Compositional End Members in Gale Crater, Mars

Conference or Workshop Item

COMPOSITIONAL END MEMBERS IN GALE CRATER, MARS.

C. C. Bedford[1], J. C. Bridges[2], S. P. Schwenzer[1], A. Cousin[3]., R. C. Wiens.[3] [1]The Open University, Walton Hall, Milton Keynes, MK7 6AA (candice.bedford@open.ac.uk), [2] Space Research Centre, University of Leicester, Leicester, LE1 7RH. [3]Los Alamos National Laboratory, Los Alamos, New Mexico, USA.

Introduction: Geochemical data returned from the Mars Science Laboratory's *Curiosity* rover over 1296 sols, has revealed a previously unforeseen martian geochemical complexity. Before *Curiosity* landed in Gale Crater, Martian SNC meteorite studies [1] along with previous orbiter, rover and lander data showed Mars as being a predominantly basaltic planet with little magmatic differentiation [2]. But through using ChemCam density contour plots to collate compositional data obtained by that instrument, we can identify 4 compositional end members in Gale sedimentary and igneous samples.

Methods: The ChemCam instrument suite consists of a Laser Induced Breakdown Spectrometer (LIBS) which allows for rapid, remote rock identification and analysis [3]. Here, ChemCam data is used alongside *Curiosity*'s other instruments, plus chemical data from the Mars Exploration Rover (MER) *Spirit* and shergottite meteorite compositions [4]. We use density contour plots of ChemCam spot data in order to highlight compositional focii and trends.

Results and Discussion: Four geochemical end members have been distinguished in the igneous float rock, conglomerate clast and the sedimentary units.

Basalt: Figure 1 shows a focus at SiO_2 = ~45wt%, $Na_2O + K_2O$ = 4 wt% for both igneous float rock [4] and sedimentary samples. The unconsolidated material from the Namib dunes and soils shows the least chemical variation making it a potentially good sample to determine a bulk Gale composition, and this has a similar focus at 43 wt% SiO_2, 2.8 wt% $Na_2O + K_2O$. The CheMin results suggests a basalt mineralogy in the Namib dunes [5], which we suggest is tholeiitic, probably similar to Adirondack Class basalts at Gusev Crater [5]. The relative enrichment in alkalis and Al_2O_3 compared to shergottite meteorites indicates different mantle source regions for the bulk Gusev Crater and Gale basalts in the ancient highlands compared to the shergottites from the northern lowlands or Tharsis.

Trachybasalt: A trend in the igneous float samples [4] from 45 to 53 wt% SiO_2 is shown in Fig. 1. This trend is the result of olivine crystal fractionation from basaltic to trachybasaltic compositions [5].

Alkaline-rich: The most alkali-enriched sedimentary units are Kimberley and Shaler which are fluvial sandstones and conglomerates [6]. The Kimberley formation is especially enriched in K_2O relative to Na_2O, and this has been correlated with a high abundances of sanidine in the Windjana Drill hole [7]. Mixing between an alkali-enriched end member and the basaltic (tholeiitic) end member is evident in the spread of Kimberley data points in Fig. 1.

Silica-enrichment: Extensive silica enrichment (up to 90 wt%) is seen in the Murray [8,10] and Stimson formations [9,10]. Murray consists of lacustrine mudstones [7] while Stimson is aeolian/fluvial sandstone [9]. Silica-enriched sediments are poor in K_2O, Na_2O, CaO and MgO, though scatter in alkali compositions of 1-7 wt % suggests a potential additional trachybasaltic mixing component. Tridymite was found in abundance in the Buckskin drillhole [8,10]. The end member responsible for these compositions may be related to highly evolved silicic magmatism [8], with later alteration after deposition within the sedimentary units [10].

Conclusions: The Gale sediments have sampled; an Fe-rich basalt similar to that identified at Gusev, a trachybasalt, an alkaline igneous source and a silica-rich source. The basalt, which we suggest has tholeiitic affinities, is the dominant source composition.

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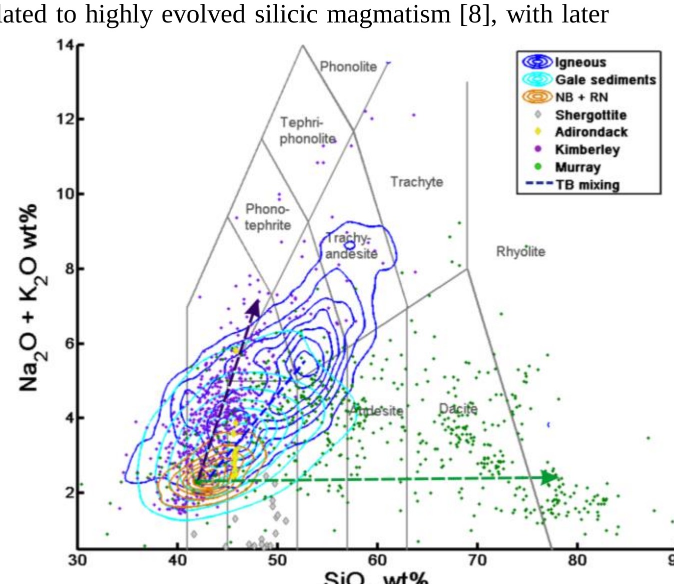

Figure 1: Total alkali v. silica density LIBS contour plot of Kimberley and Murray sedimentary units against the compositional variation in Gale sediments and igneous samples [4,5]. Mixing lines shown as dashed arrows: Alkali-basalt (purple) and Silica-basalt (green). NB + RN stands for Namib Dunes and Rocknest. Dashed blue line shows Trachybasalt-basalt (blue) fractional crystallization trend [4].