Low abundances of highly siderophile elements in the lunar mantle: evidence for prolonged late accretion

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Lunar timeline

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alker, R. J., M. F. Horan, C. K. Shearer, and J. J. Papike. "Low abundances of highly siderophile elements in the lunar mantle: vidence for prolonged late accretion." <i>Earth and Planetary Science Letters</i> 224 (2004): 399- 413.□□
arth HSE ~0.008xCl, .15% HSE added after last interaction between core and mantle□Most likely the silicate portion of the moon as stripped of HSE prior to and during coalescence of the moon.□Early lower lunar mantle probably low in HSE□□

Apollo samples

green glasses

- Mare basalt
- 3.4 Ga
- 15-19% MgO
- near primary precursors to very low TiO2 basalts.

orange glasses

- Mare basalt
- 3.3 Ga
- 14-15% MgO
- near primary precursors to high TiO2 basalts.

dunite

- cumulate
- 4.45 Ga
- 43.6% MgO
- highlands magnesian suite

→ melting of magma ocean cumulate assemblages @ >400 km depth, leaving behind ol and opx residuum → cumulate from a pre-mare basaltic melt

How do you get at the lunar mantle composition? □

Glasses most diagnostic of lunar mantle with respect to HSE□

Dunite serves as comparison to high MgO terrestrial rock□□

Exp method

- spherule sample
- spike with known isotopic composition
- etchate: digest 5-30% of sample
- remove spike from residual solids
- ground and respike
- residue: digest 10-50% rela to initial sample masses
- Uncertainties in <u>Os</u> concentration and isotopic composition were typically much less than for the other HSE.

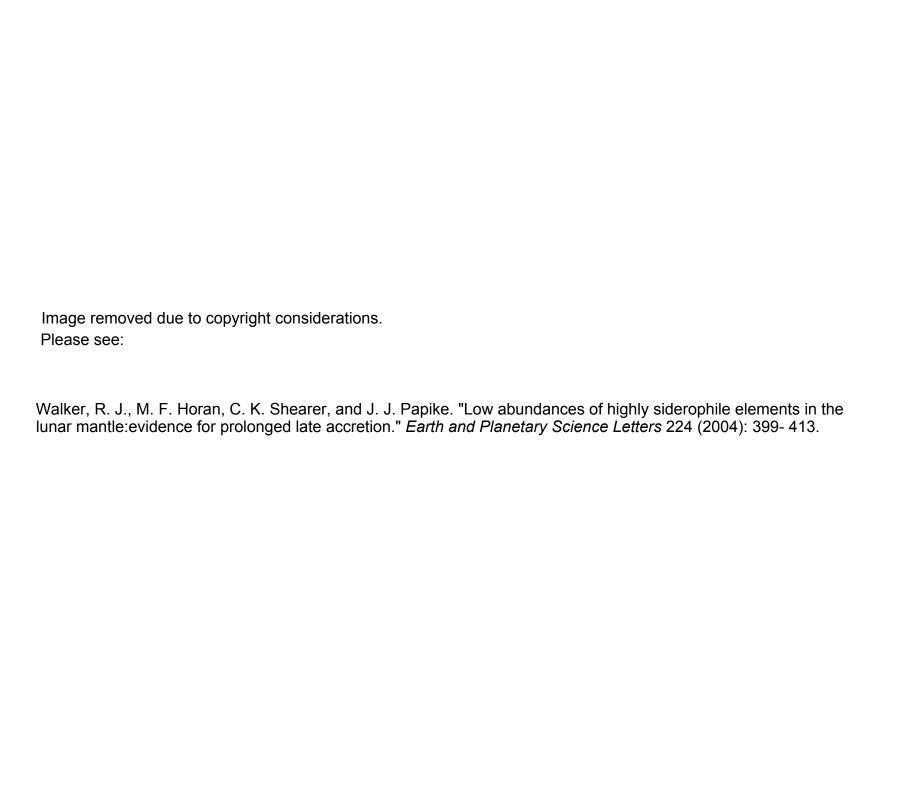


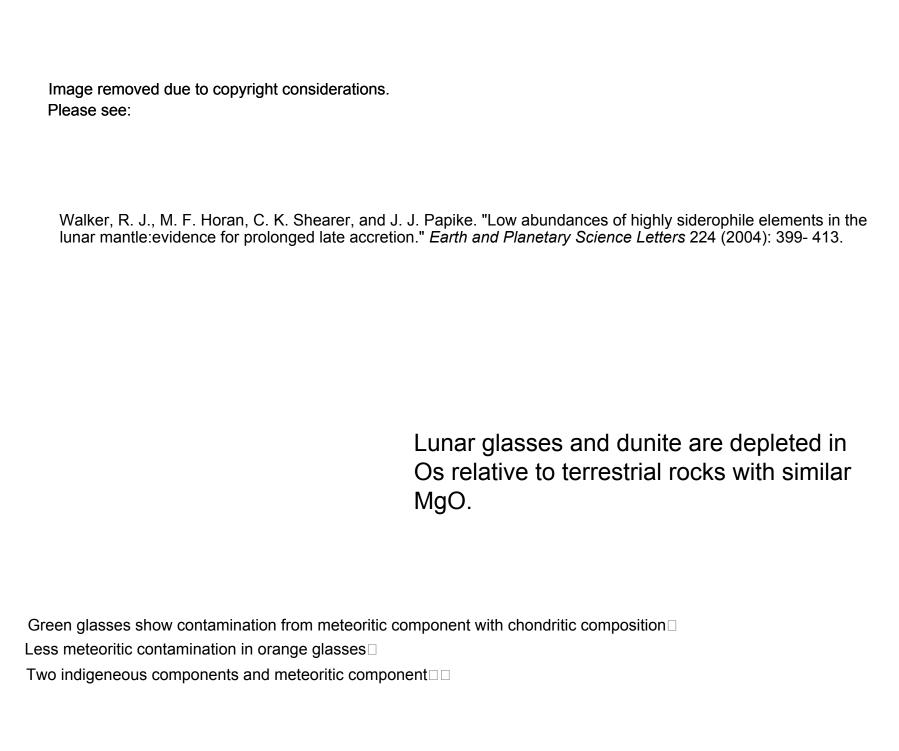
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Pd removed during leaching of samples low concentrations of HSE, dominated by blanks, great uncertainties in the concentrations. more reliable□□

Summary of results

Often...

- residues have higher 187Os/188Os ratios (are more radiogenic) than etchates (green and orange)
- residues are more fractionated than etchates (green)
- residues are depleted in HSE relative to etchates (green)
- orange etchates are more fractionated than green etchates
- finer fractions have higher Os abundances than coarser fractions (green and orange)
- The initial 1870s/1880s ratio for the dunite is within uncertainty of chondritic average at time of formation

Preferential post-eruption additions of micrometeorites to the surfaces of the finer fractions



Discussion

Possible reasons for low HSE abundances in the lunar mantle:

- Lunar mantle assembled largely from the silicate portion of a differentiated impactor (already stripped of HSE).
- 2. Segregation of the small lunar core stripped the silicate mantle of HSE.

Possible reasons for high HSE abundances in the lunar mantle:

3. Late veneer was added mostly before the formation of permanent crust.

- 1. And 2. new lunar max estimates are 40 x higher than estimated from 1 and 2.
- 2. If Os/Os chondritic suggested by dunite little core participation.
- 3. Would expect more mass to accrete to the earth.

Earth 0.1 % of Earth's mass added to account for HSE abundance in upper mantle.

If homogeneous then .4% Earth's mass added to the earth.

Earth/Moon mass influx ratio is 35 suggests .8%moon mass added. Would create similar abundances to the Earth.

Earth/Moon influx ratio may have been much higher than 35.

HSE in the Earth may not be distributed homogeneously in the mantle.

Conclusions

- HSE in the lunar samples ~1/20 terrestrial mantle
- Lunar crust 10 ng/g Os

 → 75% HSE in crust
- Lunar mantle .15 ng/g Os

This suggests late accretion post 4.4 Ga

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low HSE and high HSE/Pd → no metal subchondritic Os/Os Re/Os and relative abundances of the other HSE were not highly fractionated from chondritic in the mantle source of its parental melt