CRUSTAL EVOLUTION OF EARTH AND MARS E. Gazel[1], H. Y. McSween[2], L. R. Moore[1], Dept. of Geosciences, Virginia Tech (egazel@vt.edu), [2] Dept. of Earth and Planetary Sciences, University of Tennessee.

Introduction: Earth's crust is the life-sustaining interface between our planet's deep interior and surface. Basaltic crusts produced by melting of the upper mantle characterize terrestrial planets in the solar system [1]. In contrast, the continental masses, areas of buoyant, thick silicic crust, are a unique characteristic of Earth [2]. Therefore, understanding the processes responsible for the formation of continents is not only fundamental for reconstructing the evolution of our planet but also understanding why the Earth is unique compared to other solar system bodies.

Competing models for continental crust formation: Geochemical evidence suggests that the peak of cratonization (when most of the continents formed on Earth) occurred in the Archean between ~3.5-2.5 Ga [e.g., 3-5]. Two competing hypotheses based on contrasting geodynamic planetary regimes attempt to explain the production of early continental crust: a subduction model and a stagnant-lid model.

The subduction model is based on a uniformitarian perspective and suggests that modern-style plate tectonics operated in the Archean, despite higher mantle temperatures and complex internal planetary dynamics [6]. Subduction processes would account for the H_2O needed for melting of an eclogitic protolith as well as explain the geochemical similarities between Archean tonalite, trondhjemite and granodiorite (TTG, the building blocks of continental crust on Earth) suites and modern magmas with slab melt signatures in some subduction zones [7].

The stagnant-lid model proposes that during the early part of Earth's evolution the crust behaved as a rigid, slowly creeping lid on top of an actively convective mantle. Delamination of dense eclogite into the less viscous asthenosphere resulted in upwelling of hotter asthenosphere, catalyzing multiple melting events that generated suites of TTG [8]. Although numerical models support this hypothesis [9], the occurrence of hydrous phases in most granites and the high temperature solidus of dry eclogite imply that the source contained abundant water and thus, water is needed to generate the large volumes of TTG found at cratonic locations [10]. Finally, the lack of abundant continental crust on other terrestrial planets with stagnant-lid regimes like Mars, Venus and Earth's moon [1] suggests the need of additional processes to produce continental crust that are unique to Earth. Nevertheless, recent *in-situ* felsic data (Fig. 1A) collected in Gale Crater [11] opens the possibility of

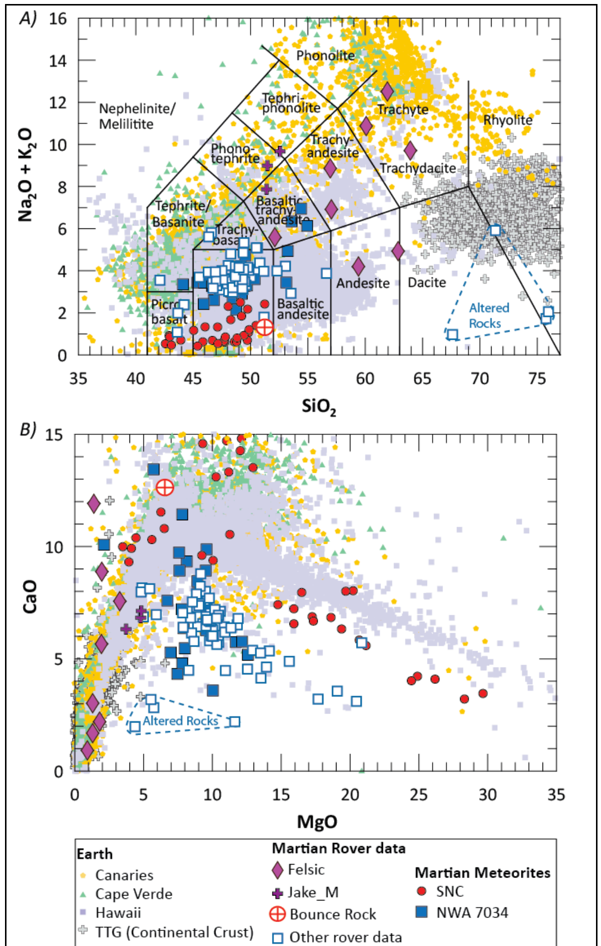

Fig. 1. Comparison of Earth and Mars geochemical data. Martian data from refs. [11, 20-26]. TTG data compiled by ref. 27. Intraplate volcanoes data compiled from the Georoc website and it is available upon request.

early continental crust production on Mars. Here we present a geochemical comparison between Archean TTG suites, intraplate volcanoes, and the available data from Martian meteorites and rover expeditions. Our goal is to test different hypotheses for continental crust formation and their implication for planetary evolution.

Results and discussion: In terms of major element compositions, the Martian data are more consistent with Earth's intraplate volcanoes than continental crust represented by TTG suites (Fig. 1A). The evolution trends produced by crystal fractionation or accumulation are remarkably similar to intraplate volcanoes (especially Hawaii, Fig. 1B). Although the trends are also alike, the only element that is more abundant in Mars' data compared to Earth's intraplate volcanoes is FeO, but this can simply be explained by

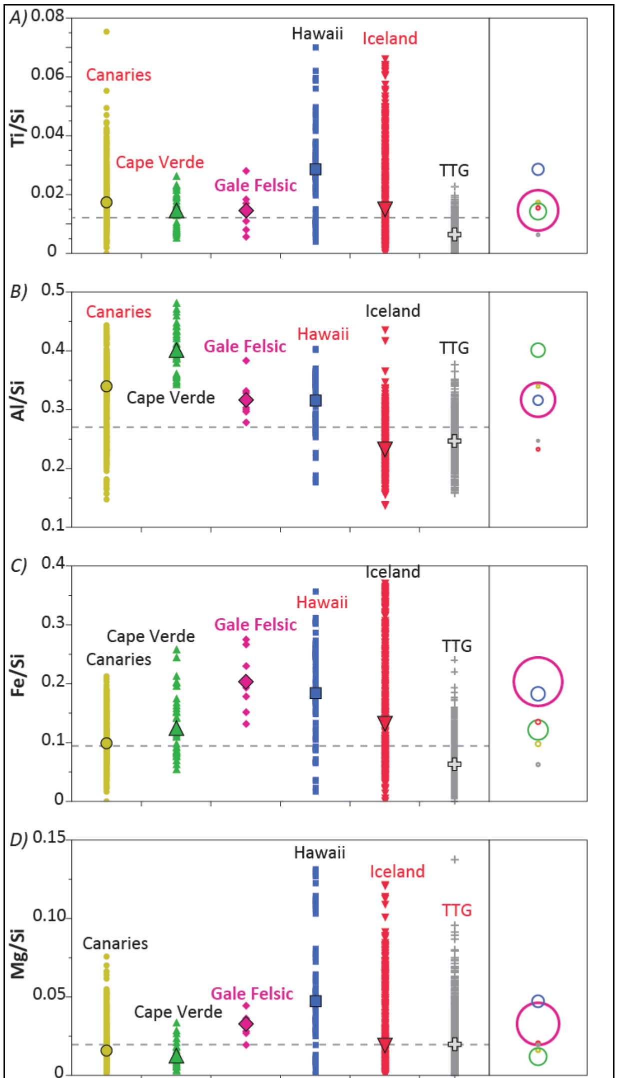

Fig. 2. Comparison between felsic rocks from Gale Crater [11] and examples of Earth (Canaries n=706; Cape Verde n=42; Hawaii n=87; Iceland n=754; and TTG n=1343). The circles in the right display the mean ±2σ comparison colored by locality. The letters in red indicate the mean (represented by bigger symbols) is within the ±2σ of the felsic rocks from Gale crater.

Mars' mantle being more enriched in Fe compared to Earth's [12].

In order to quantify the differences and similarities between Mars and Earth magmas we selected samples from our Earth dataset in the range of the felsic data from Gale Crater [11] (SiO_2 >55 wt% and Na_2O+K_2O >4 wt%, Fig. 1A). We produced major element ratios normalized to Si and compared them using a t-test at a 95% confidence level (2σ). Fig. 2 presents some examples of our statistical evaluation. For all major element ratios the felsic data from Gale Crater [11] are more consistent with Earth's intraplate volcanoes than TTG, only with the exception of Mg/Si that is also statistically equivalent with Iceland.

Earth's continental crust is distinctive from felsic magmas produced in intraplate volcanoes by assimilation and/or fractional crystallization of basaltic melts [1, 2]. Thus, it is possible that the felsic rocks from Gale Crater also represent the result of melt fractionation processes rather than early continental crust production in Mars. Additionally, the continental crust is abundant in quartz [1, 2] and the evidence from orbital chemical data from Mars suggests that both quartz and felsic rocks are not significant [13, 14]. The dominant basaltic composition of Mars' crust is also confirmed by the chemistry of Martian soils and sediments [15-18].

The current geochemical evidence collectively suggests that although there may be a few instances where felsic magmas were produced, the composition of Mars' crust is basaltic and is comparable to magmas produced in intraplate volcanoes on Earth. The continental crust is unique to Earth, and consequently the generation of continents records processes that are also distinctive to our planet. Therefore, we think that plate tectonics and subduction processes, rather than differentiation in a stagnant-lid regime, are necessary to produce continental crust on Earth [7, 19].

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