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The SuperCam Instrument for the Mars2020 Rover

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1. Introduction

Micro-scale characterization of the mineralogy and elemental chemistry of the Martian surface, along with the search for organic materials, are fundamental investigations that lay the groundwork for all types of Mars geochemistry and astrobiology investigations. SuperCam, being developed for the Mars 2020 rover, is a suite of four co-aligned instruments that remotely provide these critical observations via Laser Induced Breakdown Spectroscopy (LIBS), Raman spectroscopy, time-resolved fluorescence (TRF), visible and near-infrared spectroscopy (VISIR), and high resolution color remote micro-imaging (RMI) (Fig. 1). The LIBS, VIS, and RMI capabilities rely heavily on heritage from the ChemCam instrument on MSL [e.g. 1]. Information on the LIBS, Raman, and TRF investigations and their implementation can be found in [2]. VISIR is described in [3] and RMI in [4].

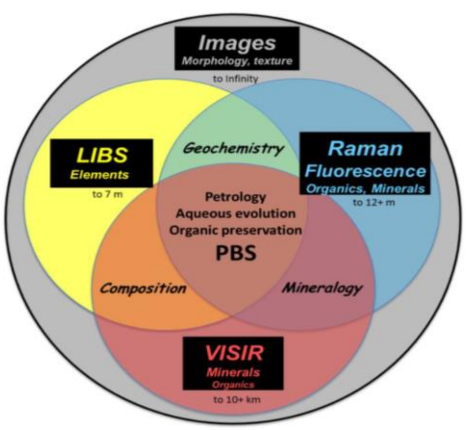

Fig. 1. SuperCam investigations contributing to the detection of Potential Biosignatures (PBS).

We focus here on the overall science objectives and their relationship with the mission goals, on the characteristic scale of each investigation, and on the implementation of observation modes to account for the versatility of the instrument.

2. Science objectives

The Science Definition Team (SDT [5]) defined four separate goals for the 2020 mission to assess whether life developed on Mars and to assemble a returnable cache of samples. Fig. 2 shows how SuperCam science objectives map with the mission goals.

1. *Rock Identification*: Mineral, chemical and textural characterization of rocks will help to determine the geological diversity, identify key processes relevant to the aqueous history, and document the context of the sample cache.

2. *Sedimentology and Stratigraphy*: Characterization of the texture and composition of the sedimentary structures will provide strong constraints for the aqueous processes as well as potential habitability.

3. *Organics and Bio-signatures*: SuperCam will remotely analyze astrobiologically relevant materials, determining the best area for contact science and caching.

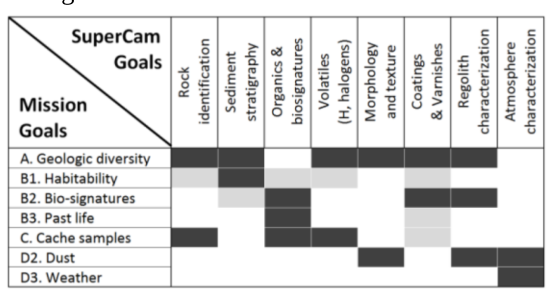

Fig. 2. Science goals and their relationship with mission objectives.

4. *Volatiles*: SuperCam will constrain the aqueous processes involving volatiles and provide data on volatile content for the documentation of cached material.

5. *Context Morphology and Texture*: High resolution color images will provide detailed information on dust cover, target morphology and texture.

6. *Coatings and Varnishes*: Analyses of coatings will allow the identification of late-stage weathering and its relationship (if any) to biological activity.

7. *Regolith Characterization*: SuperCam will address soil diversity and characterize its potential for biosignature preservation.
8. *Atmospheric Characterization*: Atmospheric molecules, water ice, and dust characteristics will address the radiative balance of the atmosphere, and will prepare for human exploration.

3. Remote Sensing and Sampling Scales.

SuperCam will make thousands of measurements at remote distances, within and beyond the arm workspace. Each co-boresighted investigation has its range of distances to target, from 2 m to 7 m for LIBS, up to 12 m for Raman and TRF, up to the horizon for VISIR and RMI, with different sampling scales. The LIBS analysis area is 300 – 600 µm in diameter. Single laser shots probe a few µm in depth, whereas hundreds of laser shots can probe up to ~500 µm in rocks. The Raman, TRF, and VISIR analysis footprints are similar, at 0.67 mrad (1.3 mm at 2 m distance). The imaging field of view is 20 mrad (pixel FOV of 20 µrad, i.e. 40 µm at 2 m).

The SDT recommended six threshold measurements including context 1) imaging and 2) mineralogy, fine-scale 3) imaging, 4) mineralogy, and 5) elemental chemistry, and 6) organic detection. SuperCam clearly meets the scale requirements (1, 2) of the context measurements, though SuperCam is not the primary context camera (Mastcam-Z fills this role). With “scan mode”, SuperCam can survey an area rapidly. SuperCam provides organic detection (6) on a broad survey scale using remote Raman, fluorescence, and VISIR spectroscopy. SuperCam also meets or approaches the SDT resolution criteria at close range (3, 4, 5). We expect arm-mounted instruments (PiXL, SHERLOC) to fulfil the fine-scale requirements.

4. Observation modes

To account for the diversity of situations, several modes of investigations are being defined (Fig. 3).

- *Survey raster*, a combination of single points to study lateral heterogeneity and chemostratigraphy. This involves the full suite of investigations within 7 m; Raman up to 12 m, and VISIR beyond.
- *Depth profile*, a unique capability of LIBS to probe the first 10 – 500 microns below the surface.

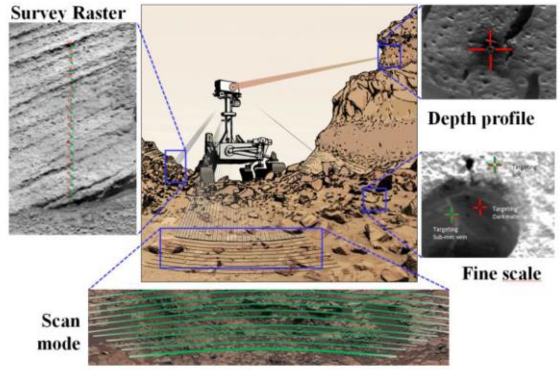

Fig. 3: Observation modes of SuperCam.

- *Scan mode*, 30° exploration in azimuth at close range (Raman + VISIR) and longer range (VISIR). While the mast is rotated at its slowest speed, Raman and/or VISIR spectra are acquired continuously.
- *Fine scale Mode*, targeted pointing at < 7 m for full chemistry and mineralogy investigations. Using JPL onboard software, AEGIS [6], laser shots can be auto-targeted at very small (e.g., mm or sub-mm) objects of interests (veins, nodules, laminae, etc.)

“Scan” and “raster” modes will be predominantly used when approaching a region-of-interest. “Fine scale” and “depth profile” modes will be used to select and document sample caching. A typical Sol on Mars might contain 11 LIBS, 8 Raman (including at least 1 time-resolved fluorescence), 16 VISIR points, and 10 images.

5. Management

SuperCam is a multi-national instrument. The US contribution is funded by NASA. R. Wiens at LANL is the instrument PI. The French contribution is funded by CNES. S. Maurice at IRAP is the deputy-PI. Spain under the leadership of F. Rull at UVA is responsible of the instrument calibration targets.
**Other collaborators of the SuperCam team are: V. Sautter, E. Lewin, E. Cloutis, F. Poulet, S. Bernard, T. McConnochie, N. Lanza, H. Newsom, A. Ollila, R. Leveille, J. Lasue, N. Melikechi, P-Y Meslin, A. Misra, O. Grasset, M.Angel, T. Fouchet, P. Beck,P. Sobron, N. Bridges, B. Bousquet, C. Fabre, P. Pinet, K. Benzarara, G. Montagnac.

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