NITROGEN AND NOBLE GASES IN TWO MONOMICT UREILITES ACFER277 AND FRO90036 FROM HOT AND COLD DESERTS. V. K. Rai[1,2], S.V.S. Murty[1] and U. Ott[3]; [1]Physical Research Laboratory, Ahmedabad-380009, India; [2]University of California San Diego, La Jolla, CA, 92093-0356, USA; [3]Max-Planck-Institut für Chemie, Becherweg 27, D-55128 Mainz, Germany.

Introduction: In our continuing effort to understand the nitrogen and noble gas isotope systematics in ureilites [1-4], we analyzed bulk samples and acid resistant residues of two monomict ureilites ACFER277 and FRO90036 (henceforth AC277 and FRO36). These two ureilites have been recovered from Sahara desert and Antarctica respectively.

Results and Discussions: The bulk samples as well as HF/HCl resistant residues of these two ureilites, AC277 and FRO36 were analyzed by stepwise pyrolysis and combustion (at 2 torr oxygen pressure) respectively. The initial two temperature steps (400º and 500ºC) of bulk samples analyses were by combustion at 2 torr oxygen pressure.

ACFER277: The bulk sample of AC277 contains 10.3×10^{-8} ccSTP/g of ^{22}Ne, with ^{20}Ne/^{22}Ne and ^{21}Ne/^{22}Ne ratios of 9.97±0.02 and 0.053±0.001, respectively. The present sample has more trapped Ne component as compared to an earlier analysis [5], though the cosmogenic ^{21}Ne contents are in good agreement. We calculate a cosmic ray exposure age of 0.6 Ma using production rates corresponding to average ureilite chemical composition and average shielding [(^{22}Ne/^{21}Ne)$_c$=1.11], following the procedure used by [3]. The meteorite contains 22.7 ppm of nitrogen with a δ^{15}N value of –32.3‰, in agreement with earlier results (N=20.9 ppm, δ^{15}N=–22.1‰) [6]. The lightest nitrogen observed at 1400ºC has a δ^{15}N value of –92.8‰, whereas the initial combustion at 400º and 500ºC releases heavier N with δ^{15}N ≥+26‰, indicative of the presence of a combustible phase that carries heavier N. The sample contains 319×10^{-8} ccSTP/g of ^{36}Ar with ^{40}Ar/^{36}Ar = 0.250±0.001. Heavy and light N components are better resolved in the combustion of the HF/HCl residue. Release patterns for, argon, nitrogen and the corresponding ^{40}Ar/^{36}Ar and δ^{15}N are plotted in Fig. 1 a,b. The lightest nitrogen (δ^{15}N ≤ -115.4±0.3‰) coincides with peak nitrogen, C and ^{36}Ar releases as well as the lowest observed value of ^{40}Ar/^{36}Ar at 700ºC. Carbon, nitrogen and ^{36}Ar are all well correlated in release upon combustion, indicative of the same carbon carrier for light N and primordial noble gases. In addition to this major light nitrogen component, nearly 11% of nitrogen, which is released in the 400ºC and 500ºC temperature steps, has δ^{15}N≥71‰. The residue contains a total 360 ppm of nitrogen with δ^{15}N of –81‰ and 12850×10^{-8} ccSTP/g of ^{36}Ar with ^{40}Ar/^{36}Ar value of 0.024±0.002. The carrier phases of the low temperature (400-500°C) heavy N and high temperature (700-800°C) light N during combustion have ^{14}N/^{36}Ar values of 12240 and 4050, respectively, and are consistent with the amorphous carbon and diamond that have been identified in other monomict ureilites [2]. The noble gas elemental ratios ^{36}Ar/^{132}Xe and ^{84}Kr/^{132}Xe for the bulk sample and the HF/HCl residue are 159, 1.11 and 259, 1.42 respectively, and are in the range normally observed in ureilites [3].

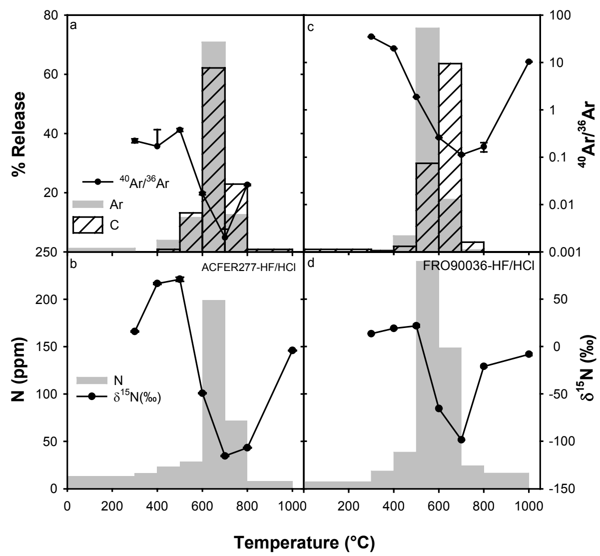

Fig. 1. ^{36}Ar, C, N release patterns and δ^{15}N, ^{40}Ar/^{36}Ar for acid resistant residues of ACFER277 (a, b) and FRO90036 (c, d).

FRO90036: The bulk sample of FRO36 has 14.3×10^{-8} ccSTP/g of ^{22}Ne with ^{20}Ne/^{22}Ne and ^{21}Ne/^{22}Ne ratios of 7.98±0.02 and 0.197±0.001, respectively. Adopting a procedure similar to the case of AC277, we calculate 6 Ma exposure age for this ureilite. N data are being reported for FRO36 for the first time. The bulk sample contains 33.5 ppm N with δ^{15}N=5.1‰. The lightest nitrogen released at 1400°C has a δ^{15}N of –85‰, whereas the nitrogen released at 400°C combustion has δ^{15}N=65‰. This indicates that there is heavy nitrogen present in this ureilite with δ^{15}N≥65‰ (N release at lower temperature steps might be diluted by surfacial terrestrial contamination). The meteorite contains 150×10^{-8} ccSTP/g of ^{36}Ar with ^{40}Ar/^{36}Ar value =

1.46±0.01. Nitrogen in the acid resistant residue of this ureilite is 15 times enriched (494.5 ppm) as compared to the bulk sample and has a $\delta^{15}N$ of –60‰. The residue contains 4690×10^{-8} ccSTP/g of ^{36}Ar with $^{40}Ar/^{36}Ar$ value of 0.471±0.002. Releases of N and noble gases (^{36}Ar) are parallel, but there is a slight shift in the peak C release to higher temperature (see Figs. 1c,d) indicating the presence of a carbon phase other than diamond, that is depleted in noble gases and light nitrogen. The lightest nitrogen released from this residue has a $\delta^{15}N$ of –98‰, slightly heavier than in the case of AC277. This could be due to co-release of relatively heavier N carried by another C phase along with light N carried by diamond. This second carbon phase with relatively heavy nitrogen might be graphite [1]. The elemental ratios $^{36}Ar/^{132}Xe$ and $^{84}Kr/^{132}Xe$ for the bulk sample and HF/HCl residue are 73,0.90 and 59,0.82 respectively. They are on the low end of the ureilite range [3]. Also, peak release of N, Ar, Kr, Xe during combustion of the HF/HCl residue occurred at a relatively low temperature of 600°C. FRO36 shows heavily shocked textures of olivines and pigeonites [7] and the shock may have disturbed the release pattern of noble gases from the carbon phases and, at the same time, caused partial loss of Ar from the amorphous carbon phase.

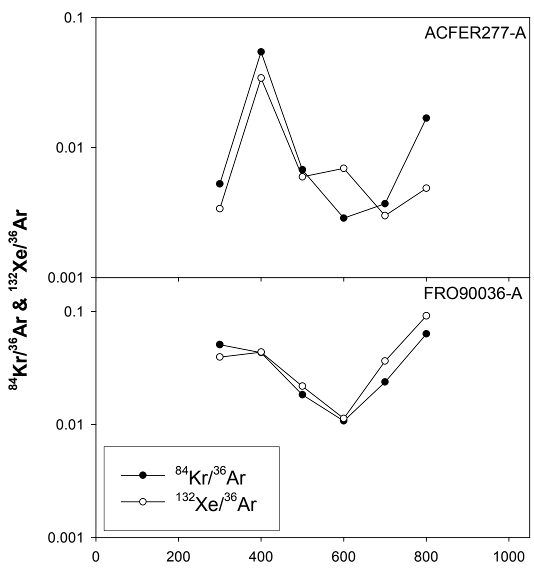

Fig 2. Noble gas elemental ratios ($^{84}Kr/^{36}Ar$ and $^{132}Xe/^{36}Ar$) during combustion of HF/HCl residues from AC277 and FRO36.

In Fig 2, it can be seen clearly that the ratios $^{84}Kr/^{36}Ar$ and $^{132}Xe/^{36}Ar$ decrease with increasing temperature in the region (600-700°C) where most of the primordial gases are released. This is an indication that the noble gases in diamonds might be ion implanted as suggested earlier [3].

Summary and Conclusions: For both ureilites, the release patterns of nitrogen and noble gases from bulk and acid resistant residue are very much similar to what has been observed for other monomict ureilites [2,3,6,8,9]. It is evident that both contain all the three forms of C- amorphous carbon, diamond and graphite – identified earlier [1-3]. Also, in both ureilites (bulk sample of FRO36 and acid residue of AC277), it can be seen that the nitrogen released at low temperatures has a $\delta^{15}N$ of ≥50‰. This low temperature combustion release is consistent with amorphous carbon being the carrier. Diamond and graphite have overlapping combustion temperatures (graphite combusting at slightly higher temperatures), releasing their gases between 600°C-800°C. Comparison of the release patterns reveals that FRO36 may have relatively more graphite than diamond. This may also be the cause for the relatively poor correlation of light N and ^{36}Ar release with the amount of C combusted in FRO36, in contrast to the good correlation observed in the case of AC277 (see Fig. 1). The light nitrogen in the HF/HCl residue of FRO36 is poorly resolved mainly due to mixing of relatively heavy nitrogen released from graphite. This is consistent with our earlier observation for the ureilite ALH78019 [1]. The occurrence of both heavy (in graphite and amorphous carbon) and light nitrogen (in diamonds) components in these two ureilites, similar to all other ureilites studied earlier, clearly demonstrates that both heavy and light nitrogen are indigenous to monomict ureilite, and not some contamination brought in by foreign components due to impactors as suggested for polymict ureilites [10]. Also, the similarity in the nitrogen and noble gas systematics of AC277 and FRO036 (from hot and cold deserts) with those of non-desert falls and finds shows that weathering due to desert environments has not caused any significant changes.

References:

[1] Rai V. K. et al. (2002) *MAPS, 37,* 1045–1055. [2] Rai V. K. et al. (2003) *GCA, 67,* 2213-2237. [3] Rai V. K. (2003) *GCA, 67,* 4435–4456. [4] Rai V. K. et al. (2002) *MAPS 37, A120.* [5] Ott U. et al. (1993) *Meteoritics* 28, 415-416. [6] Grady M.M. and Pillinger C.T. (1993) *LPSC* 24, 551-552. [7] Baba T. et al., (1993) *Meteoritics, 28,* 319. [8] Grady M. M. et al. (1985) *GCA, 49,* 903-915. [9] Yamamoto T. et al. (1998) *MAPS, 33,* 857-870. [10] Grady M.M and Pillinger C.T. (1988) *Nature, 331,* 321-323.