CHEMCAM ANALYSIS OF JAKE MATIJEVIC, GALE CRATER. A. Cousin[1,2], R. Wiens[2], V. Sautter[3], N. Mangold[4], C. Fabre[5], G. Berger[1], O. Forni[1], S. Maurice[1], O. Gasnault[1], R. Anderson[6], B. Clark[7], J. Lasue[1], S. Le Mouélic[4], E. Lewin[8], A. Ollila[9], S. Clegg[2] & MSL science team [1]Institut de Recherches en Astrophysique et Planétologie, Toulouse, France, [2] LANL, Los Alamos, USA, [3]MNHN, Paris, France, [4]LPGN, Nantes, France, [5]G2R, Nancy, France, [6]USGS, Flagstaff, USA, [7]SSI, Littleton, USA, [8]UjF, Grenoble, France, [9]UNM, Albuquerque, USA; [agnes.cousin@irap.omp.eu]

Introduction: Curiosity landed at Gale crater on August 6, 2012. During the first 90 Sols en route to Glenelg, all instruments were checked out. ChemCam (CCAM) [1, 2]], the remote sensing composition and imaging instrument, acquired a large amount of data (overview in [3, 4]). Jake Matijevic was the first target analyzed by both ChemCam and APXS on Sols 45-48. ChemCam used 30 laser shots on each of 14 locations on the rock, for a total of 420 spectra. We focus here mainly on the ChemCam results fron this target. Work is in progress to reconcile the two analyses. Differences with APXS observations are at this point interpreted in term of sampling area and other instrument idiosyncrasies.

Visual Aspect: Jake presents a ventifacted dreikanter shape (figure 1a) typically observed in desert environments. This rock is not smoothened with differential erosion and presents some cavities up to 2 mm diameter. This means that Jake has an irregular resistance to erosion suggesting heterogeneities in composition at the grain scale. Its base appears smoother with some cracks. Colors from MastCam and Mahli images show a dark, shiny surface (also observed with RMI) with some reddish material, likely corresponding to the dust.

Observation Points: Two sets of measurements were performed by CCAM. The first one occurred during Sol 45, while the target was at a distance of 3.8 m from CCAM, consisting of a vertical 1x5 point raster. The second was during Sol 48 from a distance of 3.2 m with a 3x3 raster grid. Figure 1 shows the location of each CCAM & APXS measurement.

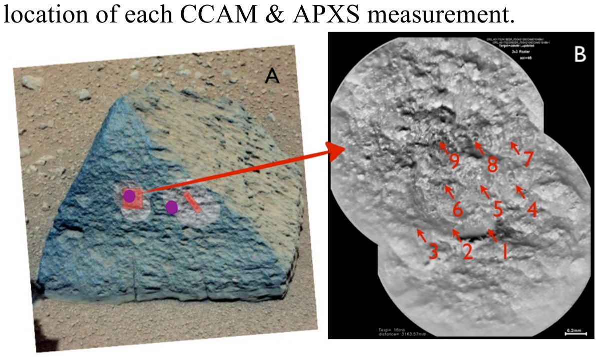

Figure 1: A. MastCam image showing CCAM (red) and APXS (purple) measurments on Jake, B. RMI mosaic of the 3 x 3 raster on Jake [5].

Does Jake Have a Surface Coating? 30 LIBS shots were performed on each location. It is therefore possible to investigate around 15 micrometers inside the rock [1]. On Jake, the first 2 shots correspond to the dust, which is enriched in Ca and Mg whereas it is depleted in Fe and Si compared to other shots. Except these first 2 shots, some compositional variations with depth are observed, but are not due to a coating (see next section). Looking at the 14 locations, a linear trend is observed between the Na and K contents, which implies that no leaching occurred [6].

Is Jake an Homogeneous Rock? The 14 spectra obtained by averaging laser shots at each location (leaving out the surface dust) show a different composition at each location. Figure 2 shows four spectra (limited here in the UV domain) labeled Jake_1, Jake_2, Jake_10 and Jake_14 in order to illustrate spectral differences. The Jake_1 (in black) shows almost no Ti and no Ca compared to Jake_10 & Jake_14 (in red and blue, respectively). The Jake_1 and Jake_14 show much more Mg than Jake_10 and Jake_2 (in green). Jake_2 shows almost no Mg, Al and Ca. Jake_14 presents the highest Si line, along with alkalis (not shown here). These spectral differences are due to heterogeneities at the laser beam scale (~ 440 µm at this distance [7]).

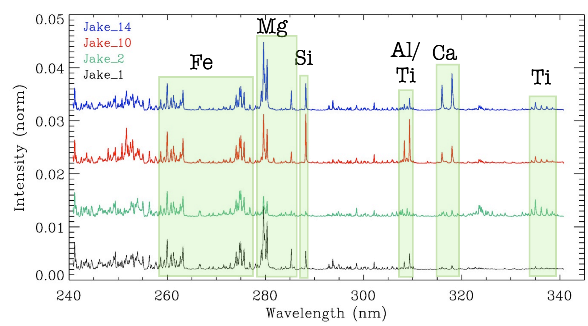

Figure 2: UV range plot of end-members spectra from Jake.

Preliminary composition in oxides weight % are obtained from the PLS data-reduction technique [8]. This calculated composition also reflects the mineralogical heterogeneity of the rock at the CCAM scale, with 4 principal endmembers: Jake_1 and Jake_10 show a lot of Si but Jake_1 is much richer in Mg compared to Jake_10, whereas Jake_2 and Jake_14 have low Si content but differ in their Fe, Ti and Ca content (figure 3). This kind of composition yields 3 major types of minerals: plagioclase, pyroxenes and olivine. Jake_2 is also different with much more ilmenite and magnetite. The Al/Si vs (Fe+Mg)/Si plot (using direct peak ratios [9], figure 4), shows also that this point appears like a Fe and Ti-rich oxide.

ICA analysis [10] for all the spectra except dusty ones (1st and 2nd shots) show major components as Mg, Fe, Ti, Ca, Al+Si, Na, and K. The Jake_2 spot is clearly the most correlated with the Fe and Ti component.

Figure 5 shows the Ti component vs the Ca component where 2 clear endmembers are observed: Jake_1 and Jake_2. Jake_2 is much more correlated with Ti, and Jake_1 shows the lowest correlation with Ca compared to other locations on Jake. Two others endmembers can also be considered, as Jake_10 and Jake_14. One explanation is that Jake_10 is more correlated to alkalis compared to the others and Jake_14 is more correlated to Ca. This Jake_14 shows a variation of the CaO and MgO content with depth. It can be observed in figure 5 trending away from the main cluster of Jake data. The left-most points in Fig. 5 correspond to the first phase observed in the shot-to-shot PLS results (figure 6). This trend shows that first a plagioclase-like phase (shots 3-7) was sampled preferentially before progressively (shots 7-20) enter into a deeper pyroxene-rich phase (shots 20-30). The slope of the correlation (figure 6) indicates a diopside-rich augite grain. This also shows that Jake contains grains larger than the laser beam sampling area. This change in composition with depth could also indicate a surface coating but the 1st phase sampled here is close to a plagioclase, which is not too different from the whole-rock composition with a strong feldspathic component, obviating the coating hypothesis.

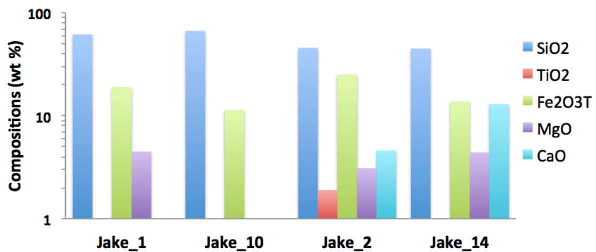

Figure 3: Histogram showing the most differences in composition between the four end-members of Jake.

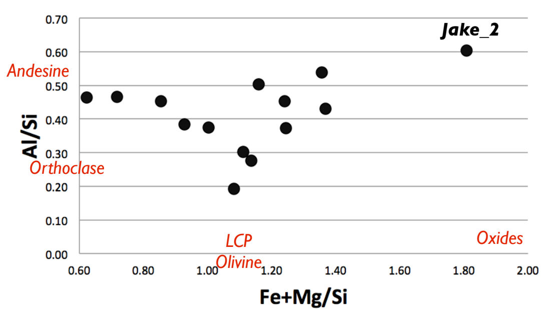

Figure 4: Al/Si vs (Mg+Fe)/Si for the 14 locations on Jake, from univariate analysis.

Jake and the Minor Elements: These spectra show some minor elements, including Li, Cr, Mn, Rb, Sr and Ba, as observed in most of rocks analyzed so far. Nevertheless Jake_1 shows much more Li and Mn, similar to the amount observed in Bathurst and Rocknest3, respectively. Concerning other minors such as Ba, Cr and Sr, on average Jake shows approximately the same contents than observed in other Gale rocks. The relatively high Mn content in Jake_1 is not due to a coating as its intensity increases with depth. Cl is not observed, but the detection limit for CCAM is quite high (35 000 ppm [2]).

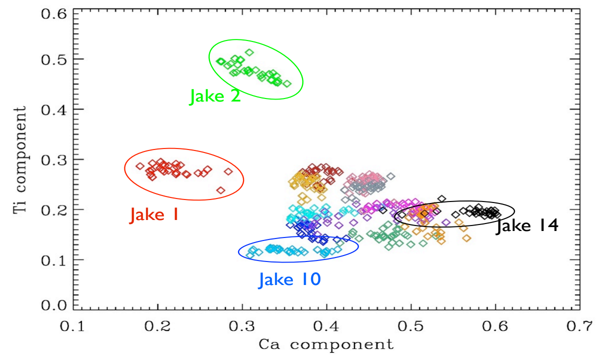

Figure 5: ICA plot showing Ti component vs Ca component for all the 392 spectra obtained on Jake.

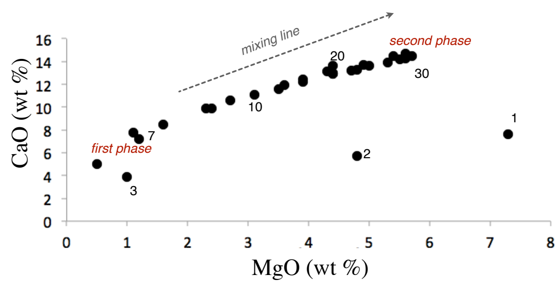

Figure 6: Jake_14 CaO vs Mg0 % through the 30 spectra.

Conclusion The 14 LIBS analyses performed on Jake Matijevic target show an overall basaltic composition, with plagioclase, pyroxene and olivine. Jake is a heterogeneous rock at the laser beam scale, suggesting either a porphyric volcanic rock or a coarse grained igneous rock. This points out a difference between APXS and CCAM analysis: when the target is heterogeneous, LIBS analysis do not give the whole rock composition with a single point measurement. Here a first interpretation is done with the 14 points on Jake, but Anderson et al. [11] have shown than at least 20 analyses are required for an accurate whole-rock compositions of samples with mean mineral grain sizes of several millimeters or larger. Results from Jake confirm that ChemCam is a powerful tool to observe the mineralogical heterogeneities on a rock.

References :[1] Maurice et al. (2012) *SSR, 170, 95-166* [2] Wiens et al. (2012) *SSR, 170, 167-227* [3] Maurice et al. (2013), this meeting [4] Wiens et al. (2013), this meeting [5] LeMouélic et al. (2013), this meeting [6] Berger et al. (2013), this meeting [7] Maurice et al. (2012) LPSC 42th abstract #2899 [8] Lasue et al. (2013), this meeting [9] Fabre et al. (2013), this meeting [10] Forni et al. (2013), this meeting [11] Anderson et al. (2011), Icarus, 215.