K-RICH ROCKS AT GALE, DINGO GAP TO THE KIMBERLEY: AN APXS PERSPECTIVE. L. M. Thompson[1], M. Schmidt[2], G. Perrett[3], B. Elliott[1], R. Gellert[3], M. Fisk[4] and the APXS Team. [1]Planetary and Space Science Centre, University of New Brunswick, Fredericton, NB E3B5A3, Canada lthompso@unb.ca; [2]Department of Earth Sciences, Brock University, St. Catharines, ON L2T3V8, Canada; [3]University of Guelph, Guelph, ON N1G2W1, Canada; [4]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331 U.S.A

Introduction: Curiosity's APXS instrument has acquired 112 rock and soil analyses up to the Kimberley waypoint (Fig. 1), recording a diversity of rock compositions and encountering a number of K-rich (1-3 wt% K_2O) rocks. After landing in Gale crater on Bradbury Rise, Curiosity head towards the Yellowknife Bay (YKB) area before driving towards Mount Sharp. Four waypoint locations: Darwin, Cooperstown, the Kimberely and Murray Buttes were selected for more in-depth exploration by the rover along the route to Mount Sharp. The Kimberley waypoint (Fig. 1) was selected as the third drilling location as it represents an area with at least three orbitally distinct units: the striated unit, the middle unit, and the smooth, hummocky plains unit. From Dingo Gap to the Kimberley, APXS analyzed rock targets at three in situ outcrops, as well as two float rocks. These analyses are compared with the compositions of all rocks analyzed by APXS on the MSL mission since landing [1].

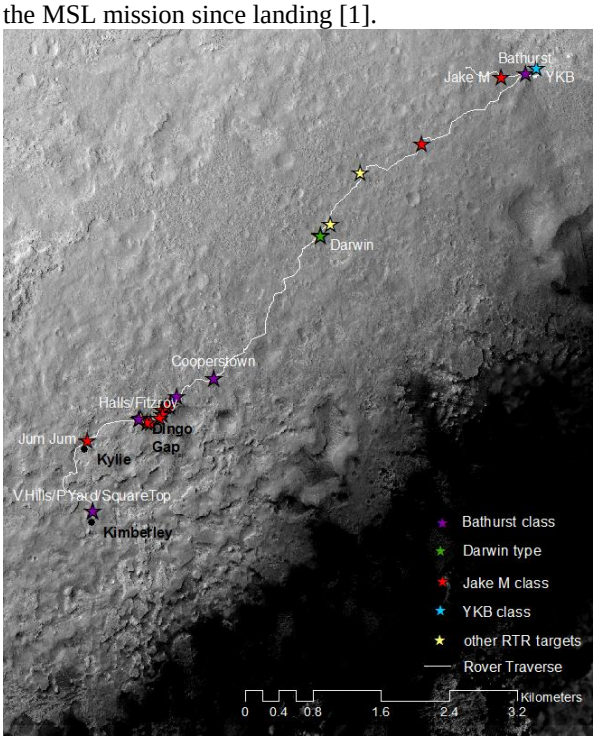

Figure 1: Locations of AXPS analyses. HiRise base map from [2].

Location, Description, Stratigraphic Context and Composition of APXS Targets: See Figure 1 and Table 1 for the location, description and stratigraphic context of APXS targets. See Table 1 and Figure 2 for APXS results.

Target	Metres	Region	Class	Physical Characteristics	Composition
Halls	10	Dingo Gap	Bathurst	bedrock near vein; striated or middle unit; dusty, raised, knobbly textured	high K, Fe, Mg, Mn, Zn, Cl and Br; low Si, Na
Fitzroy	10	Dingo Gap	Bathurst	bedrock; striated or middle unit? dusty, knobbly textured	high K, Fe, Mg, Mn, Zn; highest Br (1017 ppm); low Si, Na, K
Jum Jum	404	Kylie	Jake M	bedrock; striated unit? grey, pitted matrix of breccio-conglomerate face	highest K (3.8%); high Na, Al, Zn; low Ni
Secure	678	Pink Route	Et Then	float; indurated, grey, fine grained, smooth, large cavities, some pitting & shiny coating (varnish?)	highest Fe (28%); high K, Na; low Mg, Si, Al, Cl, Cr, Ni, Zn
Monkey Yard	705	Pink Route	Jake M	float; grey, fine grained, light toned inclusions, pits & holes, relatively dust free, fine striations on some surfaces	high Na, K, Si, Al, Zn; low Fe, Mg, Mn, Cr, Ti, Ni
Square Top	1063	Kimberley	Bathurst	striated unit outcrop; indurated, finely laminated, dark grey silt/sandstone with coarser clasts/nodules; layer defines large scale striations of the unit	high K, Fe, Mn, Cr, Br; highest Zn (1906 ppm); low Si, Na, K
Pandanus Yard	1063	Kimberley	Bathurst	striated unit outcrop; dusty, more recessive, coarse sandstone beneath Square Top	high K, Fe, Mn, Zn, Br; low Si, Na, K
Virgin Hills	1063	Kimberley	Bathurst	striated unit outcrop; dusty top surface of Square Top	high K, Fe, Mn, Zn; low Si, Na, K; higher Na than Square Top
Bathurst	453	Bradbury Rise	Bathurst	almost in situ bedrock; well indurated, fine grained, finely laminated grey sand/siltstone; moderate fine dust coverage	high K, Fe, Mn, Zn; low Si, Na, K
Jake M	294	Bradbury Rise	Jake M	float; indurated, dark grey, fine grained, light toned inclusions, pits & holes, relatively dust free; fine grained basal layer?	high Na, K, Al, Si; low Fe, Mg, Cr, Ni
Cumberland Drill Fines	727	YKB	YKB	drilled bedrock; dark grey mudstone	high Fe, Mn, Mg, Ni; low Si, Al, Na, K
Bardin Bluffs Matrix	1814	Darwin	Darwin	bedrock; coarse, pebbly sandstone/ conglomerate	moderate Si, Al, K, Na, Zn; low Ni, Cr

Table 1: Details of location, rock description, classification and compostion of select AXPS analyses. Metres in black are the distance from Dingo Gap, metres in red are the distance from landing and metres in blue are from YKB.

Results and Discussion: The in situ rocks analyzed by the APXS from Dingo Gap to the Kimberley waypoint exhibit high K (1-3 wt% K2O) contents (Fig. 2). Furthermore, the Halls, Fitzroy, Virgin Hills, Square Top and Pandanus Yard exposures share many compositional characteristics with Bathurst-class rocks. In contrast, the Jum Jum breccio-conglomerate rock typically plots along a linear trend between high alkali, Si and Al JakeM-class rocks and low Si and Al Bathurst and YKB-class rocks, exhibiting many compositional similarities to the Darwin-class rocks.

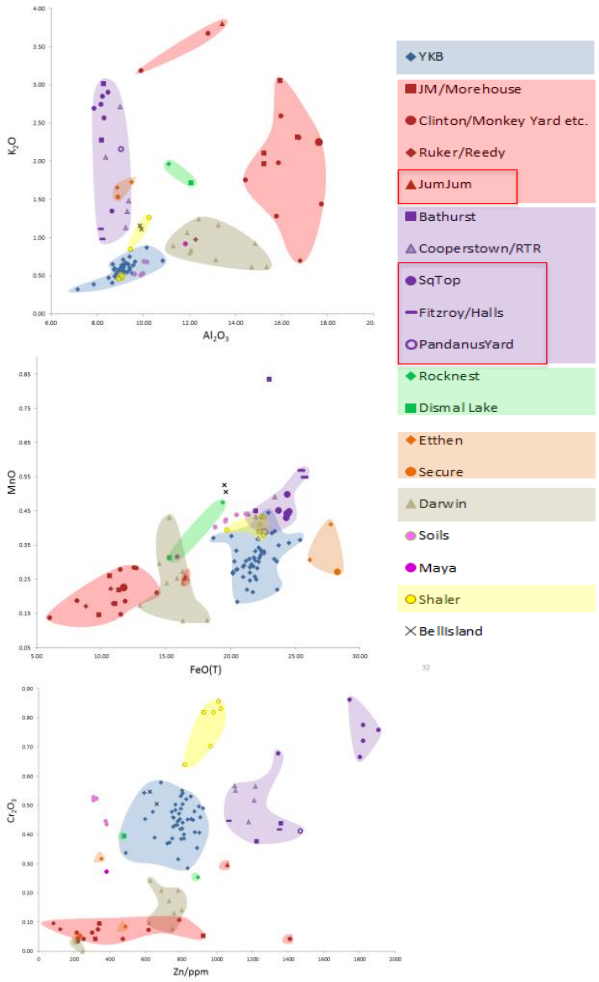

Figure 2: Selected geochemical plots of all MSL APXS data to Kimberley. Blue: YKB rocks, red: Jake M-class rocks, purple: Bathurst-like rocks; green: Rocknest-like rocks; orange: Et Then-like rocks; buff: Darwin-like rocks, yellow: Shaler-like rocks (see [1])

The high-K content is somewhat anti-correlated with Al, Si, and Na, consistent with an increase in K-feldspar at the expense of plagioclase; relative to the average YKB rocks for the Square Top et al. rocks and relative to the JakeM-class rocks for Jum Jum. This apparent increase in the K-feldspar content could reflect an original source rock that is enriched in K-feldspar, or a sedimentary and/or weathering process that preferentially concentrates K-feldspar versus plagioclase. K-feldspar may not be a primary igneous mineral. Authigenic K-feldspar can form from the action of brines on plagioclase. We might expect to see elevated Cl and Br if this were the case, which is not evident from the APXS data. The K-bearing phase could also be an alteration product after alkali feldspar, like illite. However, if this were the case we might expect to see an associated increase in the Al content of these rocks. Kalsilite, leucite, K-bearing zeolite, amphibole and biotite are also possible phases.

There is an associated increase in Cr and Zn, and to a lesser extent, Fe and Mg (Fig. 2), which might indicate the presence of other secondary or authigenic minerals and/or cements and/or amorphous material. However, calculations of the composition of the amorphous component from APXS and CheMin analyses of YKB do not indicate a significant K content for the amorphous material in those rocks [2]. The association of the high K with high Fe, may indicate the presence of jarosite, but if there, it is probably not present in large quantities, since the SO_3 content would be higher. For example, if 1.5 wt% K_2O were associated with jarosite, 5.1% SO_3 would be required, which would account for all the sulfur in the analyses. This is unlikely, as we can see dust in the images, and dust comprises significant SO_3. CheMin analyses of this K-rich material at Kimberly should aide in addressing the nature of the K-bearing phases in these rocks and provide insight into the potential source rocks and diagenetic processes that have taken place.

The similarity in the composition of the Jum Jum breccio-conglomerate to the Darwin rocks, which are also relatively coarse grained and tend to lie on a linear tend between the YKB rocks and JakeM-class rocks, may indicate that this coarser material had a common JakeM-like source area, distinct from the low Si, Al source for the finer grained, YKB basaltic source rocks and Bathurst-class rocks. The Jum Jum and Darwin rocks may represent a mixing of these two, coarse and fine sources. The very high K-content of the Jum Jum rock and other targets along the Pink Route, may point to a common secondary effect, such as alteration/fluids, that affected all these units during burial and diagenesis.

Conclusion: APXS has proven invaluable at identifying compositional trends along our traverse within Gale crater. Since landing, Curiosity has encountered a wide diversity of rock compositions at Gale crater, implying variations in the source rocks for the predominantly sedimentary lithologies observed. In particular, Curiosity has encountered high K and Fe Bathurst-class rocks and high Na+K, Si and Al Jake M-class rocks, distinct from those analyzed on MER.

References: [1] Schmidt M.E. et al. (2014) 44th LPSC, Abstract #1504. [2] Morris, R.V. 44th LPSC, Abstract #1319. [3] Calef, F.J. III et al. (2013). 44th LPSC Abstract #2511.

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