**IS BATHURST INLET ROCK AN EVIDENCE OF EXPLOSIVE VOLCANISM IN THE ROCKNEST AREA OF GALE CRATER ?** V.Sautter[1], A. Cousin[2], G. Dromart[3], C . Fabre[4], O. Forni[2], O. Gasnault[2], S. Le Mouélic[5], N. Mangold[5], S. Maurice[2], P.Y. Meslin[2], M.E. Minitti[6], H.E. Newsom[7], P. Pinet[2], J. Schieber[8], M. Toplis[2], R.C. Wiens[9], and MSL team. [1]LMCM, MNHN, Paris, France, [2]Institut de Recherche en Astrophysique et Planetologie, Toulouse, France, [3]ENS Lyon, France, [4]G2R, Nancy, France, [5]LPGN, Nantes, France, [6]Applied Physics Laboratory, Johns Hopkins University, USA,[7]Univ. New Mexico, Albuquerque, NM, USA, [8]Indiana University Bloomington, IN, USA , [9]LANL, Los Alamos National Laboratory, USA, [vsautter@mnhn.fr].

Introduction : 50 sols after landing at Bradbury within the Hummocky terrain where rocks appear mainly as floats, Curiosity arrived in an area called Rocknest characterized by dark layered rocks with vesicular or laminated morphology. The rock Bathurst Inlet is laminated and blue toned in stretched MastCam and Mahli images and displays fine-grained textures that might be interpreted as sedimentary siltstone or as volcanic tuff related to pyroclastic processes involving a variety of transport and deposition mechanisms. In this abstract we assess the explosive volcanism hypothesis at Rocknest using textural (MAHLI, MastCam, ChemCam imager RMI) and chemical data (ChemCam LIBS, APXS intruments).

Geological context : The Rocknest area is located 440 meters east of the Bradbury landing site and 100 m from the Glenelg depression [1]. It has been mapped [2] as CS1, a cratered unit, distinct from the so-called Hummocky terrain where Curiosity landed.

Textural analysis : Bathurst Inlet rock belongs to a brittle looking rock unit, apparently well consolidated showing laminated beds. These layers form wedges (Fig.1a-b). Close-up observations (MAHLI/RMI) [3] revealed a fine grained sandstone-like rock with cm-scale layering where variable roughness seems to reflect variable grain sizes (rough: coarser; smooth; finer) (Fig.1a-b). The areas targeted for APXS and ChemCam analyses, have a dark groundmass with grain size ranging from 50 to 120 μm (detector pixel size of 20μrad at 2.55 meter i.e. 1 pixel for 50μm). The rock is covered by sandy particles up to 500μm diameter. Scattered bluish features (MAHLI image in Fig.1c) up to 1mm long and less than 250μm wide with curvilinear concave boundaries, appear to be held within the dark rock's matrix. They could represent either interstitial impact melt pockets or shards of volcanic glass. `
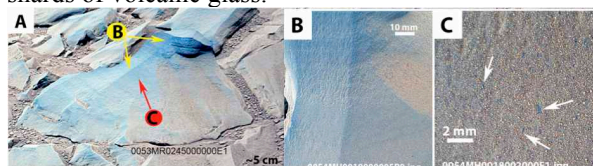
Figure 1 adapted from [3]: a) Mastcam image of Bathurst Inlet providing context for b) and c). b) Roughness variations between layers could be an expression of variable grain size. c) arrows point to angular features with concave boudaries that could be glass shards.

Whole-Rock (WR) and mineral compositions (table 1) have been obtained from one APXS spot (1cm dia) and a raster of five ChemCam LIBS points (of 390μm dia each at 2.55 meter distance). APXS **WR** composition [4] plots in TAS diagram in the alkali basalt field.
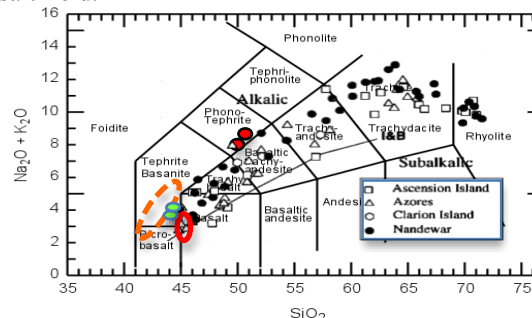

Figure 2 : Chemical classification diagram for volcanic rocks, showing Bathurst Inlet (green spot) and Jake-M (red spot) rocks. Orange and red fields are Gusev rocks, respectively Home plate alkali suite and Adirondack class. These martian alkaline compositions are compared with terretrial alkaline volcanics.

CIPW calculations (table 1) using $Fe^{3+}/Fe^{2+} = 20\%$ consistent with Mossbauer measurements on Gusev rocks [5] gives 24% olivine which allows classification of the rock as a basanite. We obtained a Mg number of 40 consistent with primitive basalt composition resulting from partial melting at depth of a primitive martian mantle with Dreibus and Wänke composition [6]. As a whole, the relative modal proportions (olivine 24%: total pyroxene 28%: total feldspar 37%) are similar to Adirondack class basalts at Gusev [5]. Despite the obvious difference of spatial scale, it is also worth noticing that the high FeO content (22.7 to 23.9 wt%) together with the relatively low SiO_2 (less than 45 wt%) and Al_2O_3 (around 8%) matches the GRS chemical surface composition of Syrtis major a volcanic province older than 3.5Ga [7]. The Bathurst Inlet rock's most striking feature is its high K_2O content (3%) relative to Na_2O (1.9%) which corresponds to a modal proportion of orthoclase reaching 14%, compared to only 0.14% in Adirondack rock [7] (table1). Interestingly the five ChemCam points all plot along a correlation line in Na vs. K Independent Component Analysis (ICA, [8]) plot indicating a constant K/Na ratio (Or/Ab ratio of 2.5)

distinct from Jake-M and Rocknest lines (respectively 0.8 and 1.0 in Fig.4). This trend suggests a mixing of felsic and ferro-magnesium phases in different proportions for each observation. Within a Ca vs. (Fe + Ti) ICA plot (Fig.3a-b), the five points vary in iron and titanium for constant calcium content. Additionally, because each ChemCam observation point represents an average of 30 shots, it is possible to assess compositional variation with depth. ICA plots of individual shot spectra (excluding the first 5 which are contaminated by dust) all cluster in one area in Ca, Fe, Mg principal components space. This is consistent with a small average grain size ($\approx$ half the ChemCam spot size of typically 350-400 micrometers at 2.5 meter distance) or smaller. Finally, no hydrogen peak was detected in ChemCam spectra.
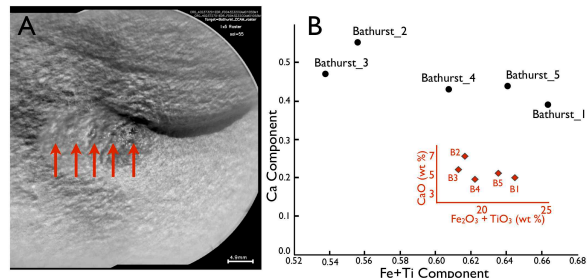
Figure 3 : a) RMi image showing the 5 LIBS points ; b) the 5 LIBS points in the ICA diagram Calcium vs. Iron + Titanium component.
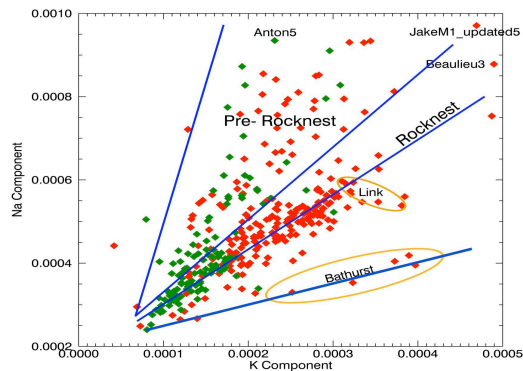
Figure 4 : Potassium component vs. Sodium component [8] showing the K-rich trend for Bathurst rock compared to Rocknest and pre-Rocknest trends.

Discussion : Iron content is the main variable parameter in Bathurst Inlet rock, and it covaries with Ti while Ca, Al/Si, Na/K stay relatively constant in ChemCam spectra. Considering the relatively high S, Zn and Cr content in APXS's WR composition, this suggests high and variable iron oxide and sulfide mineral proportions in the studied rock. Potassium content is tied to sodium and suggests a concentration controlled by feldspar mineralogy. Moreover, the GRS map at Gale crater shows that K is not correlated with Cl, a volatile element. This is consistent with the

CheMin data for Rocknest's soil analysed nearby that indicates pristine basaltic particles [9]. Finally, Bathurst Inlet presents some similarties with the unique 2.1 Ga old martian meteorite Humayan [10], paired with NWA7533 [11], a basaltic breccia including Cl-apatite-K-Spar clusters and magnetite-rich spherules. Therefore, high K_2O content in the Bathurst area appears to be a primary magmatic feature rather than a secondary alteration feature in the anhydrous somewhat pristine igneous Bathurst Inlet rock composition.

Conclusion : Sedimentary-like texture with a granular matrix including putative glass shards together with igneous rock composition are consistent with a volcaniclastic origin. Bathurst would be fine-grain tuff of consolidated volcanic ash. This would involves the presence of explosive volcanism at Gale crater as previously shown in Gusev crater at Home plate by the Spirit rover [12]. Within the set of hypothesis at this point, Bathurst Inlet would be the first documented evidence of K-rich explosive volcanism on Mars. Experiments using martian basaltic composition [13] shown that silica undersaturated potassic alkali series with high Fe contents result from partial melt of martian mantle with low H_2O content. In such a context, gas explosion explosion could relate to high CO_2 concentration in the deap mantle source.

References

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Table 1 APXS analysis and CIPW norm calculation

	Bathurst bottom	Fe $^{3+}$/Fe $^{2+}$=20%	
SiO2	43.8	Anorthoclase	14.02
TiO2	1.43	Albite	16.66
Al2O3	7.84	Anorthite	6.42
FeO	23.86	Diopside	18.78
MnO	0.84	Hypersthene	9.31
MgO	6.63	Olivine	23.72
CaO	6.40	Magnetite	6.66
Na2O	1.89	Ilmenite	2.83
K2O	2.28	Apatite	1.64
P2O5	0.72		
SO3	3.07	Mg/Mg+Fe	40
Cl	0.65		
Cr	1700		
Ni	295		