DIVERSE IGNEOUS PROTOLITH CONTRIBUTIONS TO SEDIMENTS IN GALE CRATER: VARIABLE METASOMATISM OF THE MARS MANTLE. M.E. Schmidt[1], M.R.M. Izawa[1], A.P. Thomas[1], L. Thompson[2], R. Gellert[3], [1]Brock U. (ON L2S3A1 Canada; mschmidt2@brocku.ca), [2]U. New Brunswick (NB E3B5A3, Canada), [3]U. Guelph (ON N1G2M7, Canada),.

Introduction: Igneous float rocks and least altered sedimentary bedrock examined in Gale Crater by the Mars Science Laboratory (MSL) rover Curiosity provide insight to the petrogenesis of the crystalline basement. The MSL Alpha Particle X-ray Spectrometer (APXS) uses ^{244}Cm sources for X-ray spectroscopy (PIXE and XRF) to find major, minor, and some trace element abundances ~1.7 cm areas on rocks ± dust/soil [1]. The suite of elements includes major, minor (K, P, Ti) and trace elements (Cr, Ni) that range in behavior from very incompatible to very compatible in basaltic melts (Fig. 1), allowing petrologic modelling to constrain their igneous histories and the character of the Martian mantle.

Igneous endmembers: Sedimentary rocks examined early in the mission (until sol 742) display elemental variations that are consistent with mixing between igneous mafic and felsic lithologies and largely isochemical alteration (±Fe-oxide cement) [2]. Later rocks exhibit enrichments that are thought to reflect both later alteration and detrital silica [3]. Variable and high concentrations of alkalis (up to 3.73 wt% K_2O) determined in igneous float and sediments are thought to reflect primary enrichment [2, 4, 5].

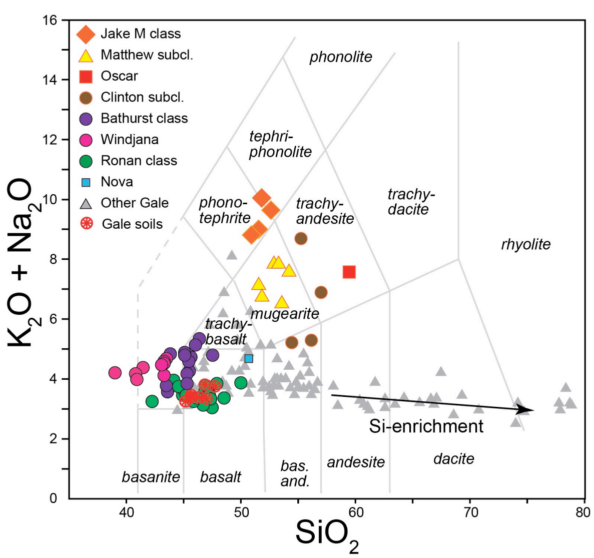

Fig 1. Total alkali vs. SiO_2 diagram with igneous float and least altered basaltic sediment APXS classes shown. [6, 7]

Least altered basaltic sediments of the Bathurst class (n=13; includes Windjana drill sample [5]) comprises dark-toned potassic siltstone sandstone, to matrix-supported conglomerate of the Bradbury Group [8]. Phases identified by CheMin in the Windjana sample include sanidine, plagioclase, pyroxene, and magnetite and are thought to reflect the igneous protolith [5]. Enrichments in Zn and Ni (up to 4681 and 516 ppm, respectively) are thought to reflect enrichment in the sediment source.

The Jake M class (n=13) includes igneous float blocks and cobbles that likely weathered out of conglomerate bedrock, and ranges in composition from phonotephritic to trachyandesitic. Jake M rocks are notably rich in Na, K, P, and Al (up to 16.9 wt% Al_2O_3) and have low concentrations of Ni and Cr. Subclasses (Matthew and Clinton) are identified on the basis of data clusters withing variation diagrams that correspond to rock textures (e.g., plagioclase phyric).

Another float rock of likely igneous origin, called Nova is fine-grained and enriched in P_2O_5 (3.2 wt%).

Least altered, basaltic Stimson sandstone targets (sol 974 to present [8]) are classified as the Ronan class (n=14) and are similar in composition to local soils, but are more variable, particularly in Al_2O_3, and range to lower K_2O and higher Ni. CheMin analysis of the Ronan class Big Sky sample indicates it is dominated by plagioclase and pyroxene [9].

Petrogenesis: Variations in incompatible and compatible trace elements among the SNC meteorites are likely caused by combination of minor mantle heterogeneity/ contamination, followed by later fractional crystallization [e.g., 10, 11]. Variations in K, P, Ti, Ni, and Cr among the Gusev basalts are consistent with 2-stage partial melting of typical Mars mantle (WD: modeled based on variations in SNC meteorites [12, 13]) with residual olivine, 2 pyroxenes, and spinel, but with extra K. This hints at a heterogeneous distribution of alkalis in the Mars interior caused by mantle metasomatism.

Elevated K and compatible metals (Ni and Cr) observed in least altered basaltic sediments (Bathurst and Ronan classes) cannot be attributed to partial melting of typical WD Mars mantle (Fig. 3). Very low degree melting (≤0.5%) would yield melts with sufficient alkalis, but such low degree melts are unlikely to migrate and their Ni would be too low by a factor of 4 to 11. Instead, the character of the Gale mantle is likely alkali and Ni-enriched by an oxidizing metasomatic event. Both alkali contents and oxidation state are variable in the Mars interior.

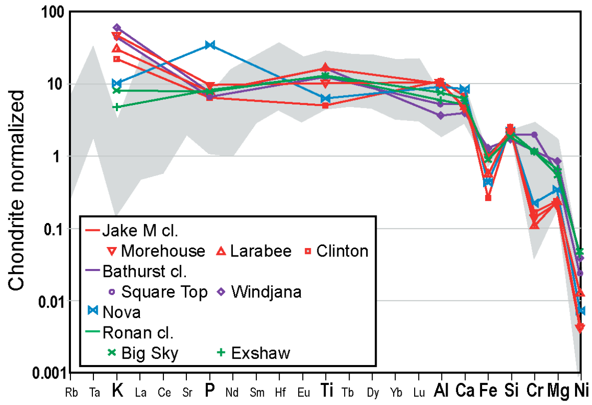

Fig 2. Chondrite normalized [14] element abundance diagram, ordered by increasing compatibility in basaltic melts. Representative Gale igneous endmembers are plotted. Gray field represents range in SNC meteorites [15].

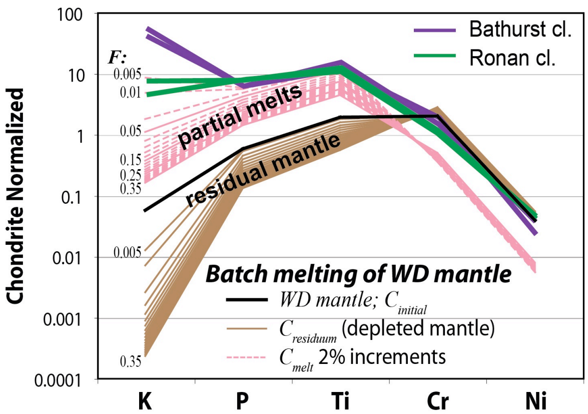

Fig 3. Modified chondrite normalized [8] element abundance diagram with representative least altered basaltic Gale sediments. Batch partial melts (C_{liq}) of WD mantle, C_{init} [8] (residual phases 50% olivine, 24% cpx, 24% opx, 2% chromite) are overlain. Gale basaltic sediments are elevated in incompatible and compatible elements relative to partial melt, even at low melt fractions (F).

The Jake M class and Nova demonstrate that Mars generates diverse evolved alkaline magmas. Variable alkali contents over a limited range in SiO_2 among Jake M rocks (4.1-7.1 wt% Na_2O, 0.7-6.0 K_2O/TiO_2, and 49-53 wt% SiO_2; Fig 4) are probably not a result of fractional crystallization of a single parental magma. More likely, Jake M rocks and Nova are a product of fractional crystallization of a range of parental magmas derived from variably alkali and P-enriched and metasomatised mantle.

Conclusions: Varying degrees of partial melting of WD mantle and fractional crystallization alone cannot account for the diverse compositions among igneous and least altered sediments from Gale Crater. Variable alkali contents and oxygen fugacity in the mantle source were likely caused by oxidizing metasomatic events. Mars generates diverse evolved alkaline magmas that were generated by fractional crystallization of multiple parental basaltic melts derived from a heterogeneous mantle

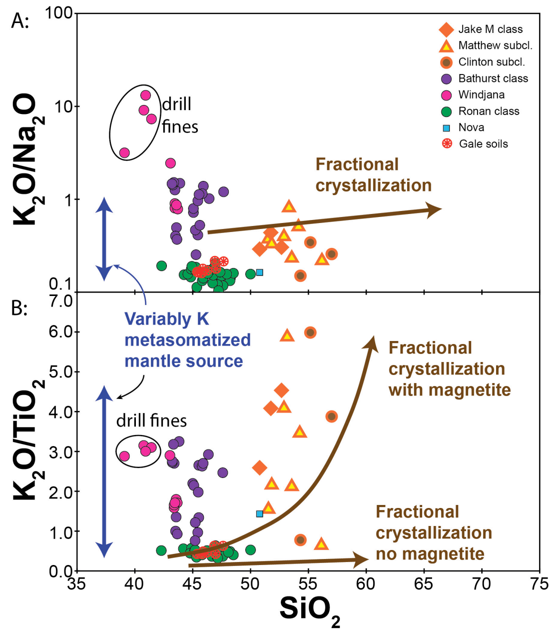

Fig 4A: Plot of K_2O/Na_2O and B: K_2O/TiO_2 vs. SiO_2 with igneous endmember groups indicated. Igneous fractionation trends are based on terrestrial alkaline (Tenerife, Mauna Kea) and tholeiitic suites (Askja) (GEOROC).

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