NOBLE GASES IN ALLENDE FLUFFY AND COMPACT CAIS. N. Vogel[1], R. Wieler[1], H. Baur[1], A. Bischoff[2], [1]Institute for Isotope Geology and Mineral Resources, ETH Zürich, CH-8092 Zürich (vogel@erdw.ethz.ch), [2]Institute for Planetology, University of Münster, D-48149 Münster.

Abstract: The Ne and Ar isotopic composition of Allende CAIs can consistently be explained by cosmogenically produced Ne and Ar. Thereby, the extraordinary chemistry of CAIs and the large preatmospheric size of Allende, which may cause significant cosmogenic production of ^{36}Ar from Cl, were taken into account. In contrast to earlier workers, we conclude that no trapped noble gas components are needed to explain the Ne and Ar signatures of Allende CAIs.

Introduction: Calcium-aluminum-rich inclusions, CAIs, represent the oldest available material that formed in the solar system [1]. Due to their extraordinarily refractory chemistry CAIs are either interpreted as the first condensates from a cooling nebula of solar composition, or as the most refractory residues left over from an intense fractional evaporation process [2]. CAIs experienced higher peak temperatures than chondrules [3], which lost *most* of their primordial ^{20}Ne and ^{36}Ar due to the melting event, e.g., [4]. Thus, it could be expected that CAIs lost *all* of the primordial ^{20}Ne and ^{36}Ar. Nevertheless, [5] reported a trapped Ne component in fine-grained Allende CAIs, and [6] reported Ne-E consisting of nearly pure ^{22}Ne [7] in an Efremovka CAI. If CAIs were formed close to the young sun as proposed by [3] they could be expected to contain at least remnants of solar-like noble gases.

We measured Ne and Ar in fine-grained fluffy and coarser-grained compact Allende CAIs to re-examine the presence of a trapped component besides cosmogenic noble gases, and to rule on differences in the formation of fluffy and compact CAIs.

Experimental: 22 samples of 5 fluffy and 4 compact Allende CAIs were separated under a binocular microscope. After a 24 hour bake out in vacuum to remove adsorbed atmospheric gases, the noble gases were extracted by melting the samples with an IR laser (CW mode). This provides very low blanks of ~1×10^{-13} and 2×10^{-13} cm^{3}STP for ^{20}Ne and ^{36}Ar, respectively, contributing <6% to both, the measured ^{20}Ne and ^{36}Ar signals.

Results and Discussion:

Neon isotopes: In contrast to matrix-like samples (grey triangles in Fig. 1) the compact and fluffy CAIs (black solid and open circles, respectively) plot on a line between chondritic cosmogenic Ne and Ne-E. However, also calculated cosmogenic Ne-isotopic compositions of mineral phases common in CAIs as well as pure Na and Al (production rates from [8] for a body of 50 cm radius and a mean shielding depth of 25 cm) plot on this line. Thus, the Ne-data can be explained straightforwardly by cosmogenic Ne produced from Na and Al bearing phases present in CAIs, although they do not contradict the presence of Ne-E in the CAIs. None of the CAI data points plots above this line, which would indicate a trapped component as reported by [5].

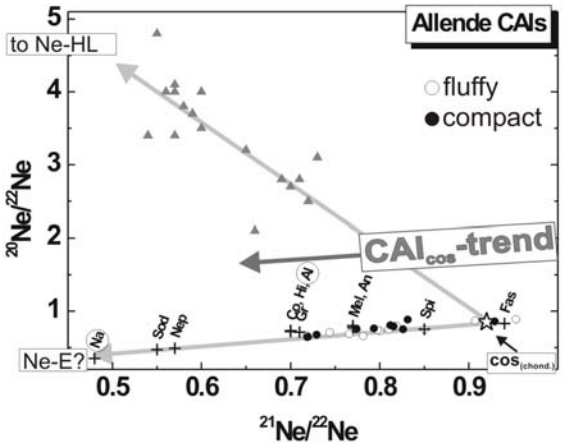

Fig. 1. Neon isotopic composition of fluffy and compact CAIs (open and black solid circles, respectively.). For comparison, also Allende matrix data are plotted (grey triangles). Fas=fassaite, Spi=spinel, Mel=melilite, An=anorthite, Gr=grossite, Co=corundum, Hi=hibonite, Nep=nepheline, Sod=sodalite. See text for further explanation.

Argon isotopes: In contrast to the Ne isotopes the ^{36}Ar/^{38}Ar ratios of the fluffy CAIs (open circles in Fig. 2) are distinctly higher than those of the compact CAIs (black solid circles), which are close to the chondritic cosmogenic ratio of ~0.65 (dashed line in Fig. 2). This could point to the presence of a primordial noble gas component in the fluffy CAIs. However, the data can also consistently be explained by cosmogenically produced Ar from Ca and Cl with different ^{36}Ar/^{38}Ar ratios of ~0.65 and ~100, respectively. Both elements are anticorrelated in fluffy and compact CAIs: [9,10] reported 1-12% of Ca in fluffy CAIs and on average 3 times higher Ca concentrations, 9-26%, in coarse-grained CAIs. Cl concentrations in fluffy CAIs can be as high as 1.7%, whereas no Cl was detected in compact CAIs [11]. Taking into account the similar average ^{36}Ar concentrations in both groups of CAIs, the higher Ca concentrations in the compact CAIs can explain the ^{36}Ar/^{38}Ar ratios closer to the cosmogenic ratio of 0.65 than those of the fluffy CAIs. The ^{36}Ar produced from Cl in the fluffy CAIs seems to roughly compensate the lower ^{36}Ar concentrations due to their lower Ca concentrations. The estimated ^{36}Ar

concentrations produced from Cl during the 5.1 Ma of irradiation of Allende of ~$5x10^{-8}$ cm^3STP/g (pers. comm. I. Leya) for the fluffy CAIs can fully explain their enhanced $^{36}Ar/^{38}Ar$ ratios compared to those of the compact CAIs. However, a small primordial Ar component could remain undetected in this semi-quantitative approach.

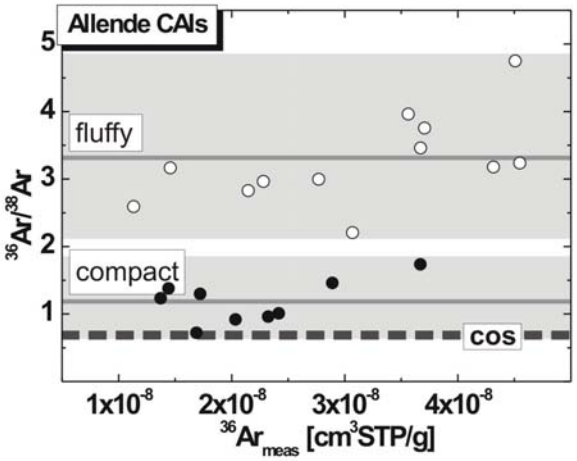

Fig. 2. $^{36}Ar/^{38}Ar$ ratios vs. the measured ^{36}Ar concentrations of fluffy and compact CAIs (open and black solid circles, respectively). Grey lines and boxes give average ratios and scatter of $^{36}Ar/^{38}Ar$ ratios of fluffy and compact CAIs, respectively. See text for further explanation.

Conclusion: The Ne isotopic composition of fluffy and compact CAIs can be explained straightforwardly by cosmogenically produced Ne from Al and Na bearing mineral phases present in CAIs, although they do not in principal allow us to exclude the presence of Ne-E. Also no primordial Ne-component with a $^{20}Ne/^{22}Ne$ >1 as proposed by Smith et al. [5] could be detected. The different Ar isotopic compositions of fluffy and compact CAIs are the result of different Ca and Cl concentrations, which led to higher cosmogenic $^{36}Ar/^{38}Ar$ ratios in the fluffy than in the compact CAIs. However, a small primordial Ar component could remain undetected in this semi-quantitative estimate. Presumed that chondrules and CAIs were formed from similar precursor materials, the complete release of primordial noble gases from the CAIs reflects their peak temperatures above the ones of chondrules, which kept small amounts of primordial ^{20}Ne and ^{36}Ar [4].

If the CAIs were formed close to the young sun, as proposed by [3] any solar signature was either lost due to the heating, or no measurable amounts of solar Ne and Ar could be dissolved into the molten CAIs.

References: [1] Allègre C. J et al. (1995) *GCA,* 59, 1445-1456. [2] MacPherson G. J. et al. (1988) *in: Meteorites and the early Solar System*, 746-769. [3] Shu F. H. et al. (2001) *Astrophys. J., 548,* 1029-1050. [4] Vogel N. et al. (2001) *LPS XXXII*, Abstract #1841. [5] Smith P. S. et al. (1977) *GCA, 41*, 627-647. [6] Shukolyukov Y. A. et al. (2001) *Geochem. Int., 39*, 110-125. [7] Black D. C. and Pepin R. O. (1969) *EPSL, 6*, 395-405. [8] Leya I. et al. (2000) *Meteorit. Planet. Sci., 35*, 259-286. [9] Grossman L. (1976) *GCA, 40*, 331-344. [10] Grossman, L. (1976) *GCA, 40,* 40967-977. [11] Grossman L. and Ganapathy R. (1975) *Proc. Lunar Sci. Conf., 6,* 318-320.