Probing crystalline and amorphous phases at Yellowknife Bay, Gale crater, Mars: comparison of ChemCam LIBS data with CheMin XRD results

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Introduction

- The Mars Science Laboratory (MSL) rover Curiosity carries a unique suite of scientific instruments capable of characterizing both the chemistry and mineralogy of soils and rocks encountered at Gale crater. This suite includes:
  - the ChemCam LIBS instrument [1,2]
  - the Alpha-Particle X-ray Spectrometer (APXS) [3]
  - the CheMin X-ray diffractometer (XRD) [4]

- In this study, we compare chemical trends observed in small-scale (≤500 µm) LIBS measurements from ChemCam with bulk crystalline and amorphous compositions derived from CheMin and APXS data, with the following objectives:
  - to get insights into some physical properties of the targets (grain size, homogeneity, coatings, etc.)
  - to identify minor mineral phases undetected by XRD
  - to better constrain the chemical composition (and thus the nature and origin) of the amorphous component

Data and methods

- Here we present ChemCam shot-to-shot data of all targets from the Sheepbed and Gillespie Lake members of the Yellowknife Bay formation (sols ~120 to 300) [5]

- The first 5 shots of each analysis point are ignored in order to remove the contribution from the dust; in addition, Ca-sulfate veins [6] and Mg-rich raised ridges [7] are plotted separately.

- The composition in major oxides was calculated for each LIBS spectrum based on a set of known samples [8]

- The mineralogy of the Sheepbed mudstone was determined by CheMin at two drill sites named John Klein and Cumberland [9], and the composition of the amorphous component was estimated through mass balance calculations [10]

Preliminary results

Comparison between the Sheepbed mudstone and the Gillespie Lake sandstone

- ChemCam shot-to-shot data show a similar dispersion between Sheepbed and Gillespie Lake members, which suggests that even though Gillespie Lake is coarser-grained (fine to medium sandstone), the difference compared to the mudstone is not significant at the LIBS scale

Comparison with CheMin mineralogy

- Crystalline phases are intimately mixed at the LIBS scale (no pure endmember sampled except Ca-sulfate in veins); however, trends are observed towards major mineral phases, mainly plagioclase

- Besides veins [6] and raised ridges [7], very few data points display outside of the point cloud, which suggests the lack of coarser grains; one exception is the target “Fury” (sol 188), which displays a series of high-Mg, high-H, low-Si compositions, suggesting the presence of a Mg-sulfate, Mg perchlorate or Mg-carbonate grain

Comparison with estimated amorphous compositions

- Because the amorphous component is at least as abundant as plagioclase [9,10], one might expect to also observe trends towards its composition in ChemCam data (depending on the size of amorphous grains/aggregates)

- The Na2O vs SiO2 diagram shows a small trend towards low-Si, high-Na compositions that could correspond to the amorphous component; these compositions are also consistent with the amorphous component in other diagrams (brown points)

Summary and future work

- The systematic comparison between ChemCam shot-to-shot data and CheMin XRD results reveals several compositional trends towards major mineral phases (plagioclase, amorphous component)

- This approach also helps highlight peculiar compositions within an otherwise homogenous outcrop

- We plan to apply this approach to other sampling sites at Gale crater, with a priority to those with a high proportion of amorphous component and/or a coarser grain size

References