GALE CRATER'S BATHURST INLET AND ROCKNEST_3 COMPOSITIONS.

J. C. Bridges[1], S. P. Schwenzer[2] F. Westall[3], M. D. Dyar[4], [1]Space Research Centre, Dept. of Physics and Astronomy, University of Leicester, LE1 7RH, UK, j.bridges@le.ac.uk [2]Dept. of Physical Sciences, Open University, MK7 6AA, UK, [3]Centre de Biophysique Moléculaire, CNRS, 45071 Orléans, France. [4]Mt. Holyoke College, South Hadley, MA 01075.

Introduction: After about 400 m of MSL Curiosity rover travel, at Bathurst Inlet, sol 54, two APXS analyses were made. On sol 102 Rocknest_3 at the Rocknest site was also analysed by APXS. Bathurst is part of an *in-situ*, eroded surface (Fig. 1a). The association of Rocknest_3 (Fig. 1b) with surrounding, similar rocks at the Rocknest site strongly suggests that it has a local origin as well. Both samples show some of the challenges of martian geology in that they are both partially dust-covered, fine grained, non vesicular and contain some traces of layering which could be consistent with igneous [1], volcaniclastic [2], impact or sedimentary origins. Here we compare the Curiosity Lander's APXS whole rock compositions of these rocks to known martian compositions e.g. [1,3] in order to help understand their origin. The APXS analyses and their uncertainties are discussed in [4].

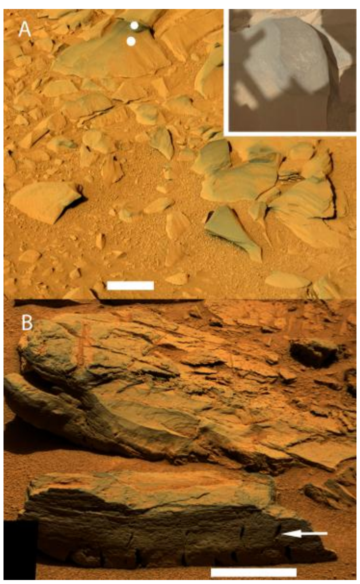

Fig. 1A. Mastcam image of Bathurst_Inlet. White circles APXS spots. Inset shows MAHLI image of Bathurst 1,2. *B. Mastcam image of Rocknest_3* (arrowed). Scale bars 10 cm. These images show the presence of mm-scale layering.

Whole Rock Compositions: The low SiO_2 contents of Bathurst 1,2 (43.8-44.2 wt%) and Rocknest_3 (46 wt%) are primitive, on the borderline of ultrabasic compositions. Bathurst is notably K_2O and FeO-rich, with values of 2.3-3.0 and 22.5-23.7 wt%. Similarly, Rocknest_3 has 2.0 and 20.0 wt% K_2O, FeO. When plotted on a $Na_2O + K_2O$ v. SiO_2 plot (Fig. 2) the compositions are on or at the margin of the terrestrial tephrite/basanite field and are close to the Wishstone class of SiO_2-poor, mildly alkaline basalts (including a possible tuff sample) from Gusev Crater [3].

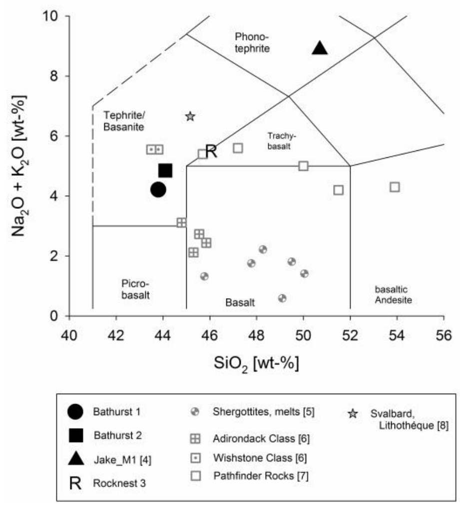

Fig. 2. Basalt Total Alkalis v. SiO_2. Star indicates tephrite sample available in the CNRS Lithothéque as a planetary analogue [8].

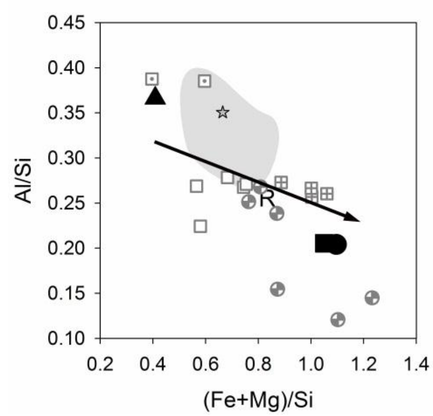

Fig. 3. Al/Si v. (Fe+Mg)/Si (at.) Array. Symbols as for Fig. 2. Grey: terrestrial field data collection of basanite/tephrites from graben settings [9-13]. Arrow indicates how accumulation of olivine in an igneous source rock would drive whole rock compositions derived from that (sedimentary or igneous) towards the lower right of the array.

However, both Bathurst and Rocknest_3 have higher FeO, Ni and lower Al_2O_3 analyses than the

Wishstone (Champagne and Wishstone samples plotted here) analyses.

The differences in FeO, Al_2O_3, CaO, Mg# contents between the Bathurst 1,2, Rocknest_3 and terrestrial tephrite/basanites could be partially explained through the control of mantle source composition which, for instance, has up to twice the FeO content and is depleted in Al_2O_3 compared to that of the Earth [14]. The low SiO_2 contents imply that if Bathurst and Rocknest_3 were derived directly or indirectly (through erosion of basaltic source rocks) the melts did not undergo extensive melt fractionation. Although the new APXS analyses extend the fields of known compositions from Mars, all of the oxide and Ni contents are consistent with a primitive martian basaltic composition (which might be within a sedimentary rock) and lie on an Al/Si v. (Mg+Fe)/Si array controlled by basaltic mineralogy (Fig. 3).

Interpretation of the halogen contents is complicated by the presence of some dust on the rock surfaces but the Br contents of 8-43 ppm in Bathurst 1,2 [4] do not indicate pervasive alteration or salts [15].

The lower FeO, similar Mg#, with higher SiO_2, Al_2O_3 contents of the Jake_Matijevic basalt [4] (Fig. 4) suggest that basalt fragment, which is not *in-situ*, did not originate in the same igneous terrain as Bathurst and Rocknest_3.

Comparisons to Martian Basaltic Compositions: The Bathurst and Rocknest_3 analyses are primitive and strongly olivine normative (~30% depending on assumed Fe^{2+}/Fe^{3+} ratio) in addition to being mildy alkaline, containing normative alkali feldspar. Other martian melt types are shergottite basaltic melts [5]; Gusev Adirondack-type which are picritic, primitive basalt melts [1]; Pathfinder's Ares Vallis basalts which have a slightly more evolved, SiO_2-rich range of compositions [7]; the Gusev Wishstone alkaline, primitive basaltic composition [9] has normative olivine contents of up to 20% i.e. lower than Bathurst, Rocknest_3.

The Bathurst 1,2, Rocknest_3 FeO contents and Mg# overlap the shergottite melt range [5] and so do not suggest extensive Fe alteration. Similarly, the Mg# of normative silicate ~35 is low but known for martian olivine e.g. the nakhlites [14]. Accumulation of Fe-rich olivine grains in a source melt could contribute to the high FeO, Ni, low Al_2O_3 compositional signature (Fig. 4) and the positions on the Al/Si v. (Mg+Fe)/Si array (Fig. 3) relative to the Wishstone class may be partly explained by this process.

Conclusions: Bathurst and Rocknest_3 have low SiO_2, olivine-rich, mildly alkaline compositions similar to the Wishstone class from Gusev Crater. Accumulation of Fe-rich olivine from a Wishstone-type source melt, may be associated with the high Ni contents. Further studies in Gale, including with ChemCam, are expected to show if erosion of such source rocks to form sedimentary rocks could explain both composition and layering of Bathurst 1,2 and Rocknest_3, and the extent of any secondary alteration overprinting their basaltic composition.

References: [1] McSween H. Y. et al. (2006) *JGR, 111,* doi:10.1029/2005JE002477. [2] Sautter et al. *LPSC* this conf. [3] McSween H.Y. et al. (2006) *JGR, 111,* doi:10.1029/2006JE002698. [4] Gellert et al. LPSC *this conf.*; Schmidt et al. *LPSC this conf.*; Stolper E. et al. *LPSC this conf.* [5] Symes S. J. K. et al. (2008) *Geochim. Cosmochim. Acta, 72,* 1696-1710. [6] McSween et al. (2008) *J. Geophys. Res. 113*, doi 10.1029/2007JE002970 [7] Foley C. N. et al. (2003) *JGR, 108*, doi:10.1029/2002JE002019. [8] Bost, N., 2012. Thèse doctorale, Université d'Orléans, 218 pp. [9] Adam, J. (1990) *J. Petrol., 31,* 1201–1223. [10] Haase et al. (2004) *J. Petrol., 45,* 883–905. [11] Jung, S. and Hoernes, S. (2000) *J. Volcanology and Geothermal Research, 99,* 27–53. [12] Jung, S., and Masberg, P. (1998) *J. Volcanology and Geothermal Research, 86,* 151–177. [13] Kooten, G. van (1980) *J. Petrol., 21,* 651–684. [14] Bridges J. C. and Warren P. H. (2006) *J. of Geol. Soc. London, 163,* 229-251. [15] Worden R.H. (1996) *Min. Mag., 60,* 259–274.

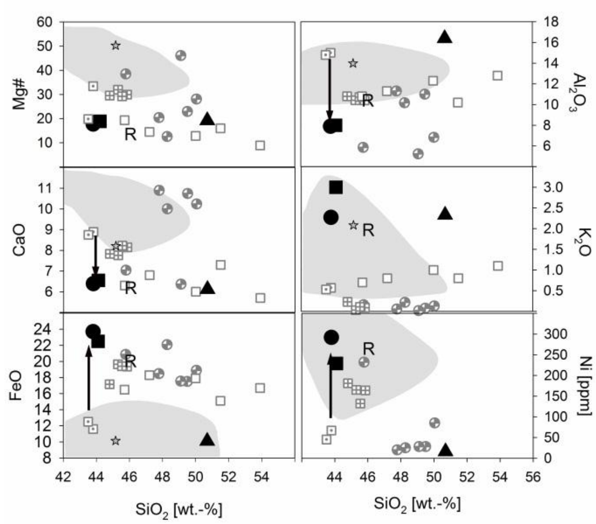

Fig. 4. Major Oxide Plots. Symbols as for Fig. 2,3. Grey: terrestrial field data collection of basanite/tephrites from graben settings [9-13]. Rocknest_3, Bathurst have high FeO, Ni, low SiO_2, Al_2O_3, CaO, mildy alkaline, basaltic compositions [9-13]. Arrows show compositional trend resulting from accumulation of Fe-rich, Ni-bearing olivine within a Wishstone-type basalt melt. Bathurst 1,2 and Rocknest_3 may be sediments which have gained their compositions from the erosion of such basalt.