Argon and nitrogen signatures in metal separates from Portales Valley (H6) chondrite

Ramakant R. Mahajan[1]
[1]*Physical Research Laboratory, Ahmedabad-380009, Gujarat, India (email: ramakant@prl.res.in)*

Introduction: Portales Valley is classified as an unusual ordinary chondrite breccia (H6). It consists of silicate mixed with substantial amounts of metal (Kring et al. 1999; Rubin et al. 2001). It shows Widmanstätten pattern in the metal part. Portales Valley was postulated to formed on a large, low density, porous asteroid where a high energy impact took place causing variable degree of melting (Rubin et al. 2001). Noble gas and nitrogen isotopic composition were reported in metal and silicate portions (Garrison and Bogard 2001; Mathew et al. 2005; Mahajan 2020a; Mahajan 2022). The isotopic composition of argon and nitrogen in two aliquots of metal separate from Portales Valley chondrite, analyzed by the method of stepwise heating, is reported.

Experimental details: The metal separates are named as PVMS and PMS. The gas extraction temperature steps were 800-1000-1200-1300-1700 ºC and 400-1000-1700 ºC for PVMS and PMS, respectively. Detailed description of the procedures for sample analysis, noble gas and nitrogen measurements, and the corrections are given in Mahajan et al. (2019) and Mahajan (2020a). Argon and nitrogen were measured in the same aliquot. Data presented in Table 1 is corrected for blanks and interferences. Calculations of cosmogenic and trapped composition were performed using methodology given in Mahajan (2022).

Results and discussion: The argon and nitrogen data for metal separates from Portales Valley are summarized in Table 1. The isotopic composition of argon is dominated by radiogenic ^{40}Ar in one of the aliquots (PVMS) compared to another sample (PMS). The large ratio of $^{40}Ar/^{36}Ar$ in both aliquots are clear evidence for possible inclusions in them. This is consistent with earlier measured samples (Mahajan 2020a). The measured $^{38}Ar/^{36}Ar$ ratio ranges between 0.352 ± 0.002 and 1.524 ± 0.013 in the metal separates, evident for cosmogenic produce as dominant component. The cosmogenic $^{38}Ar_c$ are 1.81 x 10^{-8} and 3.30 x 10^{-8} cm^3STP/g in PVMS and PMS, respectively. The concentrations of cosmogenic $^{38}Ar_c$ in the samples in this study are within the range of earlier reported values in the metal separates (Mahajan 2020a). The concentrations of trapped $^{36}Ar_t$ are 3.70 x 10^{-9} and 9.05 x 10^{-8} cm^3STP/g in PVMS and PMS, respectively. The concentrations of trapped $^{36}Ar_t$ in within the range of earlier reported data (Mahajan 2020a). The concentrations of radiogenic $^{40}Ar_r$ are, 3.18 x 10^{-5} and 5.23 x 10^{-5} cm^3STP/g in PVMS and PMS, respectively.

The N_2 abundances are 9.44 ppm and 7.85 ppm in PVMS and PMS, respectively. The stepwise release pattern is given in Fig.1. Mathew et al. (2005) reported 2.21 ppm and 3.09 ppm N in metal separates of Portales Valley. They reported light N isotopic signature in stepwise release pattern. In earlier work, 2.25 ppm and 1.18 ppm N_2 was observed with light signature in one aliquot and heavy signature on another aliquot of the metal separates (Mahajan 2020a). In contrast to the light signature, a heavy signature in nitrogen is observed in the studied both aliquots of metal separates (Table 1, Fig. 1) from Portales Valley. The cosmogenic nitrogen is estimated using average $^{21}Ne_c$, 2.33 x 10^{-8} cm^3STP/g form earlier metal separates (Mahajan 2020a) and $(^{15}N/^{21}Ne)_c$ of 1.25 (Mathew et al. 2005). The trapped $\delta^{15}N_t$ is, 15.5 ± 1.6 ‰ and 3.4 ± 0.5 ‰ in PVMS and PMS, respectively. This study of metal separates, data from Mathew et al. (2005), Mahajan (2020a) and silicate aliquots (Mahajan 2022) are evident for the anomalous signature of nitrogen in Portales Valley H6 chondrite. In all the three data sets nitrogen isotopic signatures as well as abundances are distinct.

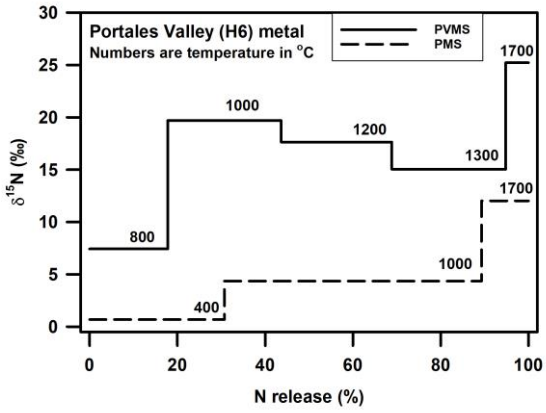

Figure 1. Nitrogen release pattern (%) in two aliquots PVMS and PMS

The bulk H chondrites shows trapped $\delta^{15}N_t$ between -41.0 ± 5.8 ‰ and +15.1 ± 2.1 ‰ (Mahajan 2023) while chondrules exhibit the range of -24.1 ± 8.4 ‰ to +89.1 ± 12.7 ‰ (Mahajan 2020b). The trapped nitrogen isotopic composition in metal separates from Portales Valley is within the range of H chondritic bulk and chondrules measurements. The trapped nitrogen in metal separates from Portales Valley may derive from silicate inclusions entrapped in it during local mixing.

Conclusions: The nitrogen isotopic composition in Portales Valley chondrite is highly heterogeneous. Distinct values of trapped nitrogen isotopic composition are evident of complex mixing between metal and silicates. Post accretionary processes that occurred on the parent body, are the reasons for this type of inter mixing of different constituents that are observed in the meteorite.

Table 1. Noble gas and nitrogen concentrations and isotopic ratios in metal separates of Portales Valley. PVMS: weight= 23.34 mg, PMS: weight = 21.70 mg. ^{36}Ar in 10^{-8} cm^3STP/g. T = Temperature step. 10% error in abundances of Ar and N.

Sample	T	400°C	800°C	1000°C	1200°C	1300°C	1700°C	Total
PVMS	^{36}Ar	-	0.14	0.20	0.88	0.30	0.03	1.55
	$^{38}Ar/^{36}Ar$	-	0.808 ±0.007	1.524 ±0.013	1.439 ±0.011	0.509 ±0.004	1.383 ±0.013	1.210 ±0.010
	$^{40}Ar/^{36}Ar$	-	14764 ±150	2785 ±22	481 ±1	477 ±1	404 ±1	2050 ±17
	N_2 (ppm)	-	1.68	2.44	2.38	2.45	0.49	9.44
	$\delta^{15}N$ (‰)	-	7.43 ±0.13	19.69 ±0.49	17.64 ±0.06	15.05 ±0.13	25.22 ±0.30	16.08 ±0.21
PMS	^{36}Ar	0.88	-	8.61	-	-	1.68	11.2
	$^{38}Ar/^{36}Ar$	0.352 ±0.002	-	0.424 ±0.071	-	-	0.608 ±0.002	0.446 ±0.058
	$^{40}Ar/^{36}Ar$	374 ±4	-	497 ±5	-	-	363 ±4	467 ±5
	N_2 (ppm)	2.41	-	4.60	-	-	0.84	7.85
	$\delta^{15}N$ (‰)	0.68 ±0.04	-	4.35 ±0.52	-	-	12.02 ±0.47	4.04 ±0.37

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