COMMUNITY USER WORKSHOP ON PLANETARY LIBS (CHEMCAM) DATA

Introduction to LIBS

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Creating LIBS Sparks

Terrestrial

Mars

3”
LIBS Spots and Dust Removal

ChemCam Dust Removal

ChemCam laser marks

Brushed Surface

“Wernecke” Sol 169

NASA/JPL-Caltech/MSSS/Honeybee Robotics/LANL/CNES

NASA/JPL-Caltech/LANL/IRAP/CNES/LPGNantes/IAS/CNRS/MSSS
| Element | Li** | Be** | Na* | Mg* | K* | Ca* | Sc** | Ti* | V | Cr** | Mn** | Fe* | Co | Ni** | Cu** | Zn** | Ga | Ge | As** | Se | Br | Kr | Rb** | Sr** | Y | Zr | Nb | Mo | Ru | Rh | Pd | Ag | Cd** | In | Sn | Sb | Te | I | Xe | Cs | Ba** | La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb** | Bi | He | Ne | Al* | Si* | P** | S** | Cl** | Ar | H2 | 5-100 ppm | 100-1000 ppm | 0.1-3% | Difficult |
|---------|------|------|-----|-----|----|-----|------|-----|---|------|------|-----|---|------|------|------|---|----|------|----|----|----|------|-----|-----|----|----|----|-----|----|----|----|-----|----|-----|----|

Approximate detection limits at Mars atmospheric pressure

X* = Reported Oxides
X** = To be reported

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LIBS Sensitivities, ChemCam Configuration

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• Not every NIST emission line is observed in a LIBS spectrum.
  – [Link](http://physics.nist.gov/PhysRefData/ASD/lines_form.html)
  – Every LIBS line must be found in NIST
  – Typically observe neutral and first ionized atoms, perhaps second ionization under ChemCam conditions.

• Must be Spectrally well calibrated!
  – Know the difference between vacuum vs. air (Earth or Mars) calibration
  – Closest NIST emission line is not good enough

• More details provided in the next few presentations
Introduction to LIBS

Raw ChemCam Spectrum – Jake_1

Peak FWHM
~3 – 4 pixels
~1.5 nm
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Carefully Processed Spectra Lead to Quantitative Analysis
Continuum Removal, Spectral Calibration, Distance Correction are Critical

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ChemCam Spectra

Fully Processed Spectra Ready for Quantitative Analysis
Much can be Qualitatively Observed
Chemical Matrix Effects Complicate Quantitative Analysis

- Conventional Elemental Analysis
  - Peak Area or Height vs. Concentration
  - Each Peak is Analyzed Independently

- Sample Elemental and Molecular Composition Influences:
  - Laser-to-Sample Coupling Efficiency
  - Chemical Reactions within the Plasma
  - Collisional Quenching

- Chemical Matrix Effects
  - Increase Scatter and Uncertainty

- Chemical Matrix Effects Compensation
  - Cal-Free LIBS
  - Various Normalization

Multivariate analyses are used to compensate for these matrix effects
### Quantitative Calibration

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<th>3 m standoff distance</th>
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* = from Dyar lab, all others from commercial sources
Ca Electronic Energy Level Diagram

Emission lines are produced as atoms relax from upper state to lower state. Lower state is not always the ground state.