume. The MGD^3 was released in three parts, based on location: equatorial (EQ), the north pole (NP), and south pole (SP))[1,2,3]. The next planned release will add mineral composition data for the larger dune fields in the equatorial and south polar regions.

While we are fortunate that Mars Science Laboratory (MSL) "Curiosity" Rover [4] was able to sample the informally named "Bagnold dunes," we must rely on satellite data to determine the composition of other dune fields on Mars. This next release incorporates thermal emission spectra in a user-friendly format to facilitate advances in Mars aeolian research.

Background: In order to better understand both surface and atmospheric processes on Mars, we need to understand how Martian dune fields are formed. For this it is important to determine the composition (mineralogy) of the sand. While dune field composition has often been treated as homogeneous in the past, it is not unreasonable to think that some, especially the largest dune fields, may have different mineral compositions in different regions due to aeolian sorting and different sediment sources. Recently, the composition of one of the large equatorial dune fields, Ogygis Undae, was analyzed, and there are indications that different mineral types may be present in different abundances across the field [5].

Collecting compositional information for as many dune fields as possible will aid in the advancement of Mars aeolian research. Within a single dune field, analyzing mineral components can be the first step in piecing together its formation and history.

Methods: The compositional data were taken from the Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES), available in the Java Mission-planning and Analysis for Remote Sensing (JMARS) from Arizona State University (ASU) [6,7]. The TES spectra were then separated into their surface and atmospheric components using the Davinci program, also designed by ASU [8]. A mineral library developed by D. Rogers and R. Fergason, which includes 44 mineral endmembers from 8 groups, was used to obtain a best fit for the composition of the dune fields [9]. The data used in this analysis were constrained to daytime, warm surface (above 250 K) and clear atmosphere (9-µm dust extinction below 0.2 and 11-µm ice extinction below 0.05) [5]. In this abstract, TES data within such constraints will be referred to as "high quality data."

There are a total of 1293 dune fields between the EQ and SP portions of the MGD^3, and the majority are smaller in size than a typical TES observation (the area covered by the 6-element TES detector array is ~9 km by ~6 km--to give some idea of the size of dune fields which can be analyzed using this method [6]). The composition portion divides all these dune fields into three data groups A, B and C. Data group A consists of dune fields which are covered by at least two high quality TES orbits which do not overlap. Data group B contains dune fields with only one such high quality orbit, and data group C contains the remainder of the dune fields with inadequate TES coverage.

The final release will contain the composition results, the location from which the data was taken, and other relevant information. There will also be a section containing nighttime thermal inertia data, which can potentially be correlated to grain size in sand [10].

Results: Data collection for the equatorial region is complete and some preliminary analysis of the largest of these dune fields has been performed. Using the data to examine some sample dune fields aids us in creating an efficient and user-friendly format for the future release. Fig. 1, below, shows the locations and average mineral abundances for some of these dune fields.

Ogygis Undae. Ogygis Undae is the sixth largest dune field on Mars outside the North Polar erg, and is located west of Argyre Planitia. Like many other Martian dune fields, Ogygis Undae is composed of basaltic sand. However, there appears to be an uneven distribution of mineral groups from west to east (see Fig. 1). Plagioclase feldspar in particular ranges from nearly 40% abundance to values below the detection limit [11]. Pyroxene also varies, with low-Ca endmembers dominating in the interior of the dune field and high-Ca endmembers becoming more prevalent near the eastern and western boundaries of the field. One possibility we have proposed for this variation is a bimodal distribution of two different basaltic sand populations, similar to a known bimodal terrestrial dune field at Grand Falls, AZ [12].

Regardless of the cause of this variation, dune fields such as Ogygis Undae demonstrate the need for more detailed analysis of the processes controlling aeolian structures on Mars.

Dune Field 2332-530. One of the dune fields chosen for preliminary analysis is identified in the MGD^3 as 2332-530. This dune field is somewhat smaller in area than Ogygis Undae and is located in Hussey crater. Compared to Ogygis Undae, this dune field is remarkably homogeneous. With a slight exception for the westernmost orbit, dune field 2332-530 is high in plagioclase feldspar (approximately 19-28%) and high-silica phases (approximately 18-28%). Pyroxene abundances for the dune field are similarly high across the dune field (21-29%), but the proportion of high to low-calcium pyroxene endmembers does vary. Olivine is lower in abundance (6-13%), although the amount is generally above the detection limit [11]. The presence of plagioclase feldspar, pyroxene and olivine indicates that 2332-530 can be summarized as a generally homogeneous basaltic dune field (Fig. 1)

Particle Sizes: Thermal inertia, also obtained by MGS TES, can potentially be related to particle sizes [13]. These data are included in the next MGD^3 release as well, since in some situations it may be valuable to compare effective particle sizes of sand populations with composition. In the case of Ogygis Undae, the slight variation in grain sizes, derived from nighttime thermal inertia data, could result in different velocity thresholds, creating a bimodal distribution [5]. Again, uneven sorting of sand populations occurs in some terrestrial dune fields, and may occur on Mars as well [12].

Conclusion: Ogygis Undae, the "Bagnold dunes" and a few others exemplify what can be learned when the composition of Martian dune fields are extensively studied. The upcoming expansion of the MGD^3 will allow analysis methods used on these dune fields to be applied to several hundred additional dune fields on Mars. In many individual terrestrial dune fields, we find unique qualities due to the sources and geological processes which formed them. A readily available dataset will help us to analyze the behaviors of individual dune fields, which we can then compare to one another. Use of this database in the coming years will aid with creating a better picture of aeolian activity on Mars.

References: [1] Hayward R. K. et al., (2007) *USGS OFR*, 2007-1158. [2] Hayward R. K. et al., (2010) *USGS OFR*, 2010-1170. [3] Hayward R. K. et al., (2012) *USGS OFR*, 2012-1259 [4] Grotzinger J. et al., (2012) *Space Sci. Rev., 170*, 5-56 [5] Charles H. R. et al., (2017) *EPSL, 458*, 152-160 [6] Christensen P. R. et al., (2001) *JGR, 106*(E10), 23823-23871 [7] Gorelick N. et al., (2003) *LPS XXXIV*, Abstract # 2057 [8] Edwards C. S. et al., (2015) *2nd Int. Planetary Data Workshop*, Abstract #7032 [9] Rogers A. D. and Fergason R., (2011) *JGR, 116*, E08005 [10] Cushing G. and Titus T. N., (2008) *JGR, 113*, E06006 [11] Bandfield J. L. et al., (2004) *JGR: Planets, 109*, E10 [12] Hayward R. K. et al., (2010) *2nd Int. Planetary Dunes Workshop,* Abstract # 2004 [13] Presley M. A. and Christensen P. R. (2010) *JGR, 115*, E07004 [14] Hill J. et al., (2014) *8th Int. Conf. on Mars*, Abstract # 1141 [15] Edwards C. S. et al., (2011) *JGR, 116*, E10008

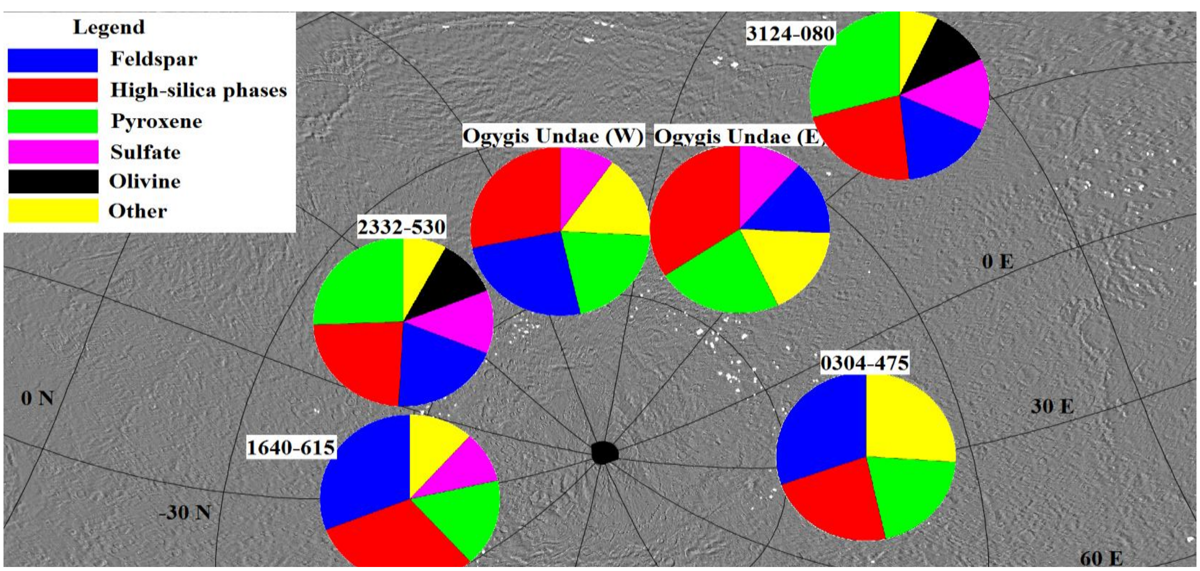

Figure 1: In this image, the most abundant mineral groups found in five dune fields from the equatorial region are shown. In the case of Ogygis Undae, the results for the western and eastern halves are shown separately due to the differences in mineral composition of each half. Some variation in the mineral groups has been noted in dune field 3124-080, but a more thorough statistical analysis is required. (Background image from THEMIS Day IR 100 m Global Mosaic version 12.0 [14,15])