A FIRST TEST OF A NEW ANALYTE.193 LASER ABLATION SYSTEM: IN-SITU HELIUM, NEON AND ARGON COMPOSITIONS OF CHONDRULE ZONES AND SURROUNDING MATRIX IN NWA 801 CR2 CHONDRITE. J. P. Das, A. P. Meshik, O. V. Pravdivtseva and C. M. Hohenberg. Department of Physics, Campus Box 1105, Washington University, 1 Brookings Drive, Saint Louis, MO 63130, USA. (jdas@physics.wustl.edu).

Introduction: Chondrites can be described as meteorites where normally chondrules are set in fine grained matrix material. Although formation of chondrule was one of the most significance processes during early stages of solar system, very little is known about chondrules and their evolution with respect to surrounding matrix [e.g., 1]. Matrix is considered pristine and it is likely that matrix might have contributed to precursor material used for the formation of chondrules. However, matrix grains are also subjected to higher secondary alteration on parent bodies. In case of gas rich meteorites, matrix is found to be rich in solar noble gases, most likely acquired on planetary surfaces. NWA 801 contains high amount of solar wind [2] and has large chondrules (up to 2.5 mm). Earlier report of presence of solar wind (SW)-like noble gases in one of the chondrules [3] also makes an important claim in support of X-wind model [4]. We take up this study on NWA801 CR2 chondrite to test the recently attached analyte.193 excimer laser to our noble gas mass spectrometer. This test study also provides an opportunity to understand formation of chondrule as well as their relation with surrounding matrix material especially in gas rich meteorites in general.

Gas extraction using excimer laser: NWA 801 meteorite was sliced in ~3 mm thick section using diamond edged disk cutter. Both the sides of the section were polished then documented by back scattered electron (BSE) imaging for textural properties of chondrules and surrounding matrix using JEOL JXA-8900R at the Institute of Earth Sciences, Academia Sinica, Taipei. For the laser probe noble gases analyses, the surface with bigger sized chondrules was chosen. Recently a new 193 nm excimer laser system (Analyte.193) is attached to the noble gas mass spectrometer (for details see [5]) in our laboratory. This system allows irradiating the polished sections with spot sizes ranging from 2.5 to 200 µm. The system has CCD and microscope, co-axial with laser beam. This high magnification set up facilitates clear view up to few µm on the polished sections. The system's ability to perform the spot analyses with precision at the level of few tens of µms found to be useful to study zones within chondrules or bigger grain. We need to ablate enough material to extract sufficient gas significantly above the blank of the noble gas mass spectrometer. For the estimation of the total gas released during ablation we have attached a baratron gauge close to sample cell. Extracted gas was first purified which was followed by trapping of Ar, Kr and Xe on charcoal using liquid nitrogen. The remaining gas introduced first in mass spectrometer for helium and neon analysis. Second, we introduced the fraction trapped on charcoal for argon analysis. Noble gas analysis of each chondrule was followed by study of adjacent matrix for comparison with the chondrule. We have analyzed three chondrules (CH-4, CH-5 and CH-6) so far. Isotopic composition of He, Ne and Ar are given in next section.

Results:

Chondrule CH4: CH4 is an elliptical porphyritic chondrule with ~ 2.3 mm diameter. BSE image shows that outer zone of this chondrule is affected by secondary alteration, disturbing the boundary of chondrule. We choose to analyze two zones: outer (CH4-1) and core (CH4-2), for this chondrule.

Chondrule CH5: This almost spherical chondrule with ~1.8 mm diameter is a porphyritic chondrule with six small (< 50 µm) metal/metal sulfide blebs within it. Three zones, outer (CH5-1), inner (CH5-2) and core (CH5-3) were analyzed.

Chondrule CH6: A thick rim (~600 µm) like texture surrounded the chondrule. This rim like texture is consisting veins most likely created by secondary alterations. Tiny dots of metal/metal sulfides are also present in this zone. Three zones, outer (CH6-1), inner (CH6-2) and core (CH6-3) were analyzed where outer zone and around half of the inner zone were comprised of thick rim like region.

As can be seen in the table, He, Ne and Ar compositions of chondrule and surrounding matrices (given in bold text) are different. Compositions in zones inside chondrules tend towards cosmogenic component, as expected, whereas matrix region just outside the respective chondrules carry predominantly trapped SW-like noble gases. This result is similar to earlier report on NWA 801 [3]. We do not see SW-like noble gases within chondrules. It should be noted that for the chondrule CH4, outer zone (CH4-1) is similar to matrix region unlike other two chondrules. However, this elliptical chondrule has disturbed boundary due to secondary alteration and it is suspected that during laser ablation some matrix region was also irradiated. We need to be cautious near the edge of chondrule as convection heating of matrix can also release some solar noble gases abundant in matrix.

We do not see any effect of special texture in case of chondrule CH6 where outer zone show cosmogenic composition of noble gas even though there is a network of veins that connect these zones to the surrounding matrix.

Table: He, Ne and Ar composition of chondrules and surrounding matrix

Sample	**$^{3}He/^{4}He$ [10^{-2}]**	**$^{20}Ne/^{22}Ne$**	**$^{21}Ne/^{22}Ne$**	**$^{38}Ar/^{36}Ar$**	**$^{40}Ar/^{36}Ar$**
CH4-1	0.042 ±0.001	10.78 ±0.03	0.131 ±0.001	0.196 ±0.001	2.40 ±0.02
CH4-2	0.482 .018	1.36 .05	0.926 .034	1.121 .051	n.d.
CH4-3	**0.038** **.001**	**11.90** **.04**	**0.051** **.001**	**0.194** **.001**	**8.71** **.03**
CH5-1	0.815 .013	1.20 .02	0.855 .011	0.765 .011	169.62 1.86
CH5-2	1.236 .023	0.96 .01	0.894 .016	0.998 .015	175.03 2.18
CH5-3	1.331 .045	0.89 .03	0.873 .027	0.900 .028	176.47 4.59
CH5-4	**0.043** **.001**	**11.89** **.02**	**0.051** **.001**	**0.194** **.001**	**5.63** **.02**
CH6-1	0.533 .014	1.67 .05	0.864 .025	0.260 .001	107.03 .48
CH6-2	.752 .034	1.08 .05	0.830 .037	0.668 .022	430.38 10.54
CH6-3	0.927 .026	1.00 .03	0.878 .026	0.857 .030	332.04 9.74
CH6-4	**0.039** **.001**	**12.03** **.03**	**0.041** **.001**	**0.191** **.001**	**1.73** **.01**
GCR [6]	-	*0.70-0.93*	*0.80-0.95*	*1.54*	-
SW[7]	*0.044*	*13.7*	*0.033*	*0.185*	-

*Isotopic ratios of surrounding matrices are given in bold text

Discussion: So far, the study of three chondrules suggests that chondrule interiors do not contain solar noble gases unlike the matrix where solar gases dominate. It is logical that chondrules lost any trapped gases, which may have been present in the precursor material, during their formation. However, it is also expected that when chondrules are finally accreted on the parent body, they may have spent considerable time in the regolith, especially in the case of gas-rich chondrites. On the other hand, the matrix can trap solar noble gases in two ways: (1) while floating in interplanetary space and (2) later as regolith. The former way of trapping noble gases in interplanetary space may be not be favored, since gas-rich meteorites are distinguished by regolith activity. The former way of trapping noble gases in interplanetary space may be not be favored, since gas-rich meteorites are distinguished by regolith activity. Moreover, the solar wind may not have been able to traverse the early interplanetary space [e.g., 8]. If matrix grains acquired the SW-like noble gases on parent body in the regolith, as is most likely, they were certainly not accompanied by chondrule pre-cursor material that retained solar wind gases, as chondrules are devoid of trapped gases unlike the surrounding matrix. With the present observations it is difficult to explain how the chondrules (devoid of solar gases) were set with solar gas rich matrix material unless the chondrules were formed in the nebula, rather than the regolith. Solar noble gases clearly are implanted into chondrule surfaces, but not the interior, and the absence of an abundance of broken chondrules suggests that compaction occurred relatively soon once the chondrules became available in the regolith. This observation provides constraints on where chondrules formed, on the total degassing of pre-cursor material, and on the timing of meteoritic formation on the gas rich meteorite parent body.

Conclusion: This test study suggests that a new Analyte.193 laser ablation system can be used for the in-situ study of chondrules and adjacent matrix on polished section. As an improvement to our present method, we need to devise a way to estimate the ablated mass from the section which will enable us to determine amount of noble gases.

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