Chassignite and Nakhlite Parental Melts Determined from Melt Inclusion Analysis

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Project Summary

Driving research question: What is the relationship between the parental melt compositions of the nakhlite and chassignite (martian) meteorites?

Why should we care? Elucidating the petrogenetic relationship of nakhlites and chassignites will constrain the degree of heterogeneity of the Martian mantle and crust.

What did we do? We conducted microanalysis on a suite of nakhlites and chassignites to determine their parental trapped liquid compositions.

What did we find? We found that nakhlites and chassignites likely formed from different, though chemically similar, parental melt compositions.

What is next? Trace element abundances will be determined for nakhlite and chassignite parental melts.

Methods

Electron Microprobe (EMP) Analysis:

-Inclusions: 15 kV accelerating voltage, 10 nA beam current
- Hosts: 15 kV accelerating voltage, 20 nA beam current
- Beam size: dependent on host phase, inclusion complexity [1]
- Inclusion phases are mode-normalized [2]

Melt Inclusion Rehomogenization:

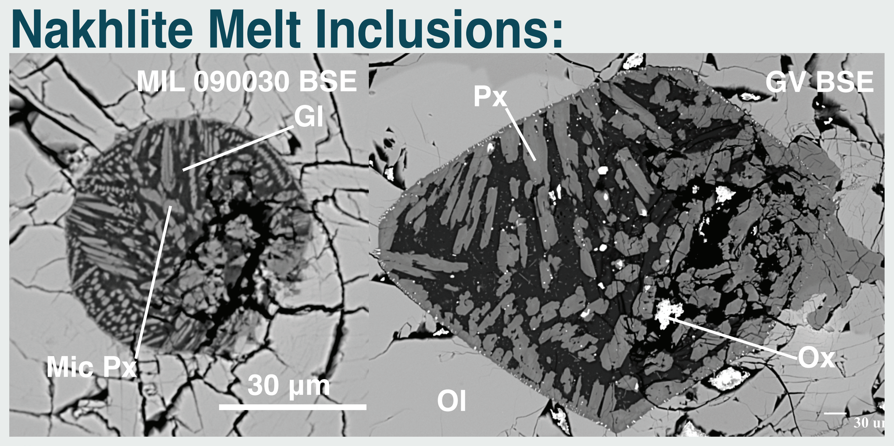
- Olivine-hosted: PETROLOG3 [3]
  - corrects reequilibration for Parental Trapped Liquid (PTL)
  - Required FeO_T value drawn from literature sources [4,5]
- Pyroxene-hosted: Rhyolite MELTS [6]
  - wall pyroxene added until it reaches equilibrium

Fractional Crystallization Modeling:

- Rhyolite MELTS [6]
  - FMQ buffer, 1 kbar pressure, H_2O from 0–2 wt.%

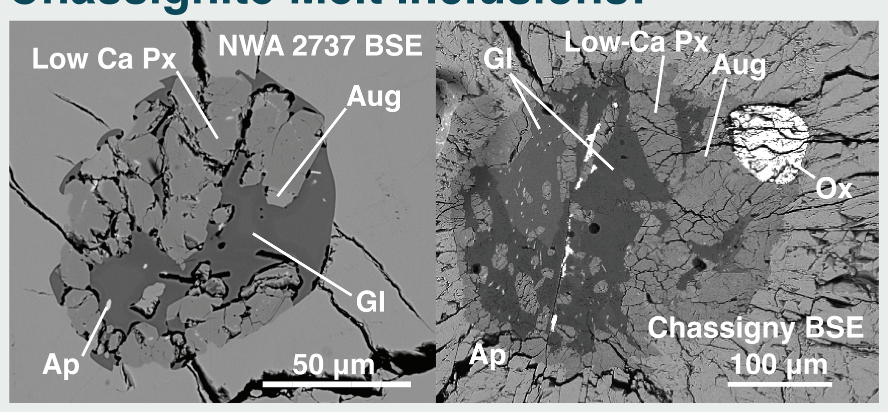
Melt Inclusions

Nakhlite Melt Inclusions:



Samples: (left) Miller Range 090030, simple phase assemblage, (right) Governador Valadares, complex phase assemblage.
Mic Px = Microlytic Pyroxene
Gl = Glass
Px = Pyroxene
Ol = Olivine

Chassignite Melt Inclusions:

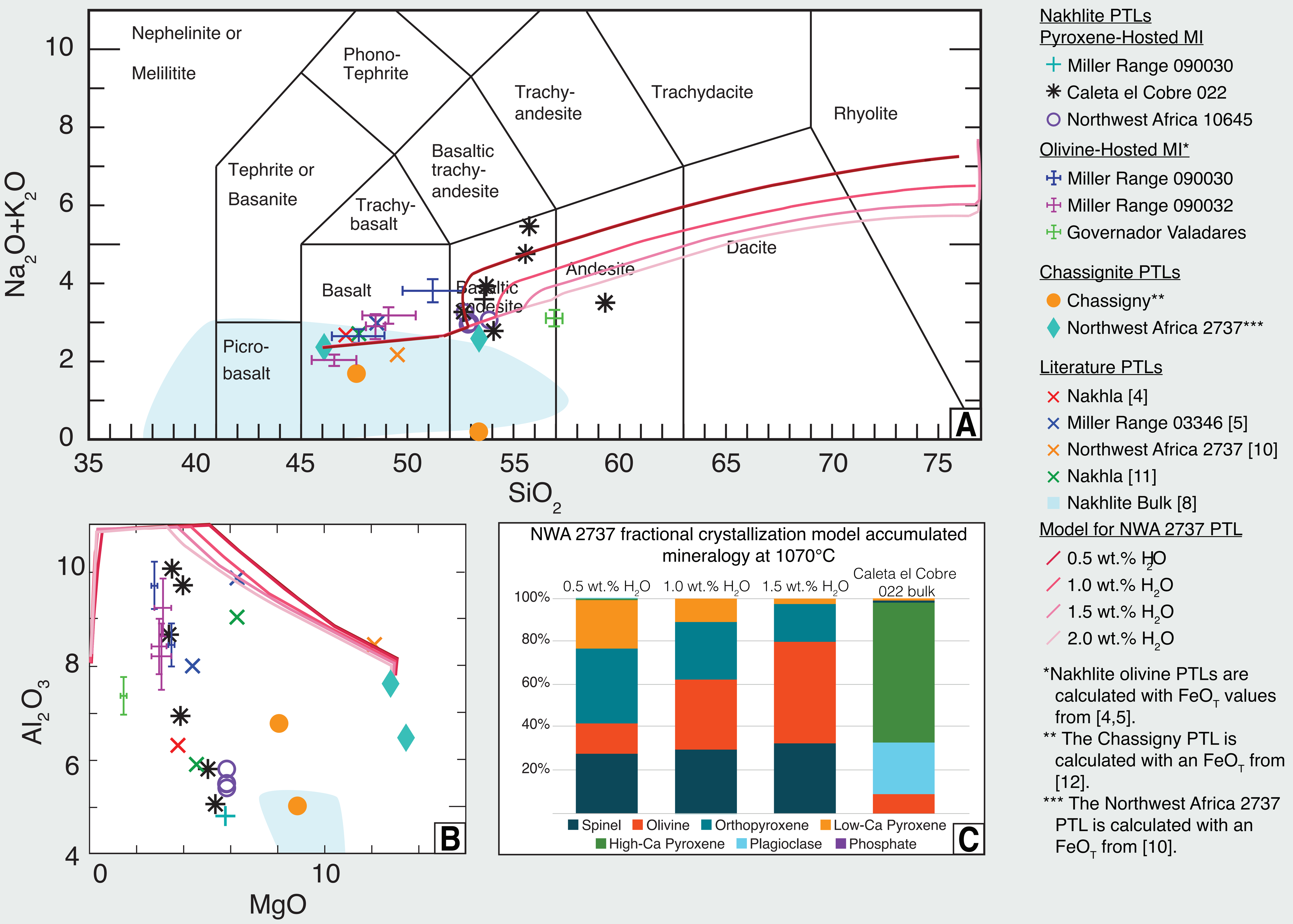


Samples: (left) Northwest Africa 2737 (right) Governador Valadares.
Low-Ca Px = Low Calcium Pyroxene
Aug = Augite
Ap = Apatite
Ox = Oxide

- Melt inclusions (MIs) are pockets of trapped melt inside of a host mineral [7]
- Host minerals are olivine and pyroxene (nakhlites) or olivine (chassignites)
- Phase assemblages range from simple (glassy) to complex (containing pyroxene, glass, oxides)

Results

Parental Trapped Liquid (PTL) Calculations and Fractional Crystallization Modeling:



- Nakhlite and chassignite parental trapped liquids (PTLs) share similar chemistry (Fig. A, B)
- Chassignite PTLs are more primitive than those in nakhlites (Fig. A)
- Northwest Africa (NWA) 2737 PTL liquid line of descent similar to pyroxene-hosted nakhlite PTLs in terms of K_2O and Na_2O, reaching 5.0 wt.% total with 49% liquid remaining at 1070°C (Fig. A)
- Overlap of nakhlite and chassignite PTLs in Al2O3 (2.7–10.3 wt.%) (Fig. B)
- NWA 2737 PTL crystallizes spinel, olivine, orthopyroxene + clinopyroxene, not observed mineralogy in nakhlites (clinopyroxene, olivine) (Fig. C)

Discussion

- There is a range in PTL compositions hosted in both nakhlite olivine and pyroxene
  - One phase may be xenocrystic [13]
- There is a large range of K_2O+Na_2O values in both nakhlite and chassignite PTLs compared to bulk sample chemistry
  - Some samples may originate from a K_2O-enriched source
  - Not present in all samples: enrichment may be secondary
- Chassignite PTLs do not fractionate nakhlite mineralogy, but are similar in chemistry
  - Chassignites and nakhlites may arise from the same or similar sources
  - Chassignites and nakhlites do not share parental melt compositions

Future Work

- Analyze trace elements present in nakhlite and chassignite melt inclusions in order to characterize the source(s) of the suite
- Additional PTL calculations for nakhlite samples, such as Northwest Africa 998 and Northwest Africa 11013
- Constrain metasomatic or hydrothermal chemical influences on nakhlite and chassignite suite

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