

THE USE OF CHEMCAM ON MSL FOR SEDIMENTOLOGICAL AND STRATIGRAPHIC STUDIES

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Introduction: The investigation of sedimentology and stratigraphy will be a paramount objective of the Mars Science Laboratory (MSL). The ChemCam instrument, with the ability to remotely determine the elemental composition of rocks and soils, combined with high resolution imaging, will provide both tactical and scientific data for the rover.

Instrument Description: ChemCam uses a laser to ablate a thin layer of material to form a plasma. Emitted light is detected by 3 spectrographs, from which characteristic emission lines are read. This technique, known as laser-induced breakdown spectroscopy (LIBS), has been used in the laboratory [1-4], providing an extensive calibration library under terrestrial pressure or vacuum (such a library for Mars conditions is under construction by the ChemCam team), and was first proposed for planetary investigation in the early 1990s [5]. The laser spot size is ≤ 1 mm and range is 1.5-7 m, providing the ability to remotely determine the fine-scale elemental composition of rocks and soils with a precision of $\pm 10\%$. The same telescope optics for the laser are also used in a passive mode, with light fed to a CCD imager. This Remote Micro-Imager (RMI) has a pixel scale of 21-22 μrad , which translates to a resolution of ~ 100 μrad [6].

Science Objectives: ChemCam provides measurements applicable to 3 of the 4 MSL science themes 1) Organic geochemistry and biosignatures, 2) inorganic chemistry and mineralogy, and 3) geology. ChemCam investigations to support these objectives include rapid remote rock identification [7], soil and pebble surveys, detection of hydrated minerals, analysis of weathering rinds, remote identification of organic minerals, and geomorphology and rock texture studies.

Role and Operations on MSL: ChemCam plays both a tactical and scientific role on MSL. Over the course of the mission, $\sim 20,000$ LIBS analyses are anticipated, dictated by the expected laser lifetime. Mission planning exercises project 6-20 analyses per sol. ChemCam will be used to assess regions of interest, with the results fed into tactical planning of where to send the rover for in situ investigation by the analytical instruments (APXS, CheMin, and SAM). A standards library will be compared to the ChemCam LIBS results to provide rapid elemental abundance measurements and rock identification [7].

Sedimentological and Stratigraphic Studies:

Sedimentary rocks are one of the most important lithologies that MSL will visit, irrespective of what landing site is chosen. With its <1 -mm laser spot size, ChemCam will be able to map out the elemental abundance of individual stratigraphic beds at fine scale. Chemical changes related to grain size and texture can be determined. These measurements include those on steep scarps or rough terrain, that are inaccessible to MSL. Elements sensitive to redox state (e.g., S, Fe, and Mn) can be identified and minerals related to pH (e.g., jarosite, alunite, kaolinite, carbonates) can be inferred based on elemental abundance. Remote micro-imaging will provide information on texture and rock fabric, including aeolian, playa and fluvial-lacustrine textures that form in dry to sub-aqueous environments. LIBS will provide information on diagenetic components, including matrix cements, silica and carbonate and concretions, such as the “blueberries” at Meridiani. Organic carbon that may be present, especially in lacustrine clay deposits may also be detected. LIBS will be able to “clean” off dust and weathering rinds to measure the pristine composition of sedimentary layers. For example, simulations with the “Slow Motion Field Test” (a rehearsal of MSL science activities, with natural targets and blind identification by the instrument teams) show the ability of ChemCam to remotely identify mudstone, dolomite, and sulfate [8]. Similarly, multivariate analysis of LIBS spectra show that igneous standards and a variety of sedimentary rocks can be identified [4]. On Mars, ChemCam will provide detailed elemental abundance and imaging data of these and any other sedimentary rocks that MSL finds.

References: [1] Cremers, D.A. and L.J. Radziemski (1983), *Anal. Chem.*, 55, 1252-1256, [2] Cremers, D.A. and L.J. Radziemski (1987), in Radziemski, L.J. et al., *Laser Spectroscopy and Its Applications* Marcel Dekker. [3] Coche, M. et al. (1989), *Appl. Spectrosc.*, 43, 646-650 [4] Clegg, S.M. et al. (2008), *LPSC XXXIX*, 2107 [5] Blacic, J.D. et al., *Proc. Inst. Symp. Spectral Sens.* 302-312, [6] Maurice, S. et al. (2009), *Lunar Planet. Sci. XL*, 1864, [7] Sirven, J.B. et al. (2007), *J. Anal. At. Spectrom.*, 22, 1471-1480. [8] Wiens, R.C. et al. (2008), *Lunar Planet. Sci. XXXIX*, 1500.