#1068

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Quantifying Moderately Volatile Elements of Mare Basalts: Application of the Method.

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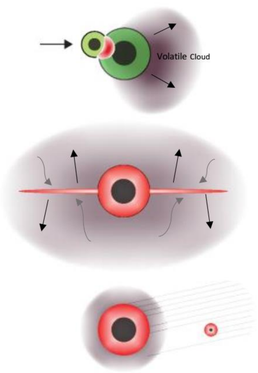
Introduction:



Modified from Hauri et al. (2015) EPSL 409, 252-264.

- Extreme conditions during the Giant Impact should have driven off volatile elements from proto-lunar disc.
- The recent quantification of highly volatile elements (H_2O, Cl, F, & S) shows this not to be the case.
- Elements with higher condensation temperatures (i.e., moderately volatile elements or MVEs) may record early lunar fractionation events.
- MVEs as a suite are difficult to measure: some have low abundances (low-ppb/high-ppt), as well as a lack of reference materials (SRMs).

Issue:

Polyatomic Interferences: e.g., ^{114}Cd

$^{98}Mo + ^{16}O = ^{114}Cd$ ➡ Oxide Interference

$^{74}Ge + ^{40}Ar = ^{114}Cd$ ➡ Argide Interference

Isotope	Zn64	Zn66	Zn68	Se76	Se77	Se78	Se80	Rb85	Rb87	Ag107	Ag109	Cd110	Cd111	Cd112	Cd113	Cd114	In115	Sb121	Sb123	Tl203	Tl205	Bi209
Isobaric									Sr													
Oxide (16)	Ti		Cr	Ni			Zn	Ga	Ga	Zr	Nb	Zr	Mo			Mo			Ag			
Argide (40)	Mg	Mg	Si				Ar	Sc	Ti		Ga	Ge	Ga	Ge		Ge				Dy	Ho	Tm
Chloride (35)		P					Sc		Cr	Ge	Ge				Se		Se		Sr	Er	Er	Yb
Dioxide (32)						Ti	Ti	Cr	Mn			Se		Se				Y	Zr	Yb	Yb	Hf
Hydroxide (17)	Ti	Ti	V	Co	Ni		Cu	Zn	Ge	Zr	Zr,Mo	Nb	Zr	Mo	Mo		Mo					

Isotope (Rel. Abund.)	Zn68 (18.75%)	Se77 (7.63%)	Rb85 (72.17%)	Ag109 (48.16%)	Cd114 (28.73%)	In115 (95.71%)	Sb121 (57.21%)	Tl205 (70.5%)	Pb208 (52.4%)	Bi209 (100%)
Isobaric										
Oxide (16)	Cr		Ga	Nb	Mo					
Argide (40)	Si		Sc	Ga	Ge			Ho		Tm
Chloride (35)				Ge		Se		Er		Yb
Dioxide (32)			Cr				Y	Yb		Hf
Hydroxide (17)	V	Ni	Zn	Zr,Mo		Mo				

1	2	3	4	5	6
Mn	Ga	Sr	Ti	Cr	Ge
Zr	Se	Mo	Nb	Dy	Yb
Zn	Mg	Tm	Co	Y	Sc
Hf	V	P	Er	Ag	Ni
Ho	Cu	Si			

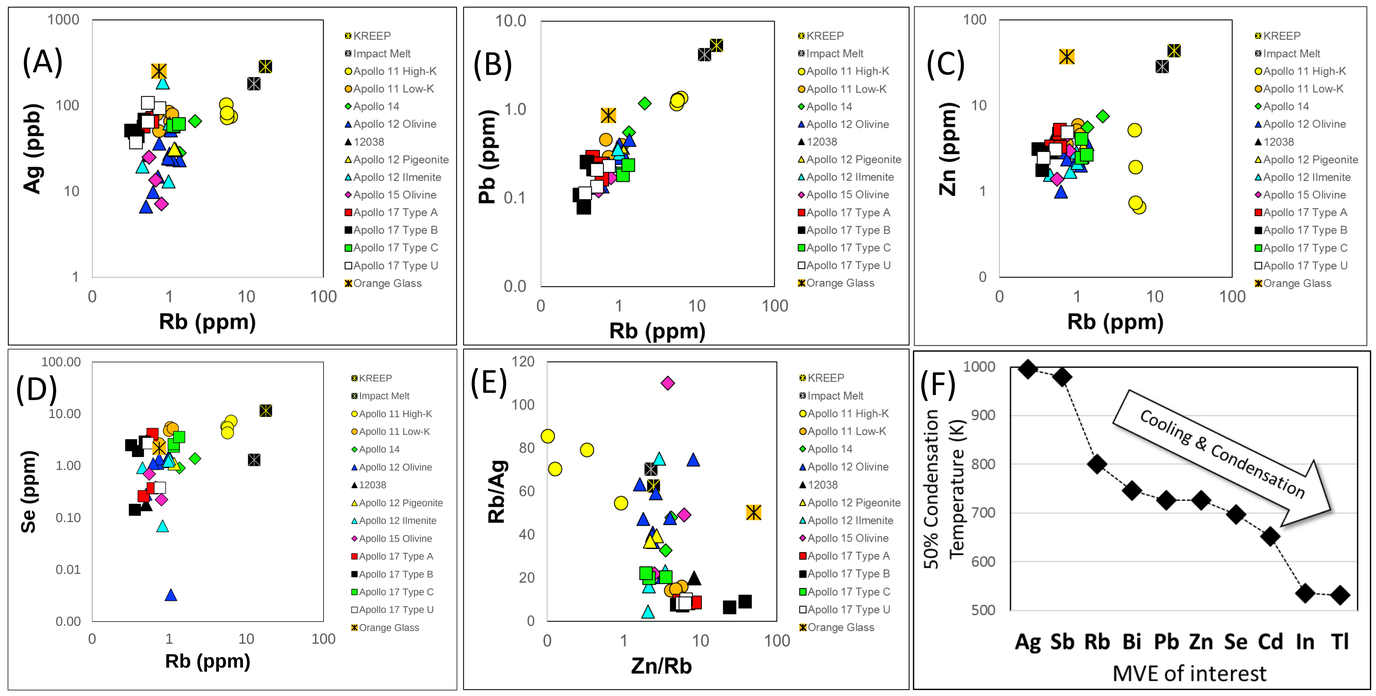
	109Ag
IS1	38
IS1	4
average	**21**
IS2	0
IS2	0
average	**0**
IS3	8
IS3	0
average	**4**
IS4	1295
IS4	1513
average	**1404**
IS5	*714962*
IS5	*729645*
average	***722303***
IS6	49
IS6	29
average	**39**

- Quantify polyatomic interferences using a set of six solutions.
- Remove the interferences from the signal on the isotope of interest to get a "corrected" concentration.
- Repeatedly run BIR-1 & BHVO-2 to establish SRMs.
- Highlighted elements in Red are below current method **detection limit** in lunar material, but measured accurately in the SRMs. Purple elements are below current method **quantification limit**, but are present in lunar material.

Left: Quantifying interferences using the six solutions.

- Solution 1 = Hydroxide (Zr)
- Solution 3 = Hydroxide (Mo
- Solution 4 = Oxide (Nb)
- Solution 5 = Spiked with ~5ppb Ag
- Solution 6 = Chloride (Ge)

Results:



- Figure 1a-c: Ag, Pb, & Zn respectively show different levels of depletions between High-Ti (circles & squaures) and Low-Ti basalts (diamonds & Triangles) with respect to Rb based on condensation temperature relationships.
- Figure 1d: While Se is difficult to measure, it shows a similar pattern as Ag, Pb, & Zn.
- Figure 1e: Rb/Ag vs. Zn/Rb illustrates how High-Ti basalts have been affected by a degassing event.
- Figure 1f: The 50% condensation temperature of the MVEs of interest.

- All elements are replicated in the SRMs with a good degree of accuracy with the exception of Se.
- Cd, In, Sb, Tl, and Bi are below current method detection limits in lunar samples.
- Zn, Se, Rb, Ag, and Pb are more abundant, and match previously published values.

Discussion:

- LMO crystallization models predict that the incompatible MVEs should be more enriched in late stage cumulate sourced basalts (High-Ti) than their early counterparts.
- These data show an unexpected depletion of the High-Ti samples from this expected linear trend.
- This a result of degassing due to a crust breaching impact that occurred toward the end of low-Ti basalt source region crystallization.

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