Parent magma compositions of lunar highlands Mg-suite rocks: A melt inclusion perspective

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1. Purpose

For the first time here, we explore whether melt inclusions can be useful in retreiving parent melt compositions of Mg-suite rocks. Our approach is to obtain chemical analyses by electron microprobe on melt inclusions in plagioclase and orthopyroxene crystals in ***Mg-norite 78235,47.***

2. Inclusion Petrography

- Melt inclusions in ***plagioclase*** occur in two textures:

  Small glass inclusions (Fig. 1a): <20 µm, mostly ~10 µm; contain siliceous glass (86-92 wt% SiO_2) + grains of oxide phases and/or Fe-Ni metal ± plagioclase crystals ± needle-shape cystals of phosphates(?); glass is heterogeneous.

  Large crystallized inclusions (Fig. 1b): ~30 µm; contain siliceous glass (88-92 wt% SiO_2) + stocky crystals of orthopyroxene ($En_{82-84}Fs_{14-15}Wo_{2-3}$) and/or Al-rich clinopyroxene ($En_{47-80}Fs_{5-12}Wo_{8-48}$, Al_2O_3 = 3.8-6.7 wt%) + grains of oxide phases; glass is heterogeneous.

- Melt inclusions in ***orthopyroxene*** (Fig. 1b, c): <20 µm; contain siliceous glass (75-99 wt% SiO_2) + grains of oxide phases ± cystals of diospide pyroxene ($En_{48}Fs_7Wo_{45}$); glass is heterogeneous.

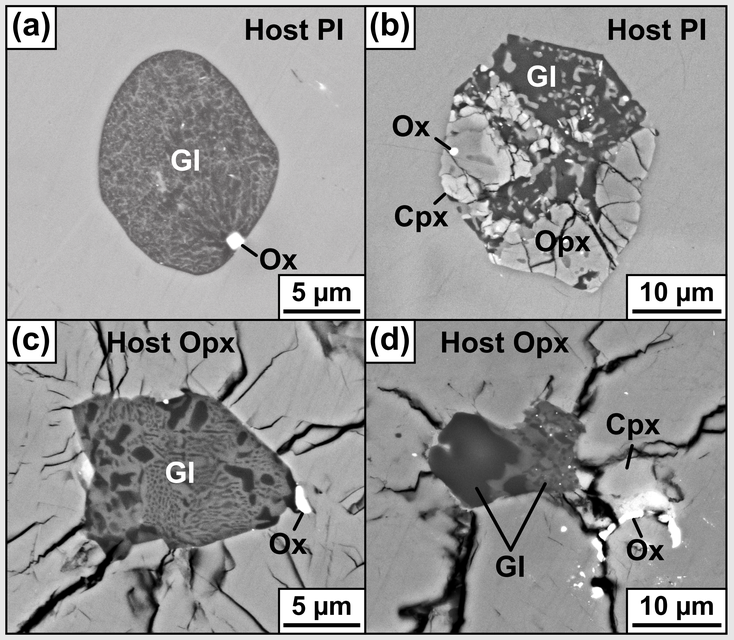

Figure 1. BSE images of melt inclusions in plagioclase (a and b) and orthopyroxene (c and d) from lunar highland Mg-norite 78235,47. Pl = Plagioclase; Opx = Orthopyroxene; Cpx = Clinopyroxene; Gl = Glass; Ox = Oxide phase.

3. Phase and bulk compositions

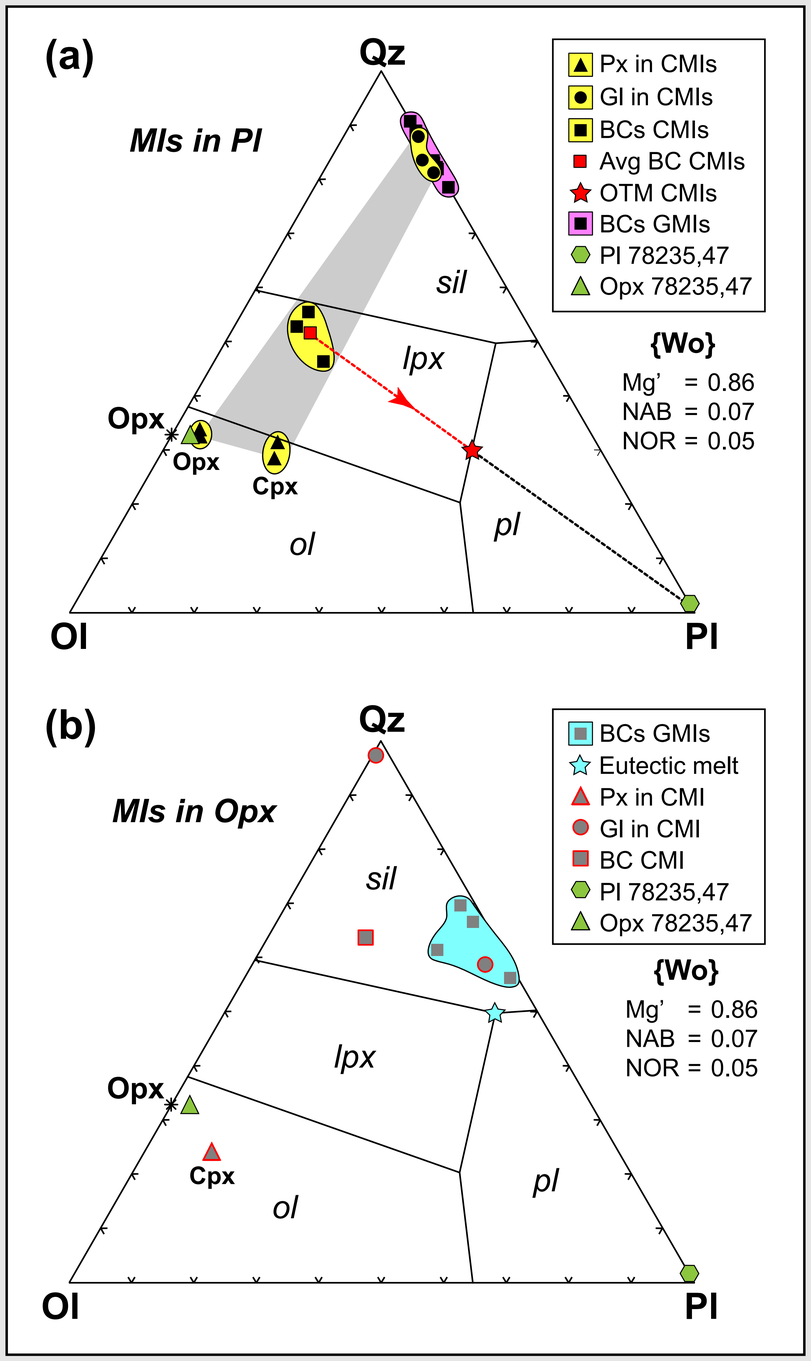

Figure 2. Phase and bulk compositions (BCs) for melt inclusions (MIs) in plagioclase (a) and orthopyroxene (b) from lunar highland Mg-norite 78235,47 projected in oxygen units from Wollastonite (Wo) onto the Olivine-Plagioclase-Quartz (Ol-Pl-Qtz) phase diagram relevant to the Mg-suite parent melt composition from [1], after [2]. CMI = Crystallized melt inclusion; GMI = Glass melt inclusion; Px = Pyroxene; Gl = Glass; OTM = Original trapped melt.

4. Original Trapped Melt

- ***Crystallized melt inclusions in plagioclase*** *(CMIs in Fig. 2a):* An approximation of the original trapped melt composition was reconstructed from their average bulk composition by adding host plagioclase to yield a melt that is cosaturated with plagioclase and low-Ca pyroxene in a model phase diagram for Olivine-Plagiolcase-Quartz (Table 1).

- ***Glass melt inclusions in plagioclase*** *(GMIs in Fig. 2a):* Bulk compositions similar to those of glasses in crystallized melt inclusions. Glass melt inclusions interpreted to be crystallized melt inclusions from which daughter pyroxene crystals were not exposed at the thin section surface.

- ***Melt inclusions in orthopyroxene*** *(CMIs and GMIs in Fig. 2b):* Could represent a metastable extension of the eutectic melt composition.

Table 1. Calculated major element composition of original trapped melt from crystallized melt inclusions in plagioclase of Mg-norite 78235,47.

SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Total
57.92	0.39	17.52	0.06	2.89	0.06	10.08	10.70	0.29	0.07	100.00

Ni, P, F, and Cl were below detection limits in all phases

5. Discussion

- The original trapped melt composition reconstructed for melt inclusions in plagioclase contains very little K_2O and no measurable P_2O_5, in agreement with the very low K_2O and P_2O_5 contents of the bulk norite [3].

- Assuming that all the K_2O in the reconstructed original trapped melt results from the contribution of a lunar KREEP component (as estimated by [4]), we calculate that the original trapped melt contained ~2.5% of that KREEP component.

➡ ***Our data is consistent with minimal contribution of a lunar KREEP component in the source area for the parent melt of norite 78235, in contradiction with the very KREEPy nature of Mg-norites parent melts inferred from trace-element data [5].***

Take home message

1. ***Melt inclusions allow retrieving Mg-suite parent melt compositions.***
2. ***Melt inclusion data is consitent with minimal contribution of a lunar KREEP component in the source area for the parent melt of Mg-norite 78235.***

References

[1] Longhi J. et al. (2010) *GCA* 74, 784-798. [2] Longhi J. (1991) *AM* 76, 785-800. [3] Dymek R. F. et al. (1975) *Proc. 6th LPSC*, 301-341. [4] Jolliff B. L. (1998) *Int. Geol. Rev.* 40, 916-935. [5] Shearer C. K. et al. (2015) *AM*, in press.