ALMAHATA SITTA UREILITES - NOBLE GASES AND COSMIC RAY EXPOSURE AGES.

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Introduction: Ureilites are mantle rocks that have undergone partial melting and melt extraction [1,2]. They contain high concentrations of trapped noble gases with isotopic compositions similar to those of the widespread Q component [3]. The degree of elemental fractionation of ureilite noble gases compared to solar noble gases is variable, i.e., Ar/Xe and Kr/Xe ratios are variable and often higher than in Q [4]. How the noble gases were incorporated into the ureilite parent body and retained after partial melting is not well understood. We report the composition and concentration of trapped noble gases in a set of Almahata Sitta ureilites and one trachyandesite, likely a ureilite parent body surface rock [2]. Samples from the Almahata Sitta strewn field include different ureilite lithologies as well as chondrites, enstatite achondrites, and trachyandesites [2,5]. The formation of asteroid 2008 TC_3 which delivered the Almahata Sitta meteorite is debated and cosmic ray exposure (CRE) ages can provide insight into parent body processing [5-7]. Initial determinations of CRE ages showed that samples had similar ages [8,9]. However, as more samples were analyzed, a spread in the CRE ages started to appear, possibly indicating that some samples had been pre-irradiated on the parent body in a regolith environment [6] or before re-accretion [5]. By determining CRE ages of a large set of Almahata Sitta ureilites we aim at better understanding the irradiation history.

Samples and Methods: We analyzed He, Ne, Ar, Kr, and Xe isotopic compositions and concentrations in 18 Almahata Sitta samples. The samples are a mix of coarse-grained, fine-grained, and mixed lithology ureilites as well as one trachyandesite (MS-MU-011). Based on the concentration of cosmogenic ^{21}Ne and production rates determined using [10] we calculated CRE ages as described in [7]. The production rates of ^{21}Ne depend in part on the samples' chemical compositions, in particular on their Mg concentrations. We currently only have the chemical composition of MS-MU-011 [2]. For the other samples, we used the average ureilite composition given in the compilation by [11]. To estimate the effect of potential compositional variability on CRE ages, we additionally calculated ages based on the elemental composition with highest and lowest Mg concentrations given in [11].

Results and Discussion: Concentrations of ^{36}Ar, ^{84}Kr, and ^{132}Xe vary by two orders of magnitude between the samples but are generally within the range of those reported for ureilites in the literature [3,4,12]. The samples have ^{36}Ar/^{132}Xe (55- 650) and ^{84}Kr/^{132}Xe (~0.75-2.4) ratios that span most of the range in previously analyzed ureilites. The Ne isotopic composition shows that Ne is predominantly cosmogenic, in some samples mixed with trapped Ne (Ne_{tr}). The $^{20}Ne_{tr}$ concentration is similar to, or lower than, those reported for other ureilites [4]. The trachyandesite has a lower $^{20}Ne_{tr}$ concentration than all ureilites for which Ne_{tr} could be determined. The $^{36}Ar_{tr}$ concentration in the trachyandesite is at the lower end of the range in ureilites and the concentrations of ^{84}Kr and ^{132}Xe are close to the median. This indicates that the partial melting on the ureilite parent body that formed the trachyandesite [2] either did not efficiently degas the noble gas carrier(s), or that noble gases in the magma were lost before or during crystallization.

Most samples have a CRE age of ~15-20 Ma. Sample MS-MU-011 has a significantly lower CRE age of ~7-8 Ma, similar to the CRE age of AhS 91A (mostly C1), determined in a previous study [6]. Some of the samples, in particular MS-MU-030 and -032, have CRE ages in-between most of the other samples and the low CRE age samples. However, the uncertainty introduced by possible variability in elemental compositions obscures the picture. To compare our CRE ages with those in the literature, we re-calculated literature CRE ages based on production rates determined the same way as done here. Combining the literature data and the new data in this study, the CRE ages of Almahata Sitta samples stretch a range from ~7 to ~24 Ma. It therefore seems unlikely that the different samples from the Almahata Sitta strewn field have the same irradiation history. Given the CRE age spread, it appears as though the true transfer time from the Almahata Sitta parent body to Earth was at most ~8 Ma and that most samples have been pre-irradiated.

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