H AND CL ISOTOPE CHARACTERISTICS OF APATITE IN BRECCIATED LUNAR METEORITES NWA 4472, NWA 773, SAU 169 AND KALAHARI 009.

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Introduction: Apatite Pb/Pb and U-Pb dating has been used to decipher ages of basaltic volcanism recorded in lunar meteorites, extending the range of Apollo mare basalt ages up to ~4.35 Ga [1] and down to ~2.9 Ga [2]. Yet interpretation of apatite U-Pb dates can be equivocal when their petrological context is lacking, for example with lone apatite grains found in breccias [3] or soils. The surge for lunar volatiles resulted in a growing database of the H and Cl isotope compositions of volatiles locked in apatites [4-9]. These data suggest that apatite in mare basalts generally show high δD values (> ~500‰) and moderate δ^{37}Cl values (~0-15‰), while apatite from Mg- and alkali-suite intrusive have moderate δD values (< ~300‰) and elevated δ^{37}Cl values (> ~25‰) [4-9]. Analysis of H and Cl isotopes in apatite lacking petrographic context in regolith breccias could, thus, constitute a powerful tool to infer their source lithology.

Results: H and Cl isotopes were measured in apatites in brecciated meteorites NWA 4472, NWA 773, SaU 169 and Kalahari 009 using the NanoSIMS 50L at the Open University [4,6]. In NWA 4472, most of the analyses yielded ~2000-6000 ppm H_2O and δD between -200 and 0‰, except for one matrix apatite containing ~6000 ppm H_2O and δD of ~500-900‰. These low-δD apatites yielded ~2500-7500 ppm Cl with δ^{37}Cl ~15-20‰, while the high-δD grain contains ~2500 ppm Cl with δ^{37}Cl values of ~7-15‰. In NWA 773, apatites fall in 2 groups: they contain ~700-2500 ppm H_2O with δD of ~0±100‰ in the first one and ~5500-16500 ppm H_2O with δD of ~250±50‰ in the second. Apatites in SaU 169 and Kalahari 009 yielded ~600-3000 ppm H_2O with δD between -100 and 200‰. In SaU 169, apatites hold ~6000-10000 ppm Cl with δ^{37}Cl values of ~5-12‰.

Discussion: Elevated δ^{37}Cl > ~5‰ suggest that even though they have experienced some terrestrial residence, apatites in these meteorites still retain their lunar isotopic signatures ($\delta^{37}Cl_{Earth}$ ~ 0‰). Most of them have δD values in the range reported for carbonaceous chondrites [10] and are similar to H_2O-rich apatites from Mg- and alkali-suite rocks [4] and KREEP basalts [7]. One apatite in NWA 4472 yielded δD and δ^{37}Cl consistent with basaltic signatures [6,8]. This grain has been dated at 4.35 Ga [3] and could be a remnant of the oldest known lunar volcanic activity. Finally, some apatites in NWA 773 have extreme H_2O contents, reaching pure hydroxylapatite composition. Fagan et al. [11] argued that numerous evolved clasts in NWA 773 formed through silicate liquid immiscibility (SLI) and these apatites could yield clues on the effects of SLI on volatiles in lunar magmas.

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