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Spectroscopic results from the Life in the Atacama (LITA) project 2004 field season. J.L. Piatek[1], J.E. Moersch[1], M. Wyatt[2], M. Rampey[1], N. A. Cabrol[3,4], D. S. Wettergreen[5], R. Whittaker[5], E. A. Grin[3,4], G. Chong Diaz[6], C. Cockell[7], P. Coppin[8], J. M. Dohm[9], G. Fisher[10], A. N. Hock[11], L. Marinangeli[12], N. Minkley[10], G. G. Ori[12], A. Waggoner[10], K. Warren-Rhodes[3,4], S. Weinstein[10], D. Apostolopoulos[5], T. Smith[5], M. Wagner[5], K. Stubb[5], G. Thomas[13], and J. Glasgow[13]. [1]Dept. of Earth and Planetary Sciences, Univ. of Tennessee, Knoxville, TN; [2]Arizona State University; [3]NASA Ames SST.; [4]SETI Institute; [5]CMU Robotics Institute, Pittsburgh, PA; [6]Univ. Catolica del Norte. Chile; [7]British Antarctic Survey (BAS),UK; [8]Eventscope, CMU, Pittsburgh; [9]Univ. of Arizona. Tucson, AZ; [10]CMU MBIC, Pittsburgh; [11]UCLA, CA. [12]IRSPS, Pescara, Italy; [13]GROK Laboratory, Univ. of Iowa, IA

Introduction: The Life in the Atacama (LITA) project includes rover field tests designed to look for life in the arid environment of the Atacama Desert (Chile). Field instruments were chosen to help remote observers identify potential habitats and the presence of life in these habitats, and included two spectrometers for help in identifying the mineralogy of the field sites.

Two field trials were undertaken during the 2004 field season. The remote science team had no prior knowledge of the local geology, and relied entirely on orbital images and rover-acquired data to make interpretations. Each field trial lasted approximately one week: the sites for these trials were in different locations, and are designated “Site B” and “Site C.”

Instrumentation: The field instrumentation included two spectrometers: one VNIR spectrometer mounted on the rover, and one human operated TIR emission spectrometer. A second human-operated VNIR spectrometer was also available in case of difficulties with the rover-mounted version; this substitution was only used at a single locale during operations, however. The rover-mounted VNIR spectrometer observes reflected light in the wavelength region from 0.5 – 2.5 µm: this wavelength region is very useful for identifying chlorophyll spectroscopically. Although the spectrometer is mounted next to the imager, the exact pointing is unknown.

The TIR spectrometer measures emitted light, and the useful wavelength range covers 8-13 µm. This instrument is human-operated; however, the planning strategy required that the remote science team treat this instrument as if it were mounted on the rover.

Orbital Results: Visible/near-infrared (VNIR) data from the IKONOS (Site B only) and ASTER instruments were used to examine the photogeology of the field site, and in conjunction with elevation from ASTER DEMs to plan the daily traverse for the rover.

ASTER thermal infrared (TIR) data has 5 bands in the 8-12 µm wavelength region with a resolution of 90 m /pixel. These images were used to try and identify the regional mineralogy of each site. The data used were already processed to remove atmosphere and do a temperature-emissivity separation. The images were processed in ENVI to identify spectral endmembers in each image. These spectral endmembers were then compared to reference library spectra (deconvolved to ASTER bandpasses), and linear deconvolution used to identify potential mineral or rock components in each endmember. The resulting list of components was then used in a linear deconvolution of the entire ASTER image (along with a blackbody function). The result was an “endmember map,” which indicated graphically the percentage of each endmember throughout the image. At both sites, 3 major mineral/rock components were identified by this method: Site B endmembers were felsic volcanics, intermediate volcanics, and carbonates, while Site C endmembers were albite, talc, and quartz. Gypsum was present in a few areas at Site C, and was listed as a fourth “minor” endmember. The endmember map from Site C is shown in Figure 1. These endmember maps were created just prior to remote operations, and were used to identify areas of interest (based on mineralogy), and to guide rover traverse planning.

Rover Spectral Results: Both instruments used during remote ops proved useful in identifying the mineralogy of the surface: however, no chlorophyll detections were made during either field trial. The VNIR results were somewhat compromised by weather (when increasing humidity increased the atmospheric noise in the results), and by incomplete calibrations at some locales. In most locales at both field sites, the VNIR results appear to be clay mineral spectra (of various species): other VNIR results suggest sulfates or desert varnish.

The TIR results were analyzed using linear deconvolution, and are consistent with the clay results identified in the VNIR. In addition, the TIR results picked up quantities of sulfates, zeolites, iron oxides or sulfides, primary igneous minerals (pyroxenes and feldspars), and quartz. Weather was also a factor in TIR acquisition.

Discussion: Given the limited number of bands in the ASTER TIR data, it is important to examine if the pre-ops conclusions (made using the ASTER derived endmember maps) are consistent with the spectra acquired by the rover during the two field trials. It is not possible, because of resolution, to directly compare the results, but the general conclusions made from the rover results can be used to better interpret the ASTER results.

At Site B, the endmembers identified were intermediate volcanics, felsic volcanics, and carbonates. While no carbonates were detected by rover spectrometers, there were no significant concentrations of carbonates identified in the ASTER data along the traverse path, so this identification cannot be confirmed. In the case of the other endmembers, a number of spectra suggested the presence of feldspar and/or pyroxene at a particular locale, which is consistent with the intermediate volcanic endmember, although alteration minerals are present at all locales. It is possible that the felsic endmember is spectrally similar to clay minerals, and this endmember should be altered intermediate volcanics, rather than felsic volcanics. These endmembers are best revised as alteration productions (clays), altered intermediate volcanics, and carbonates (?).

At Site C (see endmember map in Figure 1), the major endmembers were talc, albite, and quartz: minor concentrations of gypsum were also observed in the ASTER TIR results. The remote science team specifically targeted an area of higher quartz concentration, and results from that locale confirm the presence of quartz. The talc endmember is potentially consistent with the zeolites, micas, and clay minerals identified spectrally throughout the field area. The albite endmember is common throughout the image, and is spectrally similar to gypsum and other sulfates, although with a lower band depth. Based on the field results, it appears that while the endmember spectrum is shaped most like albite, it is more likely that the spectrum represents particulate sulfates rather than feldspar. The endmembers at this site can be revised to clay minerals, quartz, and sulfates (particulate). The presence of quartz and sulfates at various locales are important detections for the identification of potential habitats.

Implications: Even though chlorophyll was not detected spectrally during the LITA 2004 field season, the spectral results are valuable for examining the local geology, and for pinpointing potential habitats where life may be present. The picture painted by the rover results and the supporting orbital images suggest that both sites consist of altered volcanic material, with more primary material present at Site B. These volcanics have weathered over time to various clay minerals, and sulfate minerals have been deposited by precipitation or evaporation. Improved targeting and instrument calibration should lead to more conclusive results in the next field season.

Figure 1: “Endmember map” for Site C, showing concentrations of endmembers: red – quartz; blue – clay, green – sulfate (particulate), as derived from ASTE RTIR result. The ‘landing ellipse’ and the rover traverse (beginning and ending at ‘LS’) are shown in black (the traverse begins with a short eastward leg).