TRAPPED NOBLE GASES IN MAGNETIC AND NON-MAGNETIC SEPARATES FROM ALLENDE CHONDRULES: CLUES FOR NOBLE GAS FRACTIONATION DURING CHONDRULE FORMATION.

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Introduction: Chondrules were formed by high temperature flash heating and rapid cooling, however their diverse elemental properties suggest that variety of precursors could partially survive the chondrule formation event (e.g. [1]). These precursors might have carried different noble gases components. In addition, during chondrule formation noble gas components could also fractionate between various phases according sequence and duration of crystallization. To look for evidences of such possibilities Ne, Ar, Kr and Xe compositions were measured in magnetic (*M*) and non-magnetic (*NM*) separates from chondrules of Allende meteorite. Primary results were reported earlier [2].

Experimental: Individual chondrules were handpicked from gently crushed Allende meteorite under a binocular microscope. Chondrules were ultrasonicated to remove any adhering matrix material and then weighed. Chondrules were then separated in two populations: Big (> 1mg) and small (< 1mg). Each population is then crushed in agate mortar and during grinding, at regular interval; sieve was used to separate smaller grains to avoid excess grinding. Using hand magnet, the magnetic *(M)* and non-magnetic *(NM)* fractions were separated from big and small chondrule populations. Specimens from each fraction were kept aside to run EDX analyses for major element concentrations. Samples were wrapped in Pt foil and then backed up to 100°C to remove any atmospheric contamination. Noble gas study on samples was accomplished by stepped pyrolysis in three steps: 300°C, 1000°C and melting (>1800°C). Noble gases released at 300°C were similar to the procedural blank, confirming no atmospheric contamination during sample preparation. Noble gases released during 1000°C and melting steps are considered as final results. EDX analyses of each fraction were measured using JEOL 540 SEM and the Tractor Norten 5400 X-ray system. Noble gas results and major element concentrations of each fraction are listed in Table 1.

Results and Discussion:

We used a method suggested by [3] to calculate trapped ^{20}Ne and ^{36}Ar from the measured Ne and Ar compositions.

Ne: Cosmogenic neon dominates in *M* and *NM* fractions of chondrules whereas matrix is enriched in trapped component. Trapped ^{20}Ne for each fraction and matrix samples are listed in Table 1. In case of big

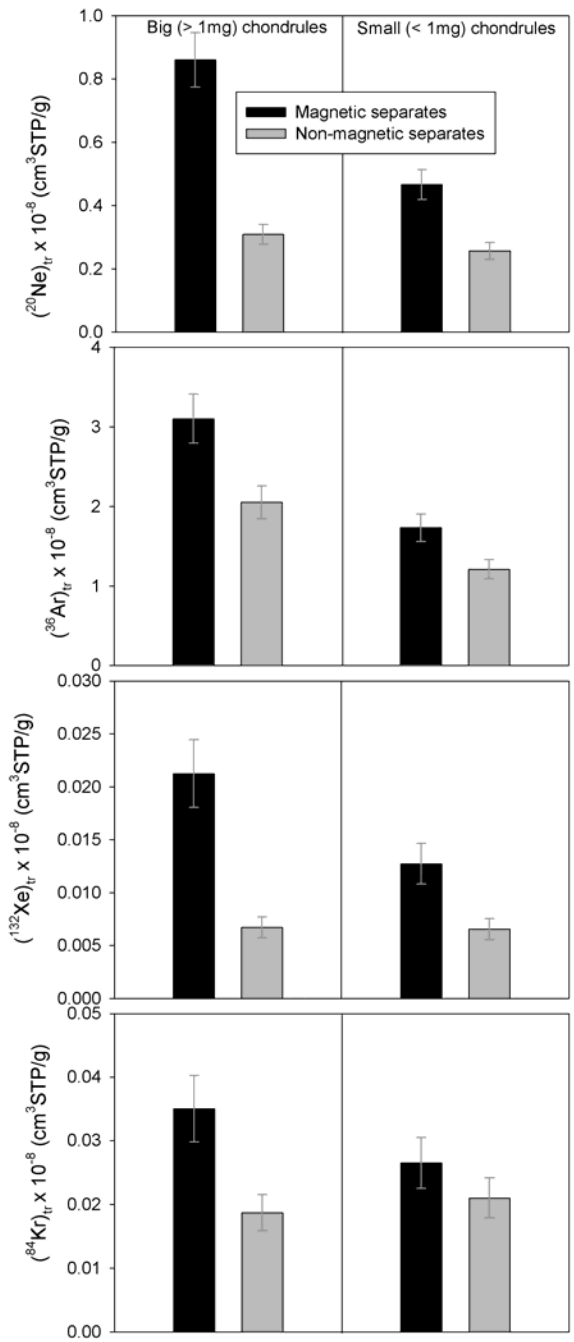

Fig.1 Trapped ^{20}Ne, ^{36}Ar, ^{84}Kr and ^{132}Xe in *M* and *NM* fractions separated from big and small chondrules from Allende. Separates from big chondrules show more difference in concentrations of trapped noble gases.

chondrules, trapped ^{20}Ne is higher in *M* fraction compared to *NM* fraction. Similar result is also observed for small chondrule fractions however, the difference is prominent in case of big chondrules (Fig. 1). Matrix carry high concentration of trapped ^{20}Ne as expected.

Ar: Similar to Ne, Ar is also dominated by cosmogenic component in chondrules and matrix is rich in trapped component. As can be seen in Table 1, trapped ^{36}Ar is higher in *M* fractions compared to *NM* fractions and similar to the case of Ne, the difference is more prominent for the fractions separated from big chondrules (Fig. 1).

Kr and Xe: ^{84}Kr and ^{132}Xe are also listed in Table 1. Similar to Ne and Ar, M fractions are depleted in ^{84}Kr and ^{132}Xe (Fig. 1). On the other hand, radiogenic ^{129}Xe is enriched in *NM* fractions for both the cases of big and small chondrules. In addition, the differences in concentrations are prominent in case of big chondrules compared to small chondrules.

Noble gas isotopic compositions of *M* and *NM* fractions are not different significantly (Table 1). As expected they typically show compositions observed for bulk chondrules (i.e., rich in cosmogenic component) in earlier studies [e.g., 3, 4, 5] as well as different than matrix. Matrix is certainly rich in trapped gases.

EDX analysis indicates that *M* fractions are rich in Fe (Table 1). The difference of Fe content is higher in case of big chondrules whereas fractions from small chondrules show little differences in their compositions. This suggests that big chondrules are less homogenized as well as we were able to separate fractions which are likely to be different. *M* fractions which are rich in Fe content tends to carry more trapped noble gases. Although the separation method we used is not accurate, it is logical to assume that *M* fractions tend to represent metal/metal sulfide rich fractions. We argue that during chondrule formation, metal/metal sulfide phases were crystallized at the end after silicate phase. These phases might have remained in molten state for longer duration therefore could trap more ambient gases compared to silicate phases. However, it is also possible that precursors were carrying different amount of trapped noble gases and during chondrule formation the noble gases were reset/re-trapped according to their melting and crystallization sequence. Nevertheless these results imply that fractionation of trapped noble gas might have occurred during chondrule formation as indicated by few earlier studies [4, 5]. However, it seems that noble gases were isotopically homogenized during chondrule formation and we could only detect difference in trapped noble gas concentrations. High radiogenic ^{129}Xe in *NM* fraction from big chondrules suggest that this fraction might be having minerals like sodalite. Concentration of Na is around 2 wt% in *NM* fraction from big chondrules, while other fractions carry < 1 wt% of Na (not listed in Table 1). However, more detailed characterization is required to confirm the carrier of ^{129}Xe in *NM* fraction from big chondrules.

References: [1] Niemeyer S. et al. (1988) *GCA,* 52, 309-318. [2] Das et al. (2010) *Meteoritics & Planet. Sci., 45*, A41 [3] Eugster et al. (2007) *Meteoritics & Planet. Sci., 42*, 1351-1371. [4] Vogel N. et al. (2004) *Meteoritics & Planet. Sci., 39*, 117-135. [5] Das J. P. and Murty S. V. S. (2009) *Meteoritics & Planet. Sci., 44*, 1797-1818.

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Table 1. Measured and trapped noble gases and major elements in magnetic and non-magnetic fractions from big and small chondrules.

Sample	$^{20}Ne/^{22}Ne$	$^{21}Ne/^{22}Ne$	$^{38}Ar/^{36}Ar$	$^{40}Ar/^{36}Ar$	$^{22}Ne_m$	$^{20}Ne_t$	$^{36}Ar_m$	$^{36}Ar_t$	$^{84}Kr_t$	$^{129}Xe_r$	$^{132}Xe_t$	Fe	Mg	Al	Ca	Si
					(10^{-8} cm^{3}STP/g)							(wt %)				
Big-Mag	1.075 .025	0.910 .005	0.276 .002	974 5	2.92	0.86	3.32	3.10	0.035	0.098	0.021	23.0	15.4	2.5	1.6	14.3
Big-NMag	0.895 .001	0.931 .002	0.653 .001	1537 28	3.03	0.31	3.13	2.05	0.019	0.239	0.007	9.7	21.9	2.2	1.7	19.4
Small-Mag	0.950 .002	0.920 .002	0.253 .004	1690 16	2.90	0.47	1.81	1.73	0.026	0.125	0.013	18.4	17.6	2.5	1.8	15.8
Small-NMag	0.877 .002	0.924 .003	0.283 .004	3137 30	3.11	0.26	1.30	1.21	0.021	0.167	0.006	14.4	17.6	3.7	2.7	17.2
Matrix-Mag	2.851 .001	0.687 .003	0.193 .001	1290 1	2.47	5.43	21.58	21.48	0.189	0.207	0.202	34.8	10.6	1.7	1.4	11.8

Errors in concentrations are 1σ. Errors in elemental concentrations are 10% at the most.