NOBLE GASES IN MINERAL SEPARATES FROM SHERGOTTY AND ZAGAMI. S. P. Schwenzer, S. Herrmann, and U. Ott, Max-Planck Institut für Chemie, J.-J, Becher Weg 27, D-55128 Mainz, Germany, schwenze@mpch-mainz.mpg.de.

Introduction: The similar "fingerprints" of noble gas abundance patterns in the SNC meteorites and in the data from the Viking mission have played a key role in establishing the SNC meteorites as Martian [1, 2]. Further, noble gases with completely different isotopic signatures have been found and are regarded as coming from the Martian interior [3]. Similar findings for nitrogen [e.g., 2] show the presence of Martian atmospheric as well as an interior component (for an overview see [4]).

Samples and methods: For this study two Martian meteorites have been used: Shergotty and Zagami (normal lithology), classified as basaltic shergottites by [5]. Both are containing mostly pyroxene (>70 %) and maskelynite (>20 %), further mesostasis, and opaques [6].

Three different samples of each meteorite have been investigated: bulk, pyroxene and maskelynite. The bulk samples – unfortunately, but due to the necessity of homogenization and splitting of the sample for parallel studies – were ground to powder. Grinding can cause incorporation of noble gases from air, which has been observed by [7, 8]. Unfortunately, gases introduced by grinding can remain in the sample up to degassing temperatures above 600 °C [9], therefore disentanglement of the Martian from the terrestrial air signature can be difficult.

The mineral separates did not suffer from this problem. They were obtained by handpicking from mildly crushed material. The purity of the separates was checked by SEM investigations. The separates were as pure as one can reasonably expect from handpicking of "big" grains. Crushing to smaller grain size might have improved the purity, but would have increased the danger of introducing air. For Shergotty 35 mg of maskelynite (grain size 0.05–1.2 mm) and 78 mg of pyroxene (grain size 0.1–1.5 mm), for Zagami 19 mg of maskelynite (0.5–1.5 mm) and 65 mg of pyroxene (0.2–1.0 mm) were obtained. For analytical details of noble gas measurements see [10].

Results and interpretation: Results are summarized in Tables 1 and 2.

Helium loss. ^{4}He has two major sources: radioactive decay of ^{238,235}U and ^{232}Th, and cosmic irradiation. Knowing the age of the meteorite, the amount of radiogenic ^{4}He can be calculated from the amounts of ^{238,235}U and ^{232}Th. The contribution from cosmic irradiation can be calculated from the amount of ^{3}He, which is almost completely cosmogenic. Subtracting the cosmogenic ^{4}He from the measured amount and comparing the result with the amount expected from U and Th decay, shows significant helium loss. This is thought to be a result of the shock pressure during the meteorite launching event [11]. As there is "no" He in the Martian atmosphere [12], shock effects cause a "one-way" effect. This is different for Ar, which is present in the Martian atmosphere in significant amount. Similar calculations can be made for ^{40}Ar from ^{40}K decay, but a surplus is observed instead of a deficit. This reflects the presence of Martian atmosphere.

Cosmic ray exposure ages. We calculated cosmic ray exposure ages via the isotopes ^{3}He, ^{21}Ne, ^{38}Ar, ^{83}Kr and ^{126}Xe using the method of [13, 14]. Our mean values obtained from ^{3}He, ^{21}Ne, and ^{38}Ar are 2.48 Ma for Shergotty and 2.75 Ma for Zagami. Mean values using all five isotopes are 2.35, and 3.10 Ma, respectively, which is in agreement with results given in literature (e.g. [14]).

Neon. Neon isotopic ratios can also be an indicator for the presence of trapped Martian atmosphere. In our data set there is clear evidence of Martian atmosphere only in one degassing step (1600 °C of Zagami maskelynite). Further some contribution of spallogenic Ne from Na is noticeable from the low ^{20}Ne/^{22}Ne and ^{21}Ne/^{22}Ne ratios, especially in the low-temperature steps of maskelynite.

Argon. In principle it is possible to obtain Ar-isochron ages from Martian meteorites (Fig. 1). These isochron-"ages" are 107 Ma for Shergotty and 133 Ma for Zagami, which are lower than the ages obtained by other methods and reported in [6]. Plotting the data in the three-isotope-diagramm $^{36}Ar_{tr}/^{132}Xe$ vs. $^{84}Kr/^{132}Xe$ shows a clear contribution of Martian atmosphere to the Ar budget of both meteorites. There is more shock-implanted Ar in maskelynite, most likely because this phase underwent more intense structural changes during the shock event, than in pyroxene and in the bulk samples. Therefore the difference can be explained by gain and loss of Ar due to shock effects. Further, for Shergotty our result also disagrees with the isochron-"age" of Terribilini et al. [15], who obtained 195 Ma. A reason may be that our data for K were taken from the literature [6] and not obtained from the same sample as the noble gases. In addition, the effect of introducing noble gases to the sample during the grinding procedure is observed.

Kr and Xe. In Kr and Xe isotopic ratios contributions of Martian atmosphere can be seen. As for Ar, more trapped Martian atmosphere is present in maskelynite than in pyroxene and bulk. From those isotopes, which are not influenced by terrestrial contamination (e. g. excess $^{129}Xe^*$) it is obvious that the two measured phases alone cannot explain the signature of the bulk sample. Therefore contribution of one or more additional carriers contributing significantly to the noble gas budget of Shergotty and Zagami is required. Further investigations, e. g. measuring magnetite, which is reported to be present in concentrations up to 2.5 % (Shergotty) and 2.8 % (Zagami) [6], may provide an answer to this question.

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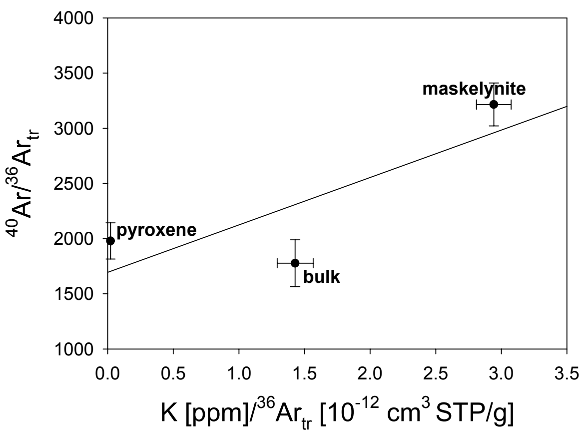

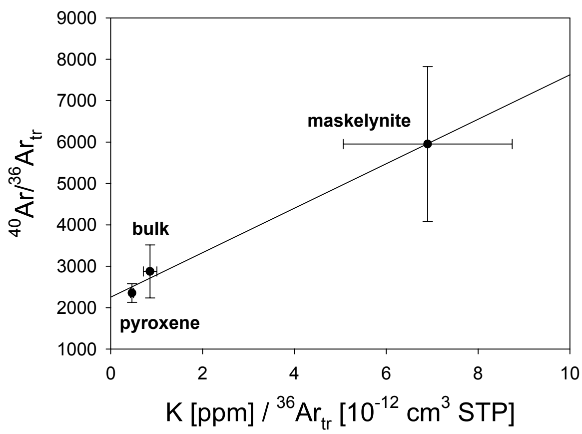

Fig. 1. K-Ar-"isochrons" for Shergotty (left) and Zagami (right). Ar is corrected for cosmogenic contribution.

Table 1. Noble gas concentrations of Shergotty and Zagami. Data for He are in 10^{-8} ccSTP/g, for Ne, Ar in 10^{-9} ccSTP/g, for Kr, Xe in 10^{-12} ccSTP/g.

Sample	^{4}He	^{22}Ne	^{36}Ar	^{84}Kr	^{132}Xe
Shergotty bulk	121±1	6.98±0.37	3.05±0.13	57.5±3.2	15.37±0.73
Shergotty pyroxene	126±1	6.98±0.23	2.84±0.08	24.5±0.9	3.60±0.36
Shergotty maskelynite	97±1	8.51±0.42	2.97±0.09	34.1±1.7	4.95±0.95
Zagami bulk	274±19	6.96±0.36	3.41±0.07	60.8±3.3	21.43±0.76
Zagami pyroxene	158±3	6.20±0.28	2.19±0.08	13.9±1.0	2.11±0.33
Zagami maskelynite	63±9	9.36±0.55	2.32±0.29	17.0±2.4	1.50±1.08

Table 2. Selected isotopic and elemental ratios of Shergotty and Zagami samples.

Sample	$^{3}He/^{4}He$	$^{38}Ar/^{36}Ar$	$^{40}Ar/^{36}Ar$	$^{129}Xe/^{132}Xe$	$^{84}Kr/^{132}Xe$
Shergotty bulk	0.0315±0.0013	0.979±0.041	738±29	1.165±0.020	3.69±0.27
Shergotty pyroxene	0.0316±0.0009	1.125±0.020	572±13	1.173±0.005	6.77±0.71
Shergotty maskelynite	0.0095±0.0002	1.039±0.014	1258±34	1.330±0.017	6.96±1.41
Zagami bulk	0.0173±0.0003	1.171±0.022	617±26	1.074±0.014	2.82±0.18
Zagami pyroxene	0.0299±0.0009	1.306±0.030	445±53	1.030±0.016	6.78±1.18
Zagami maskelynite	0.0151±0.0008	1.231±0.057	1232±61	1.467±0.059	12.24±9.19