COMPOSITION OF THE CONGLOMERATES ANALYZED BY CHEMCAM ONBOARD CURIOSITY.

N. Mangold[1], O. Forni[2], R.C. Wiens[3], L. Le Deit[1], M. Joulin[1], S. Clegg[3], V. Sautter[4], R.M.E. Williams[5], R.B. Anderson[6], D. Blaney[7], A. Cousin[3], G. Dromart[8], C. Fabre[9], M.R. Fisk[10], O. Gasnault[2], N. Lanza[3], J. Lasue[2], S. Le Mouelic[1], R. Leveille[11], E. Lewin[12], S. Maurice[2], P.-Y. Meslin[2], M. Nachon[1], H. Newsom[13], A. Ollila[13], S. Schröder[2], C. D'Uston[2], and the MSL Science Team (LPGNantes, nicolas.mangold@univ-nantes.fr, IRAP/CNRS[2], LANL[3] MNHN[4], PSI[5], USGS Flagstaff[6], JPL/Caltech[7], LGL Lyon[8], SSI9, U. Lorraine[9], Oregon State U.[10], CSA[11], U. Grenoble[12], UNM[13])

Introduction: Fluvially deposited conglomerates have been observed by the Curiosity rover along the rover traverse from sol 1 to 55 [1]. During this early phase, conglomerates were only analyzed by ChemCam at the target Link. This target showed light-toned clasts with feldspar composition and a Fe-rich dark-toned matrix with enhanced hydration suggesting an hydrated Fe-rich cement [1]. The rover then entered into the Yellowknife Bay Formation (from sols 55 to 326) finding a sequence of fluvio-lacustrine sediments, at the base of the Peace Vallis fan [2]. Hereafter, we report the observations of conglomerates along the rover traverse, after the rover left the Yellowknife Bay Formation (sol 326-450), including the targets acquired at the waypoint Darwin (sols 392-401). A total of 27 conglomerate targets (over ~200 points totaling ~7000 laser shots) were analyzed by ChemCam.

Morphology: The MastCam images of conglomerates show the presence of clast-supported fabric deposits. Exposures show various proportions of light-toned and dark-toned clasts (Fig. 1). Local rounded pebbles exist, suggesting the origin of these conglomerates is similar to the fluvial sediments observed earlier [1], but the lack of well-exposed sections usually limits the interpretation. Only the Darwin outcrop (including Bardin Bluff and Altar Mountain) enables a more detailed analysis (Fig. 1), suggesting that these blocky conglomerates with predominantly angular to moderately rounded pebbles were formed from intermittent flows and rapid deposition, rather than deposits associated with sustained river flows [3].

Bulk chemistry: The compositions extracted from PLS (Partial Least Squares) modeling show a large variation in chemistry. Several locations in the targets studied display relatively high Al and alkali elements (Na and K), correlated with higher Si, suggesting an enrichment in alkali feldspars, and usually corresponding to light-toned gravels/pebbles. Other locations display lower proportions of Si, Al and alkalis and higher Fe, corresponding to a more classical mafic composition, and usually corresponding to dark-toned gravels/pebbles. The plot in Fig.2 shows the average composition of all conglomerates from local outcrops (sols 339 to 379) compared to all Darwin conglomerates (sols 379-401) and both ratioed to the composition of the Sheepbed member, the lacustrine mudstone of the Yellowknife Bay Formation. Darwin and other conglomerates display the same trend (higher Al, Si, alkalis and lower Mg) confirming they are part of the same unit. Within these general trends some diversity is observed: Link (sol 27) has a distinct high K compared to the overall composition of other conglomerates, perhaps related to its distinct geographic location in the hummocky plains. Iron displays variability from one target to another, which may be attributed to varying abundances of Fe-rich cement and dark mafic pebbles. In general, this plot suggests a common source for most of the conglomerate materials as alkali-enriched coarse-grained igneous rocks that were transported downslope from the crater rim [4]. This source may be more felsic than the more mafic Yellowknife Bay mudstone. By comparison, pebbly sandstones analyzed at the second waypoint (Cooperstown, sol 439-453) display a composition distinct from the conglomerates and closer to the Yellowknife Bay Formation [5].

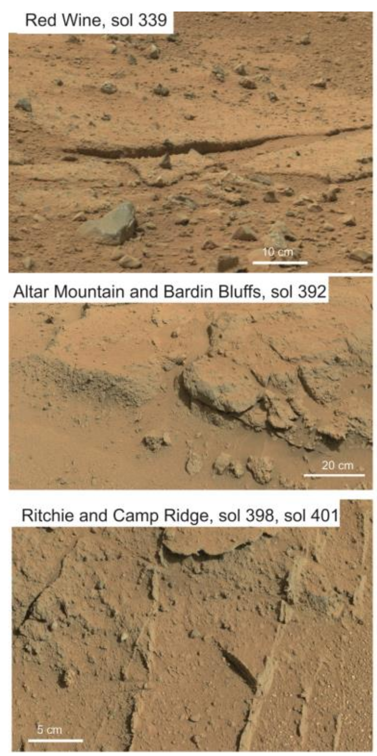

Fig. 1 : MastCam images of several conglomerate exposures on the hummocky plains (MastCam 0339MR1375000000E1_DXXX, 0390ML1607000000E1_DXXX and 0396MR1633000000_DXXX).

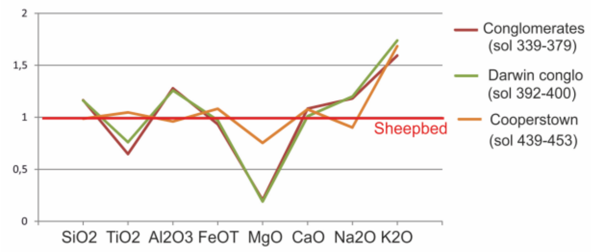

Fig. 2: Average composition of 3 types of sediments (from 69 points for the conglomerates, 57 points for the Darwin outcrops, and 86 points for Cooperstown outcrops) ratioed over the composition of the Sheepbed member of the Yellowknife Bay Formation.

Hydration and cement: An important outcome of the ChemCam data is the assessment of the hydrogen emission line [6]. Hydrogen is present at various levels in the conglomerates, but it is significant for most locations and indicates the occurrence of hydrous minerals, as shown in the close-up of the spectra of four targets at the wavelength of hydrogen, i.e. 656 nm (Fig. 3). In general, it can be concluded from this observation that these conglomerates contain either hydrous minerals in the matrix/cement, although without drilling and sampling with CheMin it is not possible to determine its precise mineralogy. At Link, hydrogen was observed to be preferentially linked to a Fe-rich cement, especially at the more iron-rich fifth location analyzed [1]. The post-Yellowknife Bay conglomerates also display Fe-rich points that are enriched in H. However, the plot of H vs Mg for these samples shows a similar trend, with less amplitude than for Fe. In contrast, we did not observe any correlation with Ca, Na and K showing the lack of role of these elements in the hydrous history.

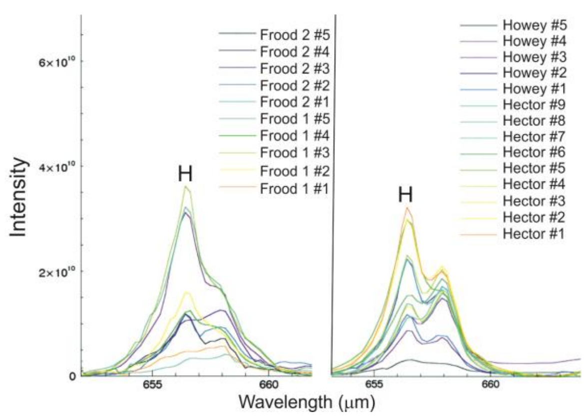

Fig. 3: Hydrogen emission lines of selected conglomerates (Frood, sol 343, Hector and Howey, sol 353). The H line is observed for most locations on conglomerates except when the laser hit pebbles.

Veins: Darwin conglomerates are crosscut by straight fractures that are sometimes filled by a light-toned material at Ritchie and Camp Ridge (Fig. 1). In contrast to the late stage diagenetic calcium sulfate veins found at Yellowknife Bay [7], these veins do not show any enrichment in sulfur or in calcium. Veins have compositional trends close to the surrounding conglomerates, including a strong variability from mafic to felsic end members, suggesting they formed from injection of local material. Their apparent high induration, nevertheless, suggests they experienced strong cementation due to fluid circulation. Mg is the only element to show a positive correlation with the H emission in these veins, suggesting that Mg-rich hydrated phases formed from Mg-rich fluids. In this case, the cementation may be related to the early diagenetic episode found at Yellowknife Bay that involved Mg-fluids [2, 8].

Conclusions: Conglomerates analyzed along the hummocky plains after the visit to the Yellowknife Bay Formation have a similar composition similar from one outcrop to the other, including at the Darwin waypoint (sol 379-401). Our study confirms that these conglomerates are likely fluvial deposits composed of abundant feldspar-bearing clasts with hydrated phases into the fine-grained component. In contrast, the Cooperstown waypoint (sol 439-453) displays pebbly sandstones distinct in bulk composition from the conglomerates [5] suggesting the rover entered there in a distinct geological unit. Conglomerates are derived from the erosion of Gale crater rim and offers the possibility to sample the early martian crust. From pebble compositions, ChemCam data suggest that this crust was actually more felsic and feldspar-rich than previously expected.

References: [1] Williams R.M.E. et al. (2013), Science 340, 1068-1072, DOI 10.1126/science 1237317. [2] Grotzinger J.P. et al. (2013), Science, DOI 10.1126/science.1242777. [3] Williams R. M.E. et al., (2014) LPSC XXVII, 1344–1345. [4] Sautter V. et al., (2014) JGR, 119, 1-17. [5] Le Deit, L. et al., this meeting [6] Schröder et al., Icarus, submitted. [7] Nachon et al (2014) *LPSC,* Abstract #2006. [8] Leveillé et al., submitted to JGR. [9] Palucis et al., JGR, in press.