VOLUME CORRELATED SOLAR NOBLE GASES IN WASHINGTON COUNTY IRON METEORITE.

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Introduction: Noble gases in most iron meteorites are dominated by cosmic ray produced component, in particular for He, Ne and Ar [1]. It has been found that in non magmatic irons that have silicate, troilite and graphite inclusions, trapped noble gases of Q composition have been observed [2]. But in the unique case of Washington County (WC), an ungrouped iron meteorite, solar composition of noble gases has been detected [3], but with an ambiguity about the sample location, surface or interior [4]. Recently, surface layers of Arlington [5] and surface and interior samples of Kavarpura [6], both belonging to the non magmatic irons have been shown to contain solar noble gases. Here, we present results of noble gas measurements from well-documented samples of WC.

Samples and Experimental Procedures: Washington County is an ungrouped iron meteorite with 9.9 wt% Ni [7]. We have obtained a rectangular slab of WC (part of sample #1046) from Harvard University, Mineralogical Museum, one end of which represents the fall surface and the other end, the interior (see Fig. 1). Three samples, S (from the fall surface), A and B (from the interior) have been analysed for noble gases. The gases have been extracted from each sample by stepwise pyrolysis at 800^{o}C, 1200^{o}C and 1700^{o}C, in an all metal resistance heater with low blanks and analysed by standard procedures [8].

Results: He, Ne and Ar abundances and isotopic compositions are corrected for blank, interferences and instrumental mass discrimination. The measured amounts have been decomposed into trapped and cosmogenic components using Solar Wind (SW) as trapped component and are given in Table 1. Trapped elemental ratios are clearly trending towards SW composition, among the possible reservoirs such as SW, Q and atmospheric. Unlike the earlier report [3], the trapped elemental ratios are found to be fractionated solar values in the present work. The data for all the temperature steps of the three samples fall along SW-cosmogenic mixing line in the Ne-three isotope plot (Fig. 2), (though some air contamination is apparent in the 800^{o}C step of sample B) clearly showing the presence of solar wind Ne in both surface and interior samples. Hence, the present work demonstrates that apart from the earlier solar gas detection [3, 4] in unablated rear surface sample of WC, the interior samples also hold the solar gases. Trapped ^{20}Ne is in fact more (> 80%) in the most interior sample A, as compared to the present surface sample S (60%). Therefore, trapped solar gas distribution is heterogeneous in WC. In Fig. 3, the release pattern of trapped (^{20}Ne) and cosmogenic (^{21}Ne) components have been shown for sample A and they are very similar with peak release at 1700^{o}C. Similar behavior is observed for trapped and cosmogenic He and Ar as well and for all the three samples. If the trapped gases are surface implanted the peak release will be at much lower temperature as in the metal separated from lunar soil 68501 [9]. Peak release of trapped gas at 1700^{o}C, similar to cosmogenic gas in WC suggests that the trapped gases are volume correlated and not surface implanted.

Fig.1. *Location of samples in the WC slab that have been analysed for noble gases.*

Cosmogenic nuclides and exposure age: The cosmogenic ratios ^{3}He/^{21}Ne, ^{4}He/^{21}Ne, ^{4}He/^{38}Ar, ^{38}Ar/^{21}Ne in an iron meteorite can be used as indicators of sample depth within the meteoroid during cosmic ray exposure. The measured ratios in WC are in the range expected, suggesting their quantitative retention and negligible loss. Using (^{38}Ar/^{21}Ne)$_{c,}$ location of the measured surface sample (S) in WC was estimated at nearly 6 cm below the surface of the pre-atmospheric meteoroid of radius 12±2 cm [10].

Accordingly, the production rates of cosmogenic nuclides for a meteoroid of radius ~12±2 cm, have been calculated using the physical model [10] with (^{38}Ar/^{21}Ne)$_c$ as depth indicator. Production rates of cosmogenic nuclides ^{3}He, ^{21}Ne and ^{38}Ar were calculated by the use of only Fe-Ni composition of 90.1% Fe and 9.9% Ni of WC [7]. Inspite of having the same Fe and Ni composition for S, B and A, the production rates are different for each sample because of their difference in shielding depths (see Fig. 1).

Production rate of ^{21}Ne is particularly sensitive to S and P content of sample. We have corrected the measured ^{21}Ne$_c$ for contributions by S and P in the sample, using (^{22}Ne/^{21}Ne)$_c$ as the index [11]. Using the systematics developed by *Ammon et al*. [11], we have calculated the exposure age that is free of S and P contribution. We adopt the cosmic ray exposure age for WC as the average of T_{21} and T_{38} from all the three samples, 276±41 Ma.

Discussion and Conclusions: Neon isotopic composition and elemental ratios of trapped gases clearly show the presence of trapped solar gases in the interior sample of Washington County iron meteorite. Gas release pattern shows that, the trapped gases are volume correlated rather than surface implanted, which again confirms the presence of trapped solar gases in the interior of the meteorite. Elemental ratios of the trapped gases clearly show fractionation, as compared to the values expected, based on Genesis data [12]. So far, volume correlated solar gases (in particular for He and Ne) have been only observed in the mantle samples of Earth [13]. So the SW gases must have been acquired by WC during the formation of its parent body, in a process similar to that of Earth. So far, we have found two iron meteorites, WC and Kavarpura [6], both showing solar gases that are heterogeneously distributed in the interior samples, indicating that the solar gases are hosted in a minor phase which is heterogeneously distributed in the metal. Several models have been proposed so far for the origin of iron meteorites hosting silicate inclusions, to account for their mineralogical diversity and chemical heterogeneity [14, 15]. The present observation of solar gases provides new constraints to the existing models. It would be important to look for the carrier phase of SW gases and such efforts are presently under way.

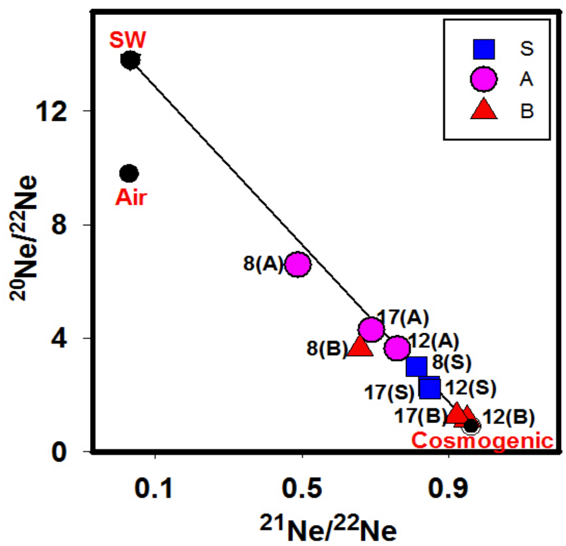

***Fig. 2**. Ne three isotope plot for all the three samples of WC. Temperature of extraction in 100s of °C is shown for each point. See Fig. 1 for sample locations.*

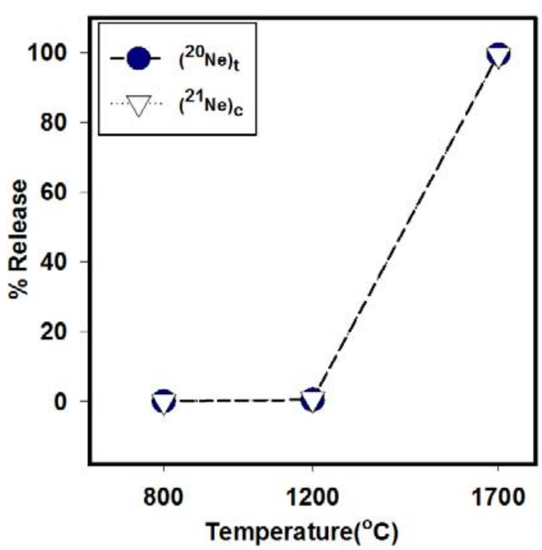

***Fig. 3**. Release pattern of trapped and cosmogenic Ne components are shown for sample A. Maximum gas for both components is released at melting step.*

***Table1**: Trapped (t) and cosmogenic (c) gas amounts (in units of 10^{-8} ccSTP/g) and ratios for the three WC samples S, A, B. (*Corrected for contributions from Sulfur and Phosphorus)*

	Surface S	**Interior A**	**Interior B**
^{20}Ne$_t$	5.31	19.5	1.22
(^{4}He/^{20}Ne)$_t$	304	320	153
(^{20}Ne/^{36}Ar)$_t$	15.3	22.6	7.2
^{21}Ne$_c^*$	2.91	2.97	2.60
(^{3}He/^{21}Ne*)$_c$	55.3	60.8	58.1
(^{38}Ar/^{21}Ne*)$_c$	4.8	6.4	5.4
T_3(Ma)	164±24	271±40	178±26
T_{21}(Ma)	225±33	391±58	260±39
T_{38}(Ma)	207±31	345±51	228±34

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