Compositional Similarities among Martian Meteorites, Regional Gamma Ray Data, and *in situ* Lander Measurements: Implications for Igneous Processes

S. R. Gordon[1], H. E. Newsom[1], F. M. McCubbin[1], C. B. Agee[1], C. K. Shearer[1] Department of Earth and Planetary Sciences, Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131 (gordons@unm.edu)

Introduction:

- Martian surface data are derived from six rover and lander missions, the Mars Odyssey Gamma Ray Spectrometer, and a suite of martian meteorites (approx. 110 named stones) [1-10].
- Integrating the martian meteorite suite into a global and regional context will elucidate (1) the role they played in the growth and evolution of the martian crust, (2) their importance in reconstructing primordial martian differentiation and mantle evolution [i.e. 11], and (3) a mineralogical and chemical starting point for reconstructing surface processes (e.g. weathering, alteration).

Ca/Al Comparisons:

- Data for each set plots in the same area, forming general locations of Ca/Al ratios for different sample groups.
- SNC meteorites are Al-depleted and the GRS data are Al-enriched, while the landing site analyses and NWA 7034 show Al concentrations in intermediate ranges.
- Preliminary data from Mars Science Laboratory [12, 13] suggest that at least some of the basaltic rocks from Gale Crater are also Al-rich.
- MSL APXS data from sols 1-102 are included in the figure [14]
- The clear discrepancy between the aluminum abundances of the landing site samples and SNC meteorites may be exaggerated due to poor detection of Al by the GRS [15].
- NWA 7034 and NWA 5789 have similar Mg/Al ratios to the current martian surface measurements from the lander and rover missions.

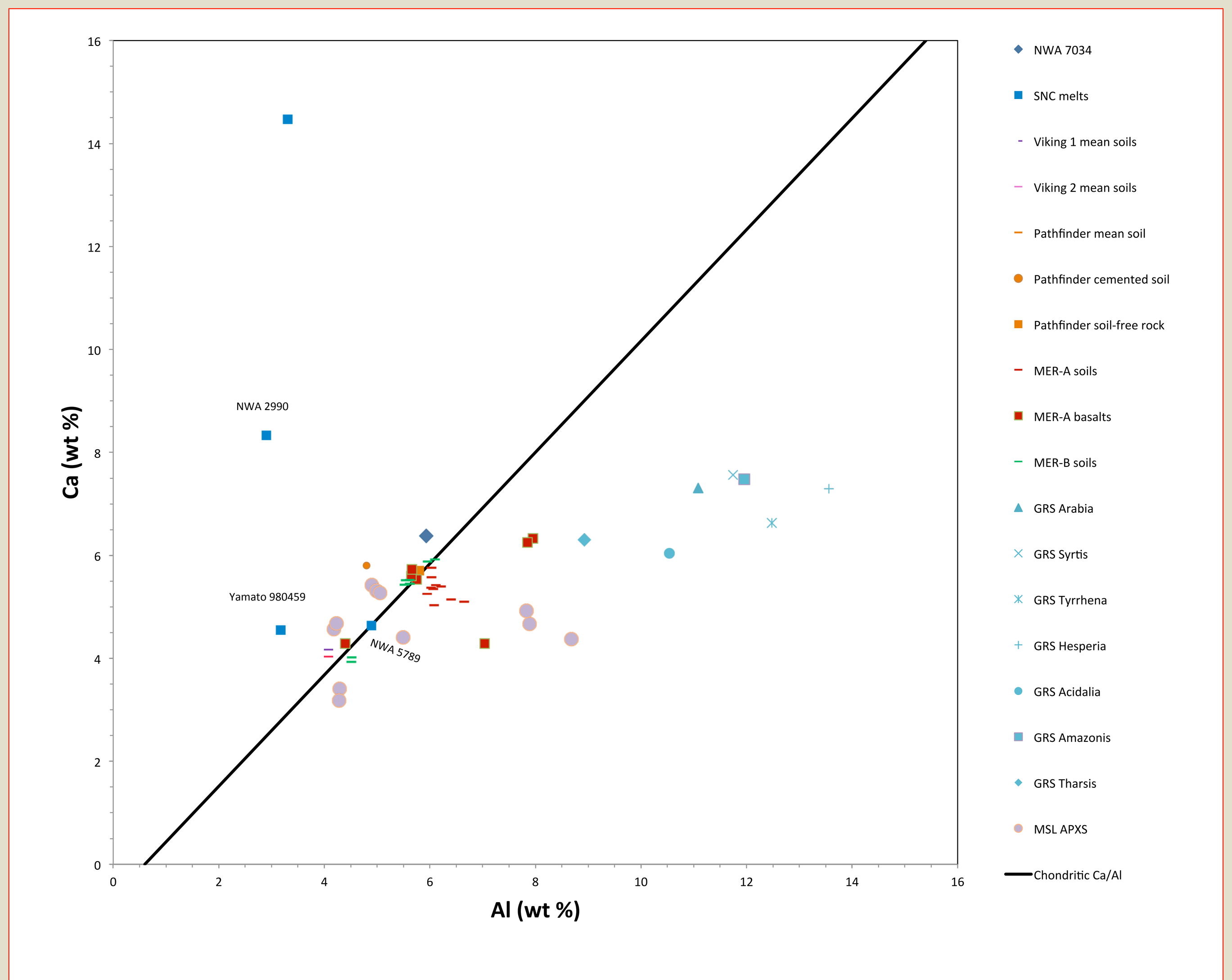

Fig. 1. Viking, Pathfinder, MER A & B, GRS, and MSL APXS data plotted with SNC melt compositions (labeled on plot) as well as the composition of NWA 7034. Black line is chondritic Ca/Al ratio, showing superchondritic Al values for the GRS data and superchondritic Ca values for the majority of the SNCs. GRS points have large uncertainties (not shown) due to the large gamma-ray footprint and poor counting statistics. Global GRS data has been statistically separated into regions by Karunatillake et al [16]

Mg/Al Comparisons:

- The black terrestrial fractionation line [17] and red shergottite fractionation line [18] have been used to distinguish between terrestrial and martian origins for rocks.
- If rocks are cumulates, their accumulated characteristics will show through in this plot [19].
- The SNC compositions plot on or near the martian fractionation line, lending credibility to their being representative of magmatic liquids.
- NWA 7034 and most of the in situ analyses of rocks and soils plot closer to the terrestrial fractionation line.
- The Pathfinder soil-free rock and Viking 1 & 2 mean soils plot along the martian fractionation line.
- MSL APXS data correspond to measurements from previous surface missions

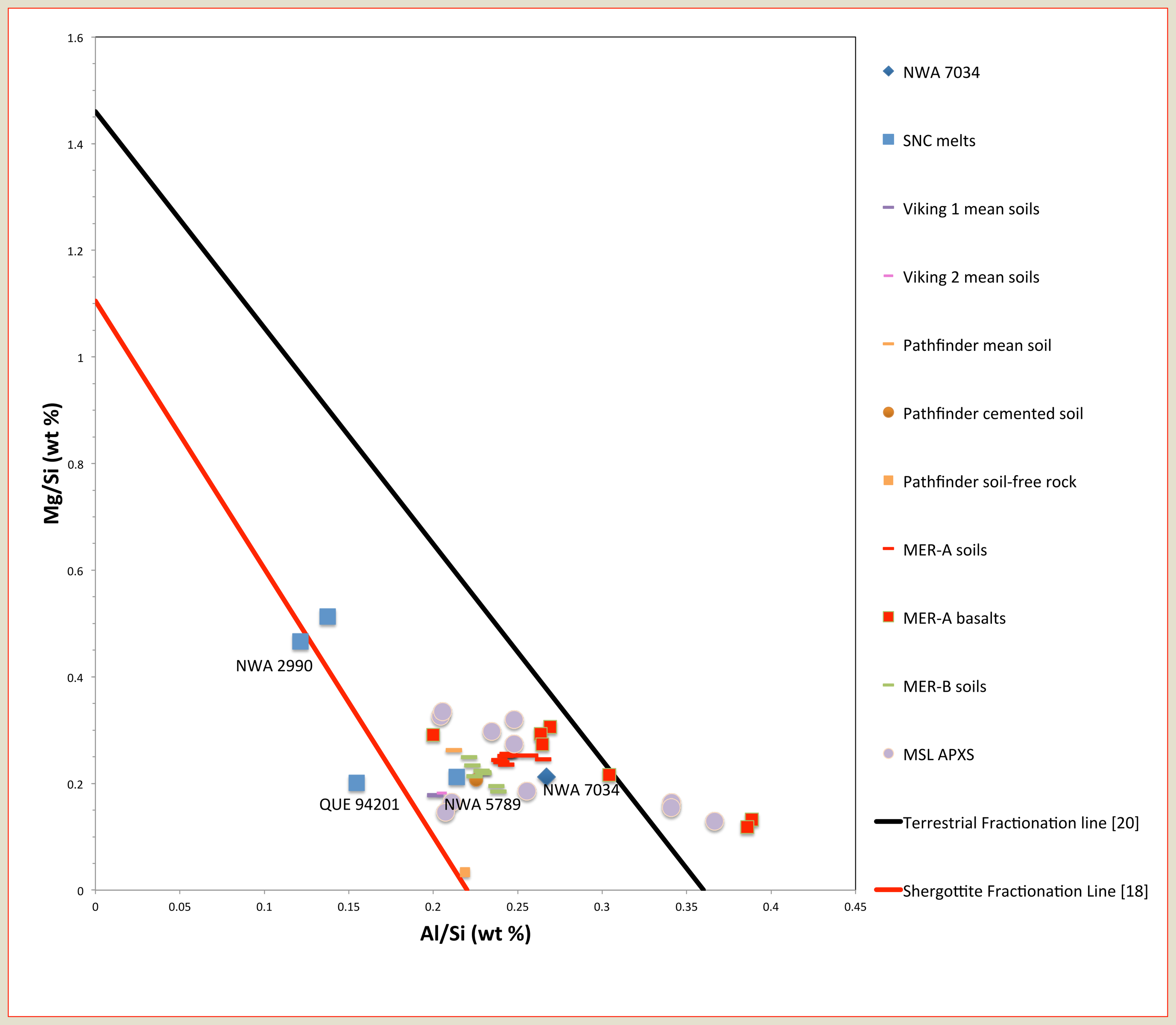

Fig. 2. Samples from Fig. 1 (except GRS data which has not reported Mg data) plotted on a typical classification plot used to distinguish primitive terrestrial rocks from primitive martian rocks.

Th as Indicator of LREE Enrichment:

- LREE-depleted SNCs have similar Th concentrations, but the enriched meteorites (NWA 2990, NWA 7034, and the shergottites) represent a range of Th concentrations.
- If NWA 7034 is confirmed as being representative of a melt composition, a positive trend could be fitted to find a correlation between Th concentration and LREE enrichment of a meteorite.
- Further study to find a correlation between LREE enrichment and a (preferably GRS-detectable) non-REE elemental concentration in martian meteorites may be a helpful tool in linking SNC and other martian melts with their region of origin on the martian surface.

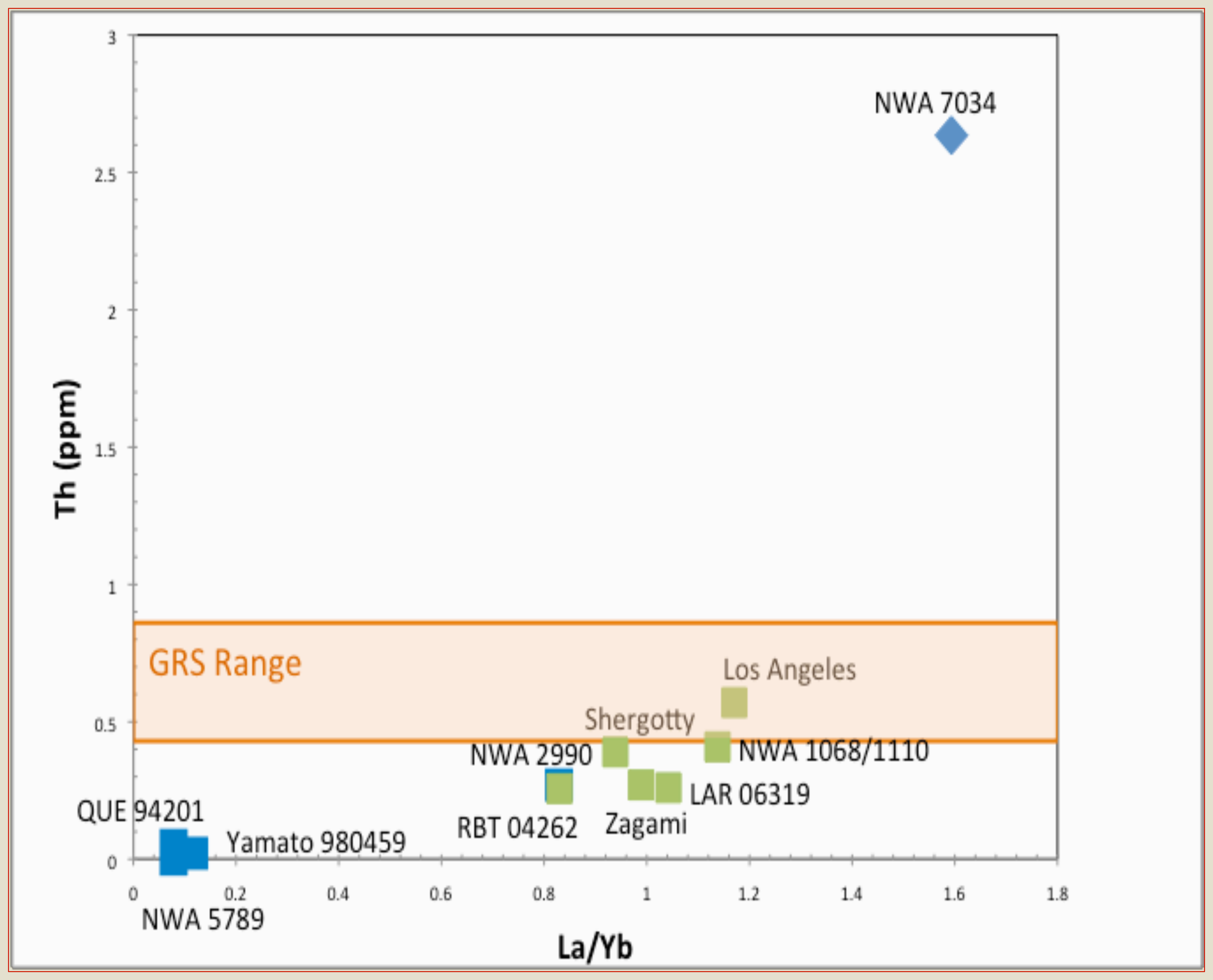

Fig. 3. Th vs CI-chondrite normalized La/Yb for NWA 7034 (blue diamond) and other enriched shergottites (melts are blue squares, others are green squares).

Conclusions:

- The ChemCam and APXS instruments on the MSL Curiosity rover are contributing elemental data from yet another landing site on Mars, allowing for more constraints on regional and global surficial chemistry [12-14].
- Preliminary MSL data from all instruments may still need adjustments before being effectively compared to other data sets.
- Using the new data from MSL, refining the Odyssey GRS data to better coincide with in situ measurements, and incorporating data from the new martian meteorite NWA 7034 will contribute to a better understanding of the surface processes and igneous formation of Mars.

References:

[1] Clark B. C. et al (1982) *JGR, 87,* 10059-10067. [2] Newsom H. E. et al (2007) *JGR, 112,* E03S12. [3] Yen A. S. et al (2005) *Nature, 436,* 49-54. [4] Gellert R. et al (2004) *Science, 305,* 829-832. [5] Bruckner J. et al (2003) *JGR, 108,* 8094. [6] Gellert R. et al (2006) *JGR, 111,* E02S05. [7] Ming D. W. et al (2008) *JGR, 113,* E12S39. [8] Meyer C. (2012) *Martian Meteorite Compendium*. [9] Filiberto J. and Dasgupta R. (2011) *EPSL, 304,* 527-537. [10] Agee C. B. et al (2013) *Science,* DOI: 10.1126/science.1228858. [11] Agee C. B. and Draper D. S. (2004) *EPSL, 224,* 415-429. [12] Newsom H. E. et al (2013) LPSC. [13] Wiens R. C. et al (2012) AGU. [14] Gellert, R. et al (2013) LPSC. [15] Boynton W. V. et al (2004) *Space Science Reviews, 110,* 37–83. [16] Karunatillake S. et al (2009) *JGR, 114,* E12001. [17] Jagoutz E. et al (1979) LPSC. [18] Wänke H. et al (1984) *Lunar & Planetary Sci., XVII,* 919-920. [19] Filliberto J. et al (2006) *Am. Mineralogist, 91,* 471-474.

Acknowledgements:

Funding for H. Newsom supplied by NASA – JPL; Funding for F. McCubbin supplied by the NASA Cosmochemistry Grant; Funding for C. Agee, S. Gordon, and C. Shearer supplied by NASA.