1. Summary

- Apatites in high-Ti basalts display a restricted OH range (~1500-3000 ppm) with large δD variations (~600-1000 ‰) whereas apatites in low-Ti basalts display a larger OH range (~500-15000 ppm), each group displaying restricted δD variations.

- Apatites in basaltic meteorites MIL 05035 and LAP 04841 expand the lower bound for basalt δD values down to ~100 ‰.

- δD variations between ~200 to 1000 ‰ resulted from different amounts of degassing of H-bearing species. Average δD values of low-Ti basalts are consistent with ~85 to ~99 ‰ degassing of H as H₂, starting from a chondritic, C-type, δD value of 100 ‰, which was favoured by the reduced nature of lunar magmas.

- In low-Ti basalts, apatite crystallised after H₂ degassing, the OH variations reflecting different degrees of fractional crystallisation. In high-Ti basalts, large δD variations with relatively restricted range in OH contents imply that apatite crystallisation and degassing were mostly coeval.

- Geochemical modelling suggests that the mantle source regions of the different low-Ti mare basalts could have contained ~5 to 50 ppm H (~45 to 450 ppm H₂O), similar to the estimated water content of the Earth’s upper mantle.

2. NanoSIMS 50 analysis of apatite

- Apatite OH content (ppm)

- ΔH content of the lunar mantle

3. Results

4. OH in lunar apatites

5. High δD of lunar apatites

6. H content of the lunar mantle

7. Source(s) of lunar H

References

Acknowledgments

Icy moon

- Modelling LMO crystallisation suggests ~1 ppm H max. in the lunar mantle [24]. Apatites in KREEP-rich samples are mostly dry [48]. Moon accreted “dry” as volatiles were lost after the giant impact [25]. But, olivine and plagioclase in FAN contain water, implying a wet LMO [26].

- Mantle source regions of low-Ti basalts contain ~5 to 60 ppm H, which may indicate H delivery to the upper mantle after LMO crystallisation [2,21].

Elevated δH values ofapatites have been linked to H delivery by comets [2]. Yet, accretion of cometary material would have also included D-enriched organic material. Hence, bulk D/H ratios of comets are likely higher than those of apatites in lunar basalts [27].

- Apatite δD values may result from >85 ‰ degassing of H₂, starting from a δD of 100 ‰, typical of C1 chondrites [27].

Easier for large chondrite-type objects to breach the crust and reach the upper mantle. Few impacts by planetesimals [28]?