MINERAL ABUNDANCE ESTIMATES AND DISTRIBUTION DERIVED FROM MARS DUNE FIELD #2938-497.

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Introduction: The surface of Mars is a dynamic and evolving environment where aeolian processes play an influential role. Dunes are one of the most common aeolian features on Mars. The processes which form dune fields are indicators of interactions between the atmosphere and the surface, and are related to both climatic and sedimentary mechanisms [1]. While less than the volume of terrestrial sand, the Mars Global Digital Dune Database (MGD^3) estimates the total volume of sand in dune fields included in the database between 65 and -65 N latitude to be from 3618.54 to 15169.16 km^3 [1]. As ubiquitous features found over many different types of topographical regions, understanding the mineral composition of dune fields is important to studying planetary processes [1].

Dune field composition is dependent on a number of factors, including the parent material mineralogy, grain size selection due to wind speed, and the different minerals' reaction and resistance to mechanical and chemical weathering [2]. These variables can potentially cause a non-uniform distribution of minerals within the dune field. Terrestrial analogs, such as the dunes in Grand Falls, AZ [3] exhibit visible segregration of minerals. It is known that Mars' crust is primarily mafic [e.g. 4] which weathers into basaltic sand. On Earth basaltic grains are considered compositionally immature as they are more susceptible to chemical weathering [5]. However, due to significantly slower chemical weathering on Mars than on Earth, basaltic minerals, such as olivine, are being considered as possible sediment maturity indices [5]. Refining our techniques for analyzing mineral composition and studying possible trends in the distribution of various minerals within a dune field will allow us to better understand the geological history of Mars.

Background: A previous study by Ahrens et al. [6] selected a dune field identified as 2938-497 in the MGD^3 [1], which is in Mars' southern hemisphere on the far western edge of Argyre Planitia. The mineral composition of the dune field was analyzed using thermal emissivity data from the Thermal Emissivity Spectrometer (TES) aboard the Mars Global Surveyor (MGS) [7]. This dune field was considered a good candidate for analysis because the available dataset contained multiple and overlapping orbital tracks. The proximity of the tracks to each other over two regions of the dune field allowed for the examination of trends in mineral abundances from west to east.

In the Ahrens study [6], it was noted that feldspar was either not present or had a non-uniform distribution across the dune field. The goal of this analysis was to determine the presence or absence of feldspar, examine its distribution if present, and identify any trends in other minerals present in the dune field.

Methods: For this study, we used the TES layer in the Java Mission-planning and Analysis for Remote Sensing (JMARS) [8] to obtain the emissivity data. The data was restricted to orbital tracks 1583 to 7000. The 1583 represents the beginning of the mapping phase for TES [7]. Above 7000, a noise anomaly of unknown origin (most likely related to spacecraft vibration) begins to appear [9]. Within this sampling of the TES dataset, eight orbits crossed the interior of dune field 2938-497. From west to east, these were orbits 3615, 5514, 4030, 5187, 3703, 5602, 5929, and 5275. Only TES observations within the boundaries of the dune field were selected from each orbital track.

We used the Davinci programming environment developed by Arizona State University (ASU) [10] to spectrally deconvolve the emissivity data. The spectral mixing analysis (SMA) function was first used to separate the atmospheric component (caused by airborne dust and aerosols) from the surface spectra. The SMA function was used a second time to determine the mineral abundances from the surface spectra alone. We used the spectral library developed by Deanne Rogers in a previous study of Mars sediments [11]. This is the same spectral library used in the Ahrens study [6], consisting of 44 minerals from 8 mineral groups (Table 1). Spectral deconvolution was conducted using two versons of the library, one that included the feldspar mineral group and one without.

Table 1: The mineral groups and spectral endmembers from the mineral library [11].

MINERAL GROUP	ENDMEMBER	MINERAL GROUP	ENDMEMBER
Feldspar	Microcline Albite Oligoclase Andesine Labradorite Bytownite Anorthite Shocked Anorthite (6 types)	**Sulfate**	Anhydrate Gypsum Kieserite
		Carbonate	Calcite Dolomite
		Olivine	Forsterite Fayalite KI (4 types)
High-Phase Silica	Illite Montmorillonite Saponite Na-Montmorillonite K-rich glass SiO_2 glass Opal A Aluminous Opal Heulandite Stilbite	**Quartz**	Quartz
		Hematite	Martian Hematite
		Pyroxene	Bronzite Enstatite Hypersthene Lindsley Pigeonite Diopside Augite (2 types Hedenbergite

Results: Of the eight mineral groups, only four (pyroxene, sulfate, feldspar, and silica) appeared in abundances of over 5%. The results for the other four (carbonate, hematite, quartz, and olivine) with one exception were below the detection limit [12].

Olivine has been identified as having a low minimum detection limit on Mars and can be detected at abundances of 5% and possibly lower, whereas most minerals have a minimum detection limit of 5-10% [12]. In half the orbital tracks removing feldspar increased olivine to as much as 7% mineral abundance.

Removing feldspar caused slight changes in the abundances for pyroxene, sulfate, and silica, but all variations were less than the estimated uncertainties. Carbonate, olivine, and hematite all saw increases when feldspar was excluded. Even with the increase, the carbonates and hematite remained under 5% abundance.

When graphed as a function of longitude, the trend in abundances for pyroxene and sulfate appeared to be loosely correlated (both with and without feldspar). There also appeared to be a correlation between the trends for feldspar and silica, which in turn were inversely related to pyroxene and sulfate [Figure 1].

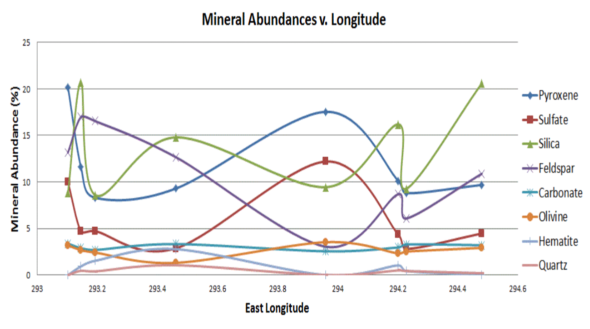

Figure 1: Mineral abundances for the eight mineral groups across the dune field. Figure 2 contains error bars for feldspar, which are representative of the error for the other seven.

Feldspar was examined in greater detail as the Ahrens study indicated that it might not be present. Figure 2 shows feldspar abundances graphed as a function of longitude. With error, feldspar could be uniform in the western half of the dune field, but in the east central section the abundance drops to a level arguably below the minimum detection limit [12] and below the error bars in the west. Further east, the abundance rises to just above the detection limit.

Conclusion: Feldspar abundances are above the minimum detection limit over most of the dune field but the abundance does drop below the detection limit in the east central portion of the dune field. Analyses in both the Ahrens study and this one show a significantly high variance in feldspar abundances between orbits. However removing feldspar from the spectral library worsens the variance, increases the RMS values, and increases abundances in minerals originally falling below minimum detection limits. Feldspar appears to be present and a non-uniform distribution may be causing the variance. Pyroxene, sulfate, and silica all appear to follow similar trends in abundance and may also be non-uniformly distributed.

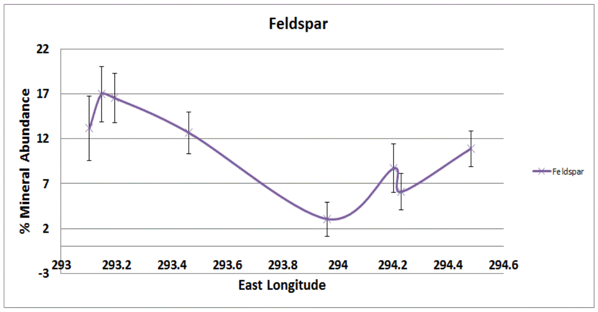

Figure 2: Feldspar abundances as a function of longitude.

Future Study: To better understand the nature of this dune field's composition THEMIS and CRISM data are being examined and will be discussed. The mineral composition results from these instruments will be compared to the TES mineral abundances.

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