THE TRAPPED HEAVY NOBLE GASES IN RECENTLY FOUND MARTIAN METEORITES. H. Busemann and O. Eugster, University of Bern, Physics Institute, Space Research & Planetary Science, Sidlerstr. 5, 3012 Bern, Switzerland, (busemann@phim.unibe.ch).

Introduction: Noble gases in Martian meteorites are an important source of our knowledge of composition and evolution of the volatile inventory of Mars [1]. Ancient (ALH 84001), fractionated (nakhlites), and recent atmosphere (shock-produced glass in shergottite EETA 79001) as well as at least one component originating from the interior (Chassigny) have been identified based on analyses of the Ar-Xe elemental and isotopic composition (e.g. [2-5]). While the interior contains Xe of solar isotopic composition, the atmosphere is fractionated relative to solar Xe favoring the heavier isotopes. Variations in the $^{129}Xe/^{132}Xe$ ratio (~2.0-2.6) represent the evolution of the atmosphere [6].

Tab. 1. Element concentrations and Xe isotopic composition ($^{132}Xe \equiv 100$) in Los Angeles, SAU 005/008, SAU 094, and Nakhla. Assumed uncertainty for concentrations 15%.

	L.A. 1	SAU 005/8 I	SAU 005/8 II	SAU 094	Nakhla
^{36}Ar	1.06	0.26	0.22	0.28	1.37
^{84}Kr	77	73	138	150	24
^{132}Xe	8.2	10.3	16.9	11.5	9.0
$^{124}Xe/^{132}Xe$	1.25	0.362	0.380	0.373	5.28
	0.10	0.016	0.029	0.024	0.07
$^{126}Xe/^{132}Xe$	1.70	0.41	0.350	0.46	8.70
	0.14	0.03	0.014	0.03	0.10
$^{128}Xe/^{132}Xe$	9.0	7.00	7.2	7.3	19.18
	0.3	0.26	0.3	0.4	0.19
$^{129}Xe/^{132}Xe$	114	127	112	120	152.4
	3	5	4	6	1.1
$^{130}Xe/^{132}Xe$	16.3	15.3	15.1	15.1	22.28
	0.6	0.7	0.5	0.8	0.24
$^{131}Xe/^{132}Xe$	83.8	79.1	78.7	80	93.8
	2.9	3.2	2.4	4	0.7
$^{134}Xe/^{132}Xe$	38.5	39.0	37.9	39.2	37.1
	1.6	1.4	1.3	2.0	0.4
$^{136}Xe/^{132}Xe$	32.8	32.8	32.7	32.9	31.3
	1.4	1.1	1.3	1.5	0.3

In 10^{-12} cm^3/g, Ar: 10^{-8} cm^3/g. Uncertainty 1σ.

We present whole rock analyses of the basaltic shergottites [7, 8] Los Angeles/L.A. (stone 1), Sayh Al Uhaymir/SAU 005/008 (2 samples) and SAU 094 in order to decipher how their trapped noble gas records fit into the picture described above. Also given are additional data for Nakhla. ^{81}Kr-Kr cosmic-ray exposure ages and the neutron-induced production of ^{80}Kr in space or regolith for these samples have been published elsewhere [9-11].

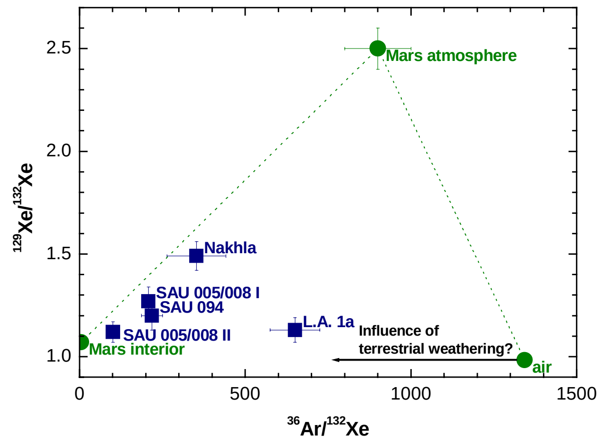

Fig. 1 This plot suggests the presence of noble gases from the Martian interior in the measured samples. The Xe isotopic composition however indicates that the observations could be at least partially the result of terrestrial weathering and preferential Xe absorption (See [1] for ref.).

Results: The samples (whole rocks of 84-810 mg) have been measured in three steps (pyrolysis at 600°C to remove absorbed air, 1700°C, and 1750°C). The gas poor steps at 1750°C indicate the complete extraction in the main steps at 1700°C. Table 1 shows the elemental and Xe isotopic composition. Table 2 gives the cosmogenic (cos) and trapped (tr) concentrations and some Xe isotope ratios after correction for Xe_{cos}. We determined $^{36}Ar_{cos}$ using $(^{36}Ar/^{38}Ar)_{cos} = 0.64\pm0.03$ and $(^{36}Ar/^{38}Ar)_{tr} = 4.6\pm0.8$. The range for Ar_{tr} encompasses values deduced for Martian atmosphere (~5.3) and interior (~3.9, see [1] for ref.). For Nakhla and L.A., this correction amounts to ~80 and 50%, respectively, of the ^{36}Ar. We calculated $^{84}Kr_{cos}$ with $(^{84}Kr/^{83}Kr)_{cos} = 0.54\pm0.06$, obtained by extrapolation of our data to $(^{86}Kr/^{83}Kr)_{cos} = 0.015\pm0.015$. For trapped Kr we adopt both terrestrial atmosphere and solar wind Kr [12], because it is not clear to what extent Martian Kr is fractionated relative to solar [13]. The Xe isotope concentrations are corrected for Xe_{cos} using the Xe spectra given in [14] and Ba and REE concentrations taken from [8] for L.A. and [15] for Nakhla. For SAU we used an average shergottite composition due to the lack of data for this shergottite [14]. We adopted terrestrial as well as Martian atmosphere [15] and solar wind Xe [12] as trapped component. The correction for ^{84}Kr and ^{132}Xe amount to 13 and 7% for Nakhla, 2 and 1% for L.A. and less than 1% for the SAU samples, respectively. Uncertainties due to the choice of the trapped component are added.

Tab. 2. Cosmogenic ^{36}Ar, ^{83}Kr, ^{126}Xe abundances, trapped elemental and Xe isotopic composition in L. A., SAU 005/008, SAU 094, and Nakhla, corrected for cosmogenic composition. See text for assumptions.

	L. A. 1	SAU 005/8 I	SAU 005/8 II	SAU 094	Nakhla
$^{36}Ar_{cos}$ *	0.53	0.050	0.049	0.031	1.08
	0.04	0.009	0.008	0.009	0.07
$^{83}Kr_{cos}$	3.03	0.29	2.16	0.14	5.35
	0.16	0.013	0.26	0.26	0.09
$^{126}Xe_{cos}$	0.112	0.007	0.001	0.014	0.752
	0.004	0.006	0.008	0.005	0.005
$^{36}Ar_{tr}$ *	0.53	0.21	0.17	0.25	0.30
$^{84}Kr_{tr}$	75	73	137	150	21
$^{132}Xe_{tr}$	8.1	10.3	16.9	11.4	8.4
$^{40}Ar/^{36}Ar_{tr}$	995	1421	969	739	2861
	91	591	80	120	742
$(^{36}Ar/^{132}Xe)_{tr}$	650	208	101	218	353
	75	18	13	32	89
$(^{84}Kr/^{132}Xe)_{tr}$	9.3	7.1	8.1	13.1	2.5
	1.3	0.7	1.1	1.7	0.3
$^{128}Xe/^{132}Xe$	7.0	6.89	7.2	7.1	6.9
	0.5	0.28	0.3	0.4	0.9
$^{129}Xe/^{132}Xe$	113	127	112	120	149
	3	5	4	6	5
$^{130}Xe/^{132}Xe$	15.0	15.2	15.1	15.0	15.4
	0.7	0.7	0.5	0.8	0.8
$^{131}Xe/^{132}Xe$	79.4	78.8	78.7	79	67.5
	3.2	3.2	2.4	4	3.0
$^{134}Xe/^{132}Xe$	38.9	39.0	37.9	39.3	39.3
	1.7	1.4	1.3	2.0	1.1
$^{136}Xe/^{132}Xe$	33.2	32.9	32.7	32.9	33.5
	1.5	1.1	1.3	1.5	0.9

In 10^{-12} cm^3/g, $^*10^{-8}$ cm^3/g. Uncertainties of 15% for the are concentrations not included.

Discussion: A first analysis reveals that all measured elemental and isotopic abundances in the samples are consistent with a Martian origin. The signatures most indicative for a Martian origin can be identified: Large $^{40}Ar/^{36}Ar_{tr}$ ratios (Table 2), an elemental composition implying a mixture of Martian interior and atmosphere (Fig. 1), and $^{129}Xe/^{132}Xe$ ratios higher than those found in terrestrial air or solar wind (Fig. 1). However, the data also indicate contamination with absorbed fractionated air, as expected at least for L. A. and SAU, both found in the deserts of California and Oman. Except for $^{129}Xe/^{132}Xe$, all Xe isotopic ratios are consistent with air composition. The Kr isotopic composition agrees with air or solar wind. Our samples of SAU contain significantly higher concentrations of trapped Kr and Xe than combusted samples from the interior of the meteorite [16], also indicating the presence of terrestrial contamination. This agrees with the observation that SAU 005/008 I contains the smallest concentrations of trapped Kr and Xe but the most Martian atmosphere-like component ($^{40}Ar/^{36}Ar_{tr}$; Fig. 1&2) of all aliquots of SAU. Bulk samples of desert finds appear not to be the most suitable samples to determine trapped Martian noble gases. Further examinations on mineral separates and with improved analytical methods will follow.

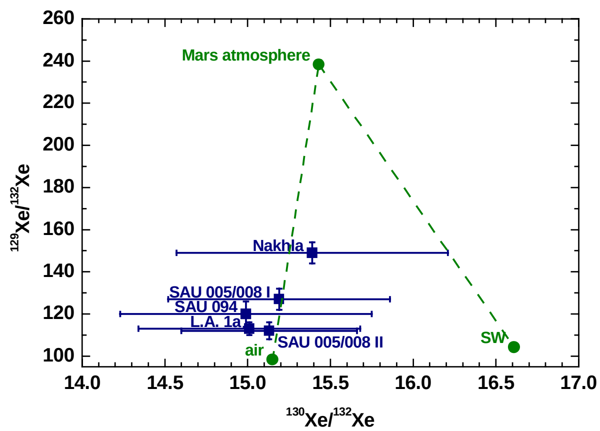

Fig. 2 After correction for Xe_{cos}, the Xe isotopic composition in all samples indicate a mixture of small amounts of Martian [15] and terrestrial atmosphere. Pure solar wind composition, which is diagnostic for Xe from the interior, can be excluded.

Acknowledgements: We thank A. Schaller for technical support and J. A. Whitby for helpful discussions. Work supported by the Swiss NSF.

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