THE ENRICHMENT OF NOBLE GASES IN CLUSTER CHONDRITE CLASTS

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Introduction: "Cluster chondrite clasts" (clch clasts) are lithic clasts in brecciated type 3 unequilibrated ordinary chondrites (UOCs) that contain round to strongly deformed, indented chondrules that appear to have collided and accreted in a partially molten viscous stage [1]. Clch clasts have very limited amounts of interchondrule matrix and chondrule rims, resulting in a very high chondrule density [1]. Since chondrules cooled very quickly [2], they probably accreted within hours to days after their formation and built up coherent chondritic rocks with clch clast textures [1]. Later, these rocks were shattered by impacts and lithified as breccias. The latter consist of unaltered clch clasts, embedded in a clastic matrix. This renders these rocks interesting objects for further analysis. For example, the primordially trapped meteoritic noble gases, carried by presolar grains and phase Q reside likely in fine-grained interchondrule matrix of clch clasts. The unusual and rapid formation of the clch clasts may have affected the trapped gas concentrations. Since accretion, these clasts have not disintegrated anymore and, hence, are among the least altered chondritic lithologies. This work complements an earlier study [3]. We present new noble gas data, correlations with petrographic type, and comparisons of noble gases with the presence of interchondrule matrix.

Experimental: We analysed samples (7–79 mg) of clch clasts and, where available, respective host clastic matrice, from 9 Northwest African (NWA) UOCs (official type 3.05-3.7, 3-4, 3-6, actual clasts were classified as 3.05-4) of the H, L and LL groups (NWA 869, 2336, 3119, 4522, 5205, 5206, 5421, 6007, and 6742). Gases were released by fusion in a single step at ~1700°C in a furnace and the isotopes of all elements were measured with a custom-built mass spectrometer [see 4 for details]. He-Xe blank corrections were typically <5 %. The highest corrections, reaching 12 %, were the result of interfering measurements of solar-wind (SW) bearing lunar meteorites.

Results and Discussion: Neon in most clch clasts is entirely cosmogenic, inline with (i) their predominant chondrule content (~90 %) that typically lack primordially trapped gases, and (ii) the presence of the clch clasts as cm-sized objects in their parent body regoliths, preventing significant SW incorporation. Surprisingly, a clch clast from regolith breccia NWA869 shows abundant SW-Ne (in two analyses), while another clast from this meteorite lacks SW. The former might be best explicable by "contamination" of the clch clast with its SW-bearingmatrix.

Most host clastic matrices contain abundant trapped Ne, of mostly SW origin. NWA 4522 (LL3.5) shows the lowest ^{20}Ne/^{22}Ne ratio reflecting the highest primordially trapped (HL) to SW ratio. Confusingly, the clastic matrix sample of NWA 5205 lacks trapped Ne and plots near cosmogenic Ne, near its clch clast counterpart and most other clch clasts. The heavier noble gases Ar-Xe in all clch clasts and clastic matrices show similar, typical trapped ^{36}Ar/^{132}Xe and ^{84}Kr/^{132}Xe ratios, near Q-gas. However, the host clastic matrix show elevated ^{36}Ar/^{132}Xe due to the presence of SW-Ar. Kr and Xe isotopes are generally of Q-gas composition. Clch clasts show typically much higher Kr and Xe concentrations than their host clastic matrix counterparts. This pattern is even more striking when normalizing the concentrations with matrix abundance (typically ~6 vol% interchondrule matrix for clch clasts and ~30 vol% fine-grained (<20 µm) fraction for the host clastic matrix). Both, clch clasts and host clastic matrix, contain similar amounts of metal and sulphide (~7 vol%). The noble gas concentrations in the clch clasts generally decrease with higher petrologic type, reflecting gas loss during metamorphism. NWA 5205, 5421, and 6742 clch clasts contain very small ^{4}He and ^{40}Ar concentrations, suggesting late almost complete gas loss. CRE ages are in the typical range, between 2 and 30 Ma; NWA 3119 and 4522, as well as NWA 5205, 5421, and 6742 seem paired.

The general lack of trapped Ne in clch clasts in their limited interchondrule matrix relative to their host clastic matrix supports the model of a rapid but hot accretion of the still viscous chondrules, which may have degassed the once Ne-bearing matrix constituents during contact and accretion. Late degassing during (mild) metamorphism can be excluded as both, an LL3.05 and an L4 clast show similar depletions. In contrast, trapped Ar-Xe is much more enriched in clch clast relative to the host clastic matrix. Clch clast interchondrule matrices retained their heavy noble gas content. Its origin is unknown, their carrier(s) might have been more gas-rich in the clch clast-forming region or could have been incorporated during rapid chondrule formation and accretion, e.g. into the metal and sulphide phase. Indeed, Vogel et al. [5] found a correlation of trapped ^{36}Ar with metal and sulphide in interchondrule matrix, and associated it with the incorporation of carbonaceous matter, the most likely noble gas carrier, during chondrule formation and extraction of both, carbon and metal-sulphide from the precursors.

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