Melt inclusions in chassignite NWA 2737: A link between processes recorded in martian meteorites and rocks at Gale Crater

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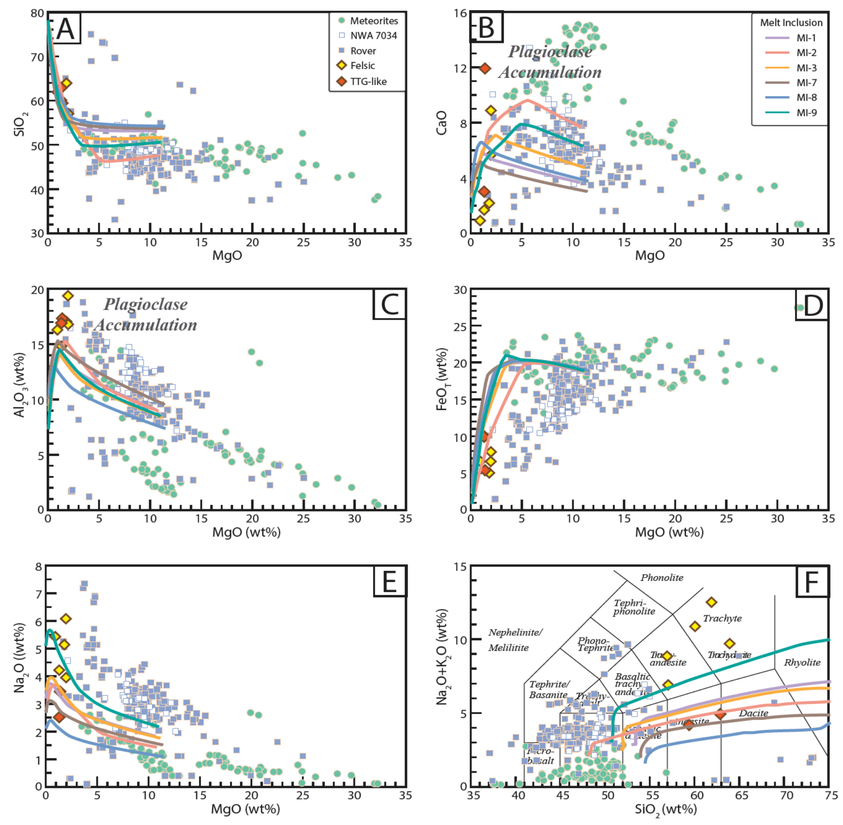
Abstract

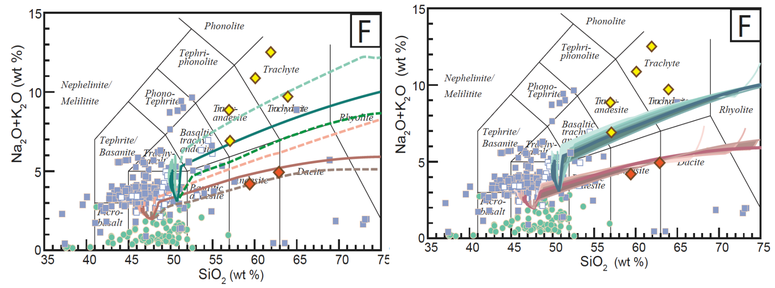
Northwest Africa (NWA) 2737, one of the only three discovered martian chassignites, provides critical constraints on the evolution of the martian mantle and crust. Because of chassignites' cumulative nature, they contain abundant melt inclusions (MI). Here, we present fractional crystallization models using parental magma composition calculated from NWA 2737 melt inclusions as starting compositions. We used the thermodynamic modeling software MELTS to model fractional crystallization of NWA 2737 parental magma compositions with a wide range of parameters (pressure, water content, oxygen fugacity). Our models show that the felsic compositions recently analyzed at the martian surface in Gale Crater, especially Sparkle and Angmaat, the two rocks thought to be analogous to the earliest continental crust on Earth, can be obtained by fractional crystallization of chassignite-like parental melts. Our results suggest a link between the processes that resulted in chassignites and the rocks analyzed in situ at Gale Crater. To assess the possible scenarios for martian magma migration and storage processes, we compared chassignites to terrestrial analogs formed via various mechanisms and proposed two mechanisms that may explain the intrusive and effusive rocks found in situ at Gale Crater: 1) emplacement and fractionation in a closed-system crustal reservoir; and 2) eruption of mafic to intermediate lavas of a relatively open-system subject to constant replenishment.

Modeled Crystallization Paths



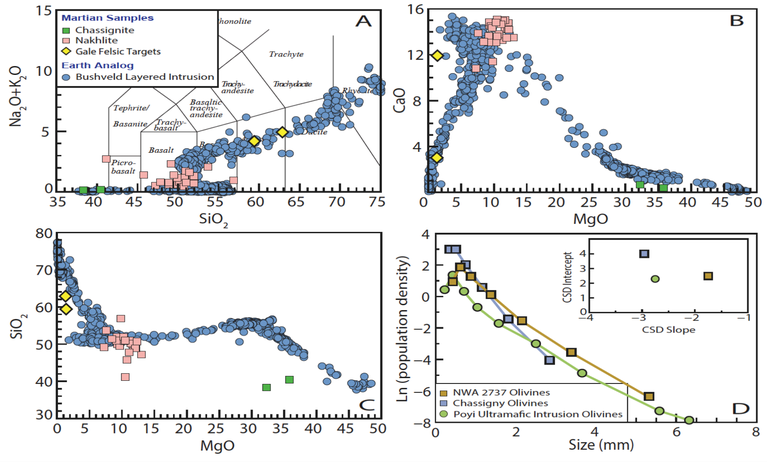
The evolved rocks at Gale Crater, specifically Angmaat and Sparkle, can be formed from fractional crystallization of the NWA 2737 melt inclusions. The enrichment in CaO content and depletion in Al_2O_3 in these felsic rocks suggest the possible fractionation/accumulation of plagioclase.

Effects of different variables

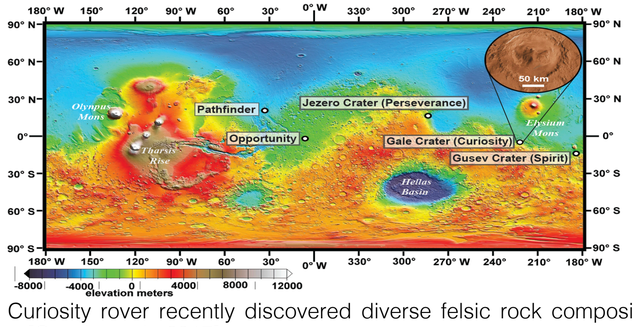


fO_2 can remarkably affect the alkali and FeO_T of the crystallization paths, due to the crystallization of magnetite, a fO_2 sensitive mineral. FeO_T and TiO_2 trends can be significantly affected by a change in water content compared to the other oxides.

Earth Analogs

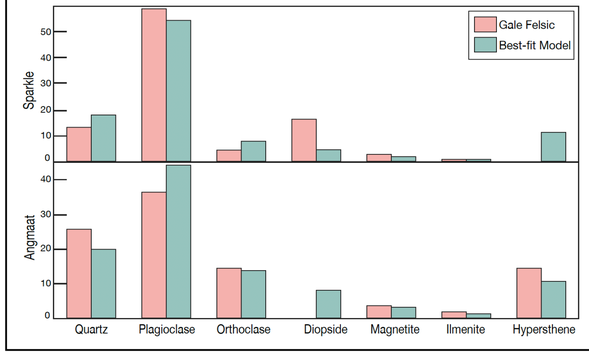


Gale Crater



The MSL Curiosity rover recently discovered diverse felsic rock compositions at Gale Crater [Cousin et al., 2017].

Modeled Phase Abundances



Overall, our models show higher plagioclase and lower K-feldspar abundances compared to the normative mineralogy of the felsic rocks at the Gale Crater. This again suggests the possible removal of plagioclase during crystallization and accumulation in the Gale rocks.

Proposed Scenarios