CHLORINE CORRELATED $^{36}$Ar IN ALLENDE FINE-GRAINED INCLUSIONS.


The proof of the one time existence of short-lived nuclides $^{24}$Pu($t_1/2$=82 m.y.), $^{129}$I($t_1/2$=17 m.y.), and $^{26}$Al($t_1/2$=720,000 y) in meteoritic materials has placed important constraints on the time scales between nucleosynthetic events and the formation of solid materials; and leads to the question of whether other short-lived nuclides may have been present as well, which would further narrow the constraints. It has, for example, been suggested that $^{36}$Cl($t_1/2$=370,000 y) may have been present in meteoritic materials (1). Indeed, excesses of $^{36}$Ar (i.e. $^{36}$Ar/$^{38}$Ar>$5.35$) have been observed in Allende fine-grained sodalite (Na$_8$Al$_6$Si$_6$O$_{24}$Cl$_2$) bearing inclusions (2,3). While Smith et al. (2) argue that the $^{36}$Ar excesses that were observed by them in fine-grained inclusions from Allende are consistent with decay of $^{36}$Cl produced by neutron capture on $^{35}$Cl; Göbel et al. (3) noted that $^{36}$Ar excesses which they observed in a suite of fine-grained inclusions from stones of differing $^{60}$Co-activity, when normalized to Cl fail to correlate as convincingly with the $^{60}$Co-activity as the correlated I-Xe ratio ($^{129}$Xe$^+$/${}^{128}$Xe$^+$) measured on the same inclusions. The unanswered questions as to whether the $^{36}$Ar excesses are indeed due to the decay of $^{36}$Cl and, if so, whether the presence of the $^{36}$Cl was due entirely to neutron capture on $^{35}$Cl in the meteorite were motivation to attempt to demonstrate a correlation (or lack of one) of the observed $^{36}$Ar excesses with Cl. As suggested by Clayton (1), the most appealing method would be an experiment of the Jeffrey-Reynolds type (4) for I-Xe whereby, for the Cl-Ar case, one produces $^{38}$Ar$_{Cl}$ in a reactor via $^{37}$Cl$^{+}$($n$, $^8$Li)$^{38}$Cl $t_1/2$=37 min $^{38}$Ar$_{Cl}$ and attempts to demonstrate a correlation of $^{38}$Ar$_{Cl}$ and $^{36}$Ar for temperature fractions of a stepwise heating experiment. A suitable reference isotope (such as $^{130}$Xe, $^{132}$Xe in I-Xe) required for forming a 3-isotope 2-component system of trapped gas + Cl-correlated gas is missing for Ar since the radiogenic contributions at $^{40}$Ar are overwhelming. Clayton (1) suggested that one could circumvent this problem by doing duplicate stepwise heating experiment on two aliquots of the same sample, one being n-irradiated and the other unirradiated. The quantities $\Delta(T)$=($^{38}$Ar/$^{36}$Ar)$_2$($^{36}$Ar/$^{36}$Ar)$_2$ and $\gamma(T)$=($^{38}$Ar/$^{36}$Ar)$_2$/$^{36}$Ar/$^{36}$Ar) are determined for each temperature step (2=irradiated, 1=unirradiated). Should a correlation exist for the various temperature steps these quantities should define a straight line connecting the two components given by $\Delta(T)$=$^{38}$Ar/$^{36}$Ar)$_2$($^{36}$Ar/$^{36}$Ar)$_2$+$^{36}$Ar/$^{36}$Ar) [1-$\gamma$]^{-1}$. Thus, the intercept of a plot of $\Delta(T)$ vs. $[\gamma-1]^{-1}$ is the Cl-correlated component, ($^{36}$Ar/$^{38}$Ar)$_{Cl}$, and the composition of the trapped component which plots at infinity is defined by the slope. The method was demonstrated to be useful by Jordan and Kirsten (5) using the Xe$^+$ systematics. A project was undertaken to employ the suggested method to search for a Cl-Ar correlation in four fine-grained sodalite-bearing inclusions taken from four stones from Allende with differing $^{60}$Co-activity (kindly provided for use by F. Begemann). The first results on an inclusion taken from stone 3529 indicate substantial excesses in $^{36}$Ar (>80% of the $^{36}$Ar$_{total}$). In a plot of $\Delta(T)$ vs. $[\gamma-1]^{-1}$ most values tend to cluster near an "intercept" value of ($^{36}$Ar/$^{38}$Ar)$_{Cl}$=0.2. Furthermore, $^{37}$Ar measurements (a measure for the spallation target Ca) indicate that most of the $^{38}$Ar in the unirradiated sample must be of spallogenic origin. Thus, the minor contribution of the trapped component may explain the clustering near the intercept of the Clayton-Plot. Removal of the spallogenic component moves most fractions to the value ($^{36}$Ar/$^{38}$Ar)$_{Cl}$=0.2 suggesting that this is the Cl-correlated ratio, ($^{36}$Ar/$^{38}$Ar)$_{Cl}$.

This is very similar to the situation in which Wasserburg and
Chlorine correlated $^{36}\text{Ar}$ in Allende...

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Huneke (6) found almost pure I-Xe ($^{128}\text{Xe}$, $^{129}\text{Xe}$) in the 9000°C fraction of a n-irradiated halogen-rich chondrule from Allende. Such a composition would plot at the intercept of a Clayton-Plot as well. The preliminary Ar results suggest that Ar in this inclusion is mainly a mixture between spallogenic and C1-correlated $^{36}\text{Ar}$ with a correlated ratio of $(^{36}\text{Ar}/^{38}\text{Ar})_{C1}=0.2$. Using an expected monitor ratio of $^{38}\text{Ar}/^{37}\text{Cl}=10^{-4}$, the C1-correlated ratio corresponds to a C1-ratio of $^{36}\text{Cl}/^{37}\text{Cl}=10^{-5}$ at the time Ar began to be retained. Whether the $^{36}\text{Cl}$ is entirely due to neutron effects on $^{35}\text{Cl}$ or in part due to extinct $^{36}\text{Cl}$ may possibly be answered by comparing the $^{36}\text{Cl}/^{37}\text{Cl}$ ratios with the Co-activities for this and the remaining three inclusions.

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References