COSMOGENIC NOBLE GASES IN CHONDRULES FROM CV AND CR CHONDRITES. U. Beyersdorf-Kuis[1], M. Trieloff[2], J. A. Cartwright[1], J. Bennett[3] and U. Ott[1], [1] Biogeochemistry Department, Max Planck Institute for Chemistry, Joh.-J.-Becherweg 27, 55128 Mainz (Germany). E-mail: uta.beyersdorf@mpic.de. [2] Institute of Earth Sciences, University of Heidelberg, Im Neuenheimer Feld 236, 69120 Heidelberg (Germany). [3]ANSTO, Lucas Heights, NSW 2234 (Australia).

Introduction: A number of previous studies [1-4] indicate that in some cases chondrules may have been "pre-irradiated", i.e. their cosmic ray exposure exceeds that of the bulk meteorite. There are two possible mechanisms for pre-irradiation: 1) Pre-irradiation in parent body regoliths for which the case seems strong [4], and 2) Pre-irradiation in a solar nebula setting [1-3], but significant uncertainties for this method remain [4]. To expand the database, we have analyzed chondrules and matrix from three primitive meteorites: Allende, Vigarano (both CV3) and El Djouf 001 (CR2).

Experimental: For chondrule separation, we used a freeze-thaw technique, similar to that described by [5]. Concentrations of important target elements were determined by instrumental neutron activation (INAA). Noble gas measurements (He, Ne, Ar) were performed on the same material analyzed by INAA, which - unlike in previous studies - eliminates problems of sample inhomogeneity. Here, we report data for neon and compare our chondrule results with our results for matrix, and with literature data. To obtain CRE ages, we used the production rate P_{21} calculated following [6].

Results and discussion: Data are summarized in Tables 1 (target element abundances), 2 (noble gas results and CRE ages) and 3 (comparison of chondrules vs. matrix).

Table 1: Target element abundances for the production of cosmogenic neon ($^{21}Ne_c$) of matrix (ma) and chondrules (ch) from Allende (Al), Vigarano (Vi) and El

	weight mg	Mg wt%	Al wt%	Si* wt%	Ca wt%	Fe wt%	Ni wt%
Al-mat	38.69	13.3	1.24	18.0	1.38	25.1	1.39
Al-ch3	5.26	20.6	1.93	17.3	1.09	15.9	1.38
Al-ch6	1.17	19.6	2.20	17.2	2.05	16.0	1.12
Vi-mat	21.58	13.9	1.74	18.2	2.17	21.3	1.25
Vi-ch3	0.37	24.8	1.15	16.9	1.42	12.8	0.90
El-mat	13.01	8.87	1.06	18.5	1.18	28.6	1.87
El-ch2	1.70	13.7	1.08	20.5	1.18	22.2	0.37
El-ch4	7.83	19.3	1.81	19.6	2.45	13.5	0.79

*Si was calculated by converting the other major elements into oxides and assume the rest to be SiO_2.

Neon isotopes and components: Neon isotopic data for our analyses are shown in Fig. 1, along with literature data for the respective meteorites. Chondrule neon is dominated by cosmogenic gases, whereas the matrix samples show noticeable amounts of trapped neon. For El Djouf 001, trapped solar wind is the dominant component and abundances are so large that determining the cosmogenic $(^{22}Ne/^{21}Ne)_c$ ratio required for shielding correction is not possible (see below).

Concentrations of target elements, and production rates: Concentrations of cosmogenic neon ($^{21}Ne_c$) in the chondrules are generally higher compared to the matrix, due to a higher abundance of magnesium, which is the most important target element (e.g., [6-7]).

Table 2: Concentrations of $^{21}Ne_c$, shielding parameters $(^{22}Ne/^{21}Ne)_c$, production rates (P_{21}), and cosmic-ray exposure (CRE) ages (T_{21}) of matrix (ma) and chondrules (ch) from Allende (Al), Vigarano (Vi) and El Djouf 001 (El). P_{21} and T_{21} were calculated with shielding correction according to [6].

	$^{21}Ne_c$	$(^{22}Ne/^{21}Ne)_c$	P_{21}	T_{21}
Al-mat	1.89(7)	1.05(2)	0.41	4.6
Al-ch3	2.64(10)	1.06(1)	0.57	4.6
Al-ch6	2.47(11)	1.06(2)	0.51	4.6
Vi-mat	1.51(8)	1.22(2)	0.21	7.2
Vi-ch3	2.32(12)	1.04(4)	0.73	3.2
El-mat	0.80(4)	see text	0.32	see text
El-ch2	1.27(7)	1.24(3)	0.20	6.4
El-ch4	2.15(9)	1.18(1)	0.31	6.9

Uncertainties in the last digits are given in parentheses. Abundances of $^{21}Ne_c$ are given in units of 10^{-8} cc/g, P_{21} and T_{21} are given in 10^{-8} cc/(g Ma) and Ma, respectively.

CRE ages compared with literature data: To compare our data with literature data (obtained on different pieces of the meteorites with different shielding), it is necessary to use shielding-corrected production rates, which we calculated following [6]. Due to the small sample weight of Vigarano chondrule Vi-ch3, analytical errors are large, thus causing a large uncertainty on the shielding parameter $(^{22}Ne/^{21}Ne)_c$. Similarly, no reliable value for the shielding parameter could be determined for El Djouf 001 matrix, because of the dominant contribution of solar Ne (Fig. 1, Tab. 2). Allende chondrules show cosmic-ray exposure (CRE) ages, which agree with previous analyses [3-4]. Concentration of $^{21}Ne_c$ and CRE age of Allende matrix are also similar to the results from former studies [4, 8-10]. Our CRE age of Vigarano matrix (7.2 Ma) is somewhat higher than previously reported [8], while for the El Djouf 001 chondrule, our CRE ages are within the range calculated from previous bulk analyses [11-12].

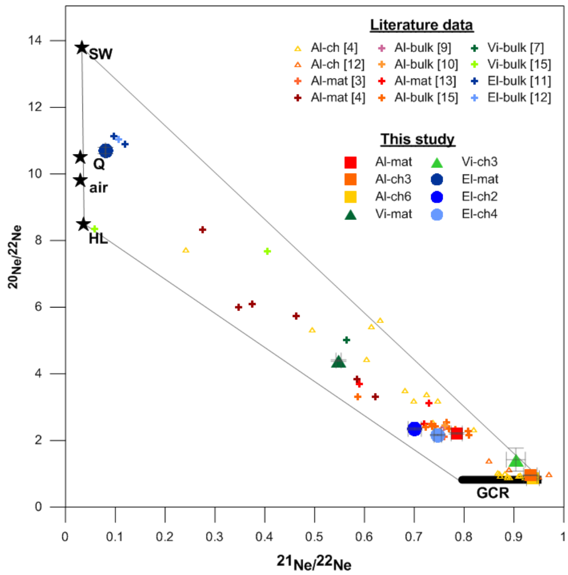

Figure 1: Three isotope plot of neon for Allende (Al), Vigarano (Vi) and El Djouf 001 (El) chondrules (ch) and matrix (mat). Data from previous analyses of chondrules (triangles) and bulk/matrix (crosses) are also plotted [3, 4, 8-15]. Values for solar wind (SW) [16], Q gas [17], air [18], neon produced by galactic cosmic radiation (GCR) [19] and HL gas [20] are also shown.

Comparison of chondrules and matrix: As our chondrules and matrix aliquots were separated from the same meteorite fragments, both experienced essentially identical shielding. A reliable comparison therefore is best performed using "nominal" (or "uncorrected") ages calculated without a shielding correction. The difference in production rates used, thus only reflects the differences in target element abundances. This eleminates uncertainties introduced in the often imperfect shielding correction (while naturally there is an offset between "nominal" and "true" CRE ages). Results from this comparison are listed in Table 3. Allende chondrules yield "uncorrected" CRE ages of 6.1 and 6.0 Ma. This is similar to the "nominal" CRE age of Allende matrix, which suggests no evidence for pre-irradiation, in accordance with the results of [4]. The same is true for our Vigarano chondrule, which is "nominally" only slightly younger than the matrix (4.7 vs. 4.8 Ma). The situation is different for El Djouf 001, where both chondrules have elevated "nominal" CRE ages when compared to the matrix. Thus, El Djouf 001 chondrules may have experienced some kind of pre-irradiation. Like Murchison [4], El Djouf contains abundant solar wind noble gases (Fig. 1), which may indicate pre-irradiation in the parent body regolith. However, as with Murchison [4], pre-irradiation in the solar nebula cannot be ruled out.

Table 3: "Nominal" P_{21} and T_{21} of matrix (ma) and chondrules (ch) from Allende (Al), Vigarano (Vi) and El Djouf 001 (El).

	P_{21}	T_{21}
Al-mat	0.30	6.2
Al-ch3	0.43	6.1
Al-ch6	0.41	6.0
Vi-mat	0.32	4.8
Vi-ch3	0.50	4.7
El-mat	0.18	3.5
El-ch2	0.32	4.0
El-ch4	0.41	5.2

P_{21} and T_{21} are given in 10^{-8} cc/(g Ma) and Ma, respectively, and were calculated without shielding correction, i.e. for $(^{22}Ne/^{21}Ne)_c$ = 1.11.

Conclusion and future work: We have analyzed abundances of important target elements and noble gases in chondrules and matrix from Allende, Vigarano and El Djouf 001 to search for evidence of pre-irradiation. "Nominal" CRE ages of chondrules from Allende and Vigarano are at most a few 0.1 Ma longer than those of the matrices, suggesting no evidence for pre-irradiation. In comparison, chondrules from El Djouf 001 yielded longer "nominal" CRE ages than the corresponding matrix. Whether El Djouf 001 chondrules were pre-irradiated in a parent body regolith setting or in a solar nebula setting cannot be determined at present. Based on the abundance of $^{21}Ne_c$ and chondrule size, twelve additional meteorites have been selected for further work. We will concentrate on enstatite chondrites and CR3 chondrites of highly primitive nature and only incipient alteration [21]. This is because these samples may have better retained potential evidence of pre-irradiation.

References:

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