MINI-TES MEASUREMENTS OF SANTA CATARINA-TYPE, STONY-IRON METEORITE CANDIDATES BY THE OPPORTUNITY ROVER.

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Introduction: After nearly 40 years of close-proximity reconnaissance, the precise role of water in the hydrogeologic and potential habitability history of Mars still remains one of the most enigmatic puzzles facing planetary science. Significant progress has been made, however, and general scientific opinion is now inclined to regard the earlier Noachian period of Mars' history as possessing the greatest potential for having been truly 'wet,' with a progression toward dryer climates during much of the Hesparian and Amazonian periods. The effects of water during these more recent periods is likely to have been subtle, requiring a sensitive indicator of its interaction with the martian surface to recognize.

Reduced meteoritic iron-nickel metal is likely the most sensitive material on the surface of Mars to aqueous alteration, oxidizing readily upon exposure to liquid water, and possibly even water vapor and ice. This sensitivity is well-known on Earth where meteorite weathering presents a problem for curators to control, and researchers to compensate for in their analyses.

Far from presenting a problem in the martian environment, however, this phenomenon can be applied to the assessment of more subtle aspects of martian climatic behavior where water may play a less major, but still significant, role. Thus a meteorite may, under the same set of conditions, provide evidence for water exposure where a martian basalt might not. At a time when phylosilicate occurrence is considered a site selection criterion for future ground missions because of its water implications, the occurrence of meteorites should be apportioned a similar weight in the "ground-truthing" of water exposure once successful landings are accomplished, particularly at mid- to high-lattitudes.

Background: Several meteorite candidates have been identified on Mars by the Mars Exploration Rover (MER) science teams at both rover locations [1]. The most recent of these, Santorini, is discussed elsewhere at this conference [2], with additional candidates discussed elsewhere still [3]. Four of the meteorite candidates have now been evaluated by the full suite of MER instruments (Alpha particle X-ray spectrometer (APXS), Mössbauer spectrometer (MB), and microscopic imager), including Barberton, Meridiani Planum, Santa Catarina (SC), and Santorini. Open questions remain for each of these relating to the degree of possible aqueous alteration they may have undergone to account for the presence of ferric iron oxides detected by Mössbauer spectroscopy [1,2]. That any such alteration might have occurred from water exposure in the near-equatorial latitudes of Mars (where such alteration is not necessarily anticipated) is a question of no small significance to our paleoclimatic understanding of the region.

As a remote sensing tool, the Mini-TES instrument has proven useful in identifying iron meteorite candidates at a distance on previous occasions at both MER sites [1]. SC was found among a large field of cobbles near the Cabo Anonimo promontory along the NNW rim of Victoria Crater during early reconnaissance of the Crater environs. Mini-TES measurements were collected for 11 cobbles in this area between sols 1046 and 1062 (including SC), and a 12[th] collected on sol 1190 during a second pass through the region *en route* to the Victoria Crater point of ingress (Figure 1). This abstract reports on Mini-TES results for these rocks.

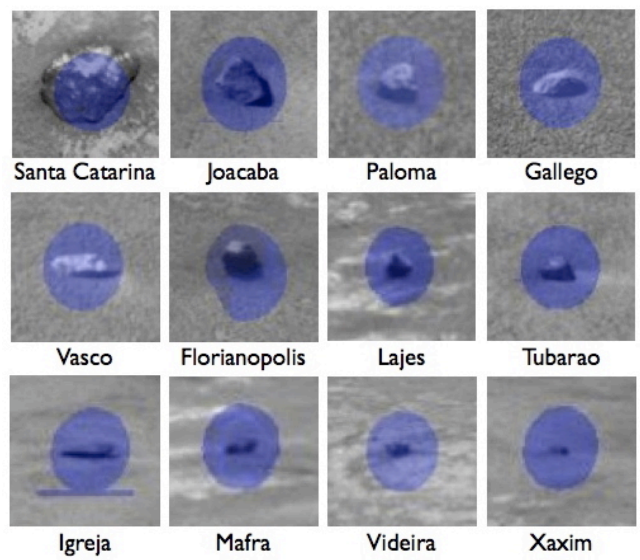

Figure 1. Navcam images of 12 cobbles within the Santa Catarina Cobble Field and their respective Mini-TES footprints (blue spots). Scales are variable; longest dimensions of largest rock do not exceed 20 cm. Image credit: NASA/JPL/Navcam/Mini-TES.

Methods: The Mini-TES instrument is a Fourier transform thermal emission infrared spectrometer with a spectral range of approximately 2000 to 340 wavenumber (cm^{-1}) (5 to 29 microns), and a spectral sampling of approximately 10 cm^{-1}. A full discussion of this instrument is provided by [4]. The spectral range between 400 and 1400 cm^{-1} is presented in this abstract, with an emphasis of the longer wavelength region where the absorption/emission effects of dust on optical surfaces are at a minimum [5].

Mini-TES Target	Sol Number	Sequence ID	Target T (K)	Delta T for target and background (K)	Target percent fraction of footprint
Santa Catarina	1055	p3852	265.22	3.17	71.30
Santa Catarina Background	1055	p3851	268.38		
Joacaba	1046	p3833	279.87	1.65	25.46
Joacaba Background	1046	p3834	278.23		
Paloma	1190	p3924	279.36	1.67	22.48
Paloma Background	1190	p3925	281.03		
Gallego	1062	p3857	281.20	3.83	20.74
Gallego Background	1062	p3858	285.02		
Vasco	1062	p3859	280.18	4.84	19.74
Vasco Background	1062	p3858	285.02		
Florianopolis	1047	p3840	276.32	1.73	14.84
Florianopolis Background	1047	p3839	278.05		
Lajes	1050	p3848	271.54	0.80	12.10
Lajes Background	1050	p3847	272.33		
Tubarao	1046	p3835	277.79	2.17	11.18
Tubarao Background	1046	p3836	275.62		
Igreja	1046	p3837	272.60	0.62	10.42
Igreja Background	1046	p3838	271.98		
Mafra	1051	p3850	271.17	1.86	10.23
Mafra Background	1051	p3849	273.02		
Videira	1053	p3843	269.97	2.64	6.58
Videira Background	1053	p3844	272.62		
Xaxim	1049	p3846	277.87	1.20	3.50
Xaxim Background	1049	p3845	276.66		

Table 1. Mini-TES rock targets in the Santa Catarina Cobble Field. Target percent footprint fractions were calculated by ratioing pixel counts for target image areas to those of the footprint. These help provide a sense for background radiance contributions to measurements.

In cases where target measurement footprints include portions of background surfaces, an additional background observation is often made for subtraction from the target-plus-background measurement. All targets in this rock suite include such measurements (Table 1), collected close in time to those of their respective rock target observations to minimize temperature differences.

Background spectra are typically dominated by hematite-rich patterns resulting from the hematite concretions characteristic of the Meridiani plains. Theoretically, subtraction of background spectra therefore results in a reduction of the hematite spectral features in favor of rock target features. Because the point spread function of the Mini-TES footprint is not distributed linearly across the spot area, however, this is not necessarily a straightforward subtraction process. Accordingly, background emissivity curves were subtracted from target-plus-background emissivity curves in 10 percent increments from 0 to 100 to monitor the evolution of spectral appearance. This procedure helped to guide the understanding of spectral features and determine their legitimacy.

Dust accumulations on Mini-TES optical surfaces interfere with target measurements, primarily within the ~800-1300 cm^{-1} spectral range [5]. These effects have been reduced in our analysis by applying the atmospheric model developed by [6]. Differences in surface temperature between the target and background measurements helps to cancel out the effects of the dust when the ΔT is less than ~5 degrees K, which is the case for each measurement pair in this analysis (refer to Table 1). Therefore, any inversion of spectra is likely the result of temperature contrasts in the scene and not from dust radiance contributions on the optical surfaces.

Results: With more than 70 percent of the Mini-TES footprint filled with the SC rock surface, the spectra for this target is the highest quality for the cobbles measured in the area. Subtraction of the SC background measurement effects the SC spectrum very little. As SC was also determined to be a meteorite candidate [1], we used this spectrum to continue the search for similar meteorite candidates among the cobbles in the suite.

In the longer wavelength (lower wavenumber) portion of the spectrum, we see a local maximum feature for SC in the approximate 420 to 500 wavenumber range that appears to be diagnostic of this rock type (Figure 2). This feature was used as a guide in discriminating between additional meteorite candidates and those unlikely to be mineralogically related to SC.

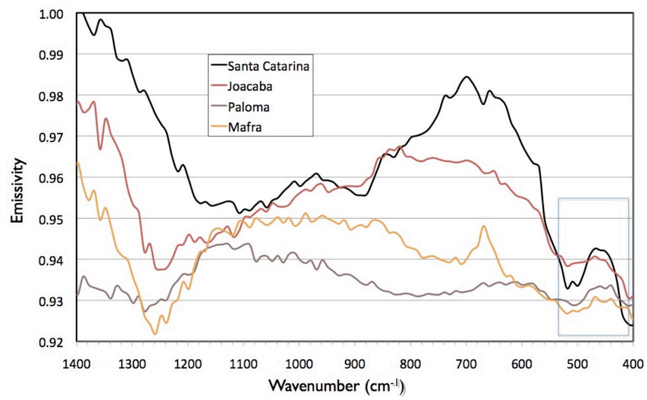

Figure 2. Local maxima features within the 420 to 500 wavenumber range (blue rectangle at lower right corner of figure) are accepted as diagnostic of Santa Catarina-type rocks, and are found with confidence in Joacaba, Paloma, and Mafra, with more ambiguous detections in Lajes, Tubarao, and Igreja (not shown).

Based on these criteria, we find Joacaba, Paloma, and Mafra to be likely Santa Catarina-type rocks, with somewhat less confidence for Lajes, Tubarao, and Igreja. Gallego, Vasco, and Florianopolis appear to be either different rock types or coated with thermally significant thicknesses of dust. The lighter tone visible in Navcam images appears to support this for Gallgo and Vasco (see Figure 1). The signal to noise ratio appears to be too low for target interpretation for Videria and Xaxim. These results are consistent with APXS and MS determinations on an emerging class of meteoritic rocks at Meridiani that may represent a strewn field, impact breccia fragments, members of a pre-atmospheric cluster or stream of meteoroid fragments, or perhaps something entirely new to science.

References: [1] Schröder C. et al. (2008) *JGR,* doi:10.1029/2007JE002990. [2] Schröder C. et al. (2009) this conference; Abstract #1165. [3] Nuding D. L. and Cohen B. A. (2009) this conference. [4] Christensen P. R. (2003) *JGR*, doi:10.1029/2003JE002117. [5] Ruff S. W. et al. (2006) *JGR,* doi:10.1029/2006JE002747. [6] Smith M. D. (2008) personnal communication.