PRIMORDIALLY TRAPPED HEAVY NOBLE GASES IN RUMURUTI CHONDRITES? H. Busemann[1,2], H. Baur[2], N. Vogel[2] and R. Wieler[2], [1]SEAES, University of Manchester, Manchester M13 9PL, United Kingdom, (henner.busemann@manchester.ac.uk). [2]ETH Zurich, Institute for Geochemistry and Petrology, 8092 Zurich, Switzerland.

Introduction: Rumuruti chondrites (Rs) are a recently established chondrite class with affinities to ordinary chondrites (OCs) [1; and references therein]. They consist of >100 members that are distinguishable from other chondrites by their O isotopic composition and their high degree of oxidation [1]. Light noble gases have been examined mainly to study pairing and the exposure of the meteoroids to cosmic rays (CRE ages) [1-4]. While many Rs show a solar wind component in the light noble gases [2], the heavy noble gases Kr and Xe including all isotopes have been studied only by [4], and the potentially present primordially trapped noble gas components are not sufficiently constrained. This knowledge is important, however, to assess whether the Rs' parent body materials incorporated the same mixture of primitive constituents including presolar grains, volatile elements, and organic matter as those of other classes [e.g., 5-6].

Here we discuss Kr and Xe isotope and element abundances in six type 3 and 4 Rs found in Northwest Africa (NWA). None of the presently examined Rs need to contain (in any case minor) phase Q gases to explain our results. Phase Q might have been destroyed by oxidation during parent body processing or, perhaps more likely by oxidation of the precursor material in the nebula [see 1 for references].

Table 1 Noble gas concentrations and isotopic ratios in R chondrites.

NWA	^{20}Ne 10^{-8} cm^3/g	^{20}Ne/^{22}Ne	^{21}Ne/^{22}Ne	^{84}Kr 10^{-10} cm^3/g
053a	0.036±0.0020	8.1±0.3	0.288±0.017	13.78±0.12
b	0.058±0.0020	1.40±0.04	0.838±0.012	2.662±0.020
total	**0.094±0.0028**	**2.05±0.06**	**0.786±0.018**	**16.44±0.12**
1472a	0.330±0.003	0.884±0.005	0.920±0.004	10.15±0.05
b	2.252±0.023	0.841±0.005	0.923±0.004	2.052±0.012
total	**2.582±0.024**	**0.847±0.008**	**0.923±0.008**	**12.20±0.05**
1476a*	0.278±0.0028	0.972±0.005	0.881±0.004	2.79±0.08
1477a	0.313±0.004	1.072±0.008	0.871±0.005	5.10±0.10
b	3.91±0.04	1.042±0.004	0.894±0.0026	13.90±0.07
total	**4.22±0.04**	**1.044±0.009**	**0.892±0.007**	**19.00±0.12**
1478a	0.360±0.004	0.867±0.004	0.917±0.004	1.174±0.010
b	3.43±0.03	0.850±0.004	0.921±0.004	3.480±0.018
total	**3.79±0.03**	**0.851±0.008**	**0.921±0.008**	**4.653±0.021**
753a	0.205±0.0022	0.897±0.006	0.895±0.0020	1.24±0.09
b	3.45±0.03	0.857±0.003	0.918±0.003	3.778±0.022
total	**3.65±0.03**	**0.859±0.007**	**0.916±0.008**	**5.02±0.09**

a= 600 ºC, b= 1700 ºC, * 1750 ºC step lost

Experimental: We examined all noble gases in uncrushed pieces of solar-wind bearing NWA 053 [2] (type R4, all petrographic classifications from [1]) and the paired and (mostly) solar-gas free [2,3] NWA 753 (R3.9), 1472 (R3/4), 1476 (R3), 1477 (R3 with shock veins), and 1478 (R3 with shock veins) by pyrolysis in two temperature steps at ETH Zürich (see [2,7] for details). Concentrations and isotope ratios are given in Table 1.

Results: *He-Ar.* All results are in agreement with previous data, the determination of CRE ages and pairing [1-3]. The low exposure age of <0.4 Ma and the lack of solar wind gases in unpaired NWA 053 [1,2] makes this meteorite the prime target to determine the isotopic compositions of potential primordially trapped heavy noble gases (see below). Neon in all other samples is mostly cosmogenic. Trapped Ne is clearly detectable only in NWA 053, particularly the 600 ºC step (Table 1) and, to a minor extent, in 600 ºC steps of NWA 753, 1472 and 1478. Extrapolation of the NWA 053 data points lead to ^{20}Ne/^{22}Ne ~11.3 for ^{21}Ne/^{22}Ne = 0.029, suggesting fractionated [see 2] solar wind Ne for NWA 053, whereas the other samples do not contain sufficient trapped Ne to be decisive. The ^{36}Ar/^{38}Ar ratios between 3 and 5 indicate some trapped Ar.

Table 1 continued

NWA	^{4}He 10^{-8} cm^3/g	^{3}He/^{4}He x 10000	^{36}Ar 10^{-8} cm^3/g	^{36}Ar/^{38}Ar	^{40}Ar/^{36}Ar
053a	264±2	2.595±0.029	1.422±0.007	5.39±0.03	868±6
b	561±4	1.863±0.016	0.640±0.003	5.21±0.03	4910±60
total	**824±4**	**2.097±0.014**	**2.062±0.008**	**5.33±0.03**	**2167±10**
1472a	790±5	129.0±1.1	1.040±0.005	4.830±0.026	1453±17
b	268±2	133.4±1.2	1.278±0.006	2.467±0.015	574.7±2.5
total	**1058±6**	**130.1±0.9**	**2.318±0.007**	**3.149±0.018**	**967±4**
1476a*	535±3	141.0±1.2	0.978±0.005	5.80±0.04	324.9±2.7
1477a	585±4	132.8±1.2	1.409±0.007	5.89±0.04	769±6
b	606±4	130.4±1.1	23.7±0.9	4.56±0.26	23.2±0.9
total	**1190±6**	**131.6±0.8**	**25.1±0.9**	**4.62±0.25**	**62.2±2.5**
1478a	745±5	134.1±1.2	0.1740±0.0013	2.63±0.03	6290±230
b	573±4	141.7±1.2	3.047±0.013	3.100±0.020	321.5±1.4
total	**1318±6**	**137.4±0.8**	**3.221±0.013**	**3.071±0.023**	**670±3**
753a	556±4	138.1±1.2	0.1672±0.0023	3.57±0.07	4340±70
b		146.0±1.2	3.71±0.21	3.43±0.18	324±19
total		**142.6±0.9**	**3.87±0.21**	**3.44±0.26**	**488±30**

Kr-Xe. The heavy noble gases consist of cosmogenic, trapped and fissiogenic components. The release of substantial concentrations of ^{84}Kr (>80% of the total) and ^{132}Xe (>60%) from the NWA 053 and 1472 600 ºC steps, ^{129}Xe/^{132}Xe ratios near 1 and all other isotope ratios (Table 1) indicate the presence of substantial terrestrial Kr and Xe, incorporated during weathering. NWA 053 with its short CRE age shows trapped Kr and Xe to be isotopically air (with excess ^{129}Xe, and minor additions of fission and cosmogenic Xe), although the ^{84}Kr/^{132}Xe ratio of 3.8 could also suggest a mixture of Q gases and (fractionated) air.

Three-isotope plots (not shown) indicate that Kr and Xe in all new measurements as well as those reported earlier [4] can be explained by mixtures of elementally fractionated air, a small solar wind component, and small contributions of fission ^{86}Kr and ^{134,136}Xe (it is not discernible whether from ^{244}Pu or ^{238}U), cosmogenic Kr and Xe, and neutron-induced ^{80,82}Kr and ^{128}Xe. Assuming air to be the trapped component for correction, all paired NWA meteorites show a constant $(^{80}Kr/^{82}Kr)_{neutron}$ of ~3, indicative of the irradiation with (epi-) thermal neutrons in a large body.

Table 1 continued

NWA	^{78}Kr	^{80}Kr	^{82}Kr	^{83}Kr	^{86}Kr
			^{84}Kr≡100		
053a	0.457±0.028*	3.95±0.08	20.1±0.3	20.09±0.28	30.5±0.4
b	0.624±0.018	3.88±0.10	20.25±0.27	19.96±0.26	30.6±0.3
total	**0.484±0.024***	**3.94±0.08**	**20.1±0.3**	**20.07±0.29**	**30.5±0.4**
1472a	0.613±0.007	4.09±0.03	20.39±0.12	20.33±0.13	30.61±0.17
b	0.657±0.014	6.22±0.09	21.15±0.23	20.62±0.17	30.9±0.4
total	**0.619±0.007**	**4.40±0.03**	**20.50±0.13**	**20.37±0.14**	**30.65±0.20**
1476a*	0.72±0.03	4.48±0.19	20.2±0.9	20.2±0.9	30.4±1.3
1477a	0.63±0.03	4.37±0.12	20.5±0.6	20.3±0.6	30.6±0.8
b	0.629±0.007	5.29±0.04	20.64±0.11	20.16±0.09	30.83±0.14
total	**0.629±0.011**	**5.03±0.06**	**20.59±0.23**	**20.21±0.22**	**30.8±0.3**
1478a	0.74±0.04	4.63±0.13	20.0±0.4	20.2±0.3	30.5±0.4
b	0.687±0.011	5.53±0.07	20.87±0.24	20.50±0.15	30.9±0.4
total	**0.703±0.015**	**5.24±0.07**	**20.61±0.23**	**20.41±0.18**	**30.8±0.3**
753a	0.69±0.09	4.5±0.5	20.5±2.3	20.6±2.2	31±3
b	0.656±0.017	5.84±0.08	20.97±0.16	20.55±0.17	31.00±0.29
total	**0.67±0.03**	**5.48±0.18**	**20.8±0.8**	**20.6±0.8**	**31.0±1.2**

*probably too low

Discussion: All Kr and Xe isotopic data can be explained with the presence of a small solar wind and an abundant (elementally fractionated) terrestrial component, without the presence of Q-gases. However, only for NWA 053 the light noble gases indicate a solar component. Hence, a small fraction of Kr-Q and Xe-Q might be present [4], but isotopically overprinted by terrestrial Kr and Xe. The isotopic data show no hints for noble gases originating from presolar grains.

Although Rs show affinities to OCs [1], the type 3 and 4 Rs [this work, 4] do no show similar phase Q and presolar grain noble gas abundances as observed for OCs of the same petrologic type. Most type 3 Rs experienced thermal metamorphism at least similar to type 3.6 OCs [8]. However, even type 3.6 OCs contain detectable Q gases [e.g., 7,9].

This discrepancy might not be surprising, if Rs indeed recorded nebula oxidation [1,10], possibly further out in the solar system than the OC formation region [10]. This oxidation could have destroyed most of phase Q, an easily oxidisable phase [7,9]. However, oxidation on the parent body could likewise have released initially present Q-gases.

Most meteorite parent bodies may have acquired a relatively homogeneous mixture of primitive organic matter, including phase Q and presolar grains [e.g., 5,6]. If so, the R chondrites must have lost these components. However, if parent body oxidation is responsible for the lack of Q-gases, noble gases in entirely unequilibrated type 3 material, which has been found so far only in rare clasts [10,11], might offer clues as to where the oxidation took place.

Table 1 continued

NWA	^{132}Xe	^{124}Xe	^{126}Xe	^{128}Xe
	10^{-10} cm^3/g		^{132}Xe≡100	
053a	2.59±0.08	0.41±0.04	0.36±0.04	7.09±0.25
b	1.73±0.05	0.362±0.018	0.358±0.017	7.14±0.21
total	**4.32±0.09**	**0.388±0.027**	**0.359±0.026**	**7.11±0.23**
1472a	2.75±0.06	0.505±0.007	0.561±0.007	7.56±0.10
b	2.14±0.05	0.446±0.008	0.430±0.006	8.39±0.05
total	**4.89±0.08**	**0.479±0.009**	**0.503±0.009**	**7.92±0.14**
1476a*	1.47±0.05	0.52±0.03	0.59±0.04	7.8±0.3
1477a	2.28±0.07	0.487±0.024	0.499±0.030	7.75±0.28
b	11.86±0.27	0.462±0.006	0.409±0.005	8.30±0.07
total	**14.14±0.28**	**0.466±0.011**	**0.424±0.010**	**8.21±0.18**
1478a	0.854±0.019	0.57±0.04	0.65±0.05	7.99±0.24
b	3.40±0.08	0.474±0.012	0.440±0.009	8.55±0.09
total	**4.26±0.08**	**0.493±0.016**	**0.482±0.015**	**8.43±0.18**
753a	0.74±0.05	0.61±0.07	0.64±0.07	8.0±0.7
b	4.11±0.09	0.472±0.013	0.424±0.011	8.61±0.13
total	**4.86±0.11**	**0.493±0.019**	**0.457±0.018**	**8.51±0.25**

More primitive R chondritic material than analyzed here or in [4], including most primitive available clasts [10,11] must be examined for Kr and Xe isotopes to better constrain the trapped component incorporated into the R chondritic parent body and help clarifying the oxidation history of R chondritic material.

Table 1 continued

NWA	^{129}Xe	^{130}Xe	^{131}Xe	^{134}Xe	^{136}Xe
			^{132}Xe≡100		
053a	98±4	15.1±0.5	78.4±2.5	38.7±1.3	32.8±1.0
b	184±4	15.2±0.5	79.6±2.0	38.8±1.0	33.7±0.9
total	**132±4**	**15.1±0.5**	**78.9±2.4**	**38.7±1.2**	**33.2±1.0**
1472a	104.2±0.6	15.15±0.12	79.2±0.4	38.82±0.25	32.81±0.18
b	235.5±1.0	15.98±0.10	81.6±0.3	39.18±0.22	33.32±0.15
total	**161.8±2.6**	**15.51±0.25**	**80.3±1.3**	**39.0±0.6**	**33.0±0.5**
1476a*	114±5	15.7±0.6	79±3	38.8±1.5	32.6±1.3
1477a	110±4	15.5±0.5	80.2±2.7	39.1±1.3	33.0±1.1
b	187.9±1.5	16.10±0.14	80.5±0.9	37.9±0.3	32.3±0.3
total	**175±4**	**16.0±0.4**	**80.5±1.8**	**38.1±0.8**	**32.4±0.7**
1478a	117.4±1.1	15.01±0.21	80.6±0.9	39.5±0.4	32.9±0.4
b	219.8±1.4	16.16±0.10	81.8±0.6	38.78±0.24	33.37±0.24
total	**199±4**	**15.9±0.3**	**81.6±1.6**	**38.9±0.7**	**33.3±0.6**
753a	113±11	15.1±1.5	80±7	39±3	33±3
b	232.3±2.0	15.94±0.25	81.0±1.1	38.2±0.5	32.8±0.5
total	**214±5**	**15.8±0.5**			**32.8±1.0**

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