THE PRODUCTION RATE OF COSMOGENIC 21-NE IN CHONDRITES DEDUCED FROM
D-6500 Mainz, W. Germany.

Cosmogenic 21-Ne is used widely to calculate exposure ages of stone mete- 
orites. In order to do so, the production rate $P(21)$ must be known. This 
rate, however, is dependent on the chemical composition of the meteorite as 
well as the mass of, and position within, the meteoroid during its exposure 
to the cosmic radiation. Even for a mean shielding the production rates de- 
termined from measurements of different radionuclides vary by a factor of 
two (e.g. [1]).

A method that can be used to determine exposure ages of meteorites that 
avoids shielding and chemical composition corrections is the 81-Kr-Kr-method 
[2,3]. However, for chondrites, in many cases, the direct determination of 
production rates for the Kr isotopes are prevented by the trapped gases and 
the neutron effects on bromine. Therefore, we have applied this method to four 
eucrite falls and then compared their 81-Kr-83-Kr-ages to their cosmogenic 
21-Ne and 38-Ar concentrations.

The eucrites - Bouvante-le-Haut, Juvinas, Sioux County, and Stannern - 
were chosen for these measurements because their similar chemical composition 
regarding the major elements. The mean concentrations (in wt%) are:

- Mg-(4.1 ±.1);
- Al-(6.7 ± .5);
- Si-(22.8 ± 3);
- Ca-(7.52 ± .12);
- Fe+Ni (14.3 ±.3).

The Kr-exposure ages of the four eucrites are calculated from the meas- 
ured isotopic composition of Kr. It is assumed that the trapped component has 
atmospheric isotopic composition and that the cosmogenic 83-Kr/86-Kr=0.015.

Tab. 1 contains the 81-Kr exposure ages together with the cosmogenic 38-Ar 
concentrations. For all samples the correction for trapped 38-Ar is less than 
1%. Fig. 1 shows the correlation between cosmogenic 38-Ar and 81-Kr exposure 
age of the four eucrites measured.

The production rate of 38-Ar in eucrites - $P(38)_E$ - is given by the slope 
of the line in Fig. 1. Considering the errors in both coordinates[4], this 
slope is calculated to be

$$P(38)_E = (0.139 \pm .005) \times 10^{-8} \text{ccSTP/gMa}$$

This production rate is about 2% lower than recently published by us [5] due 
to the additional measurement of Stannern B. Both numbers agree within the 
uncertainties.

The given production rate $P(38)_E$ is a value which pertains to the mean 
shielding of the five samples. In the following it is assumed that this 
shielding is equivalent to the mean shielding of ordinary chondrites charac- 
terized by 22-Ne/21-Ne = 1.11. Using $P(38)_E$ and the measured 38-Ar/21-Ne - 
ratios the production rate $P(21)_E$ can be calculated. For the four investi- 
gated eucrites a mean value $38-Ar/21-Ne = 0.752 \pm .041$ is received. The re- 
sulting production rate is

$$P(21)_E = (0.185 \pm .013) \times 10^{-8} \text{ccSTP/gMa}.$$  

With the mean chemical concentration of Mg, Al, Si, S, Ca, Fe and Ni of eu- 
crites and the following production rate ratios $P(21)^{Mg}/P(21)^{Si} = 5.15 \pm .3$; $P(21)^{Mg}/P(21)^{Si} = 7.5 \pm 1.0$; $P(21)^{Al}/P(21)^{Si} = 1.9 \pm .6$;
PRODUCTION RATE OF 21-Ne
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\[
P(21)_{\text{Ca}} / P(21)_{\text{Mg}} = 0.04 \pm 0.04; \text{ and } P(21)_{\text{Fe, Ni}} = (0.021 \pm 0.04) \times 10^{-8} \text{ccSTP/gMa}
\]

an elemental production rate equation (in \(10^{-8}\text{ccSTP/gMa}\)) is given by

\[
P(21) = 1.63[Mg] + 0.6[Al] + 0.32[Si] + 0.22[S] + 0.07[Ca] + 0.021[Fe, Ni]
\]

\[
\pm 0.18 \pm 0.2 \pm 0.04 \pm 0.04 \pm 0.07 \pm 0.004
\]

([X] = concentration of element X as weight fraction).

From this equation a mean \(P(21)\) is calculated for L-group chondrites using the chemical composition of the respective group [6]:

\[
P(21)_L = (0.32 \pm 0.04) \times 10^{-8} \text{ccSTP/gMa}
\]

For H-group chondrites the production rate is 6% lower.

The major contribution to the production of 21-Ne in ordinary chondrites comes from Mg (about 76%) and Si (about 18%). The large uncertainties connected with the production rate ratios of the other elements are of less importance for \(P(21)_L\).

The given value for \(P(21)_L\) is within the limits of error in the range of recently determined production rates using other cosmogenic radionuclides [1, 7, 8] but 26-Al. This isotope tends to yield higher production rates for 21-Ne. This discrepancy may be caused by variations in the cosmic ray flux e.g. [1]. Also inadequate corrections for shielding and chemical composition variations cannot be ruled out [8].

Fig. 1: Correlation of cosmogenic \(38\)-Ar and the \(81\)-Kr-exposure age of four eucrites. From the slope of the correlation line the production rate of \(38\)-Ar is calculated.

<table>
<thead>
<tr>
<th>Meteorite</th>
<th>(38)-Ar ((10^{-8}\text{cc/g}))</th>
<th>(81)-Kr-age (Ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bouvante</td>
<td>1.01 ± 0.05</td>
<td>6.71 ± 0.37</td>
</tr>
<tr>
<td>Juvinas</td>
<td>1.35 ± 0.05</td>
<td>9.55 ± 0.63</td>
</tr>
<tr>
<td>Sioux County</td>
<td>3.03 ± 0.10</td>
<td>20.55 ± 0.88</td>
</tr>
<tr>
<td>Stannern A</td>
<td>5.60 ± 0.19</td>
<td>41.1 ± 1.3</td>
</tr>
<tr>
<td>Stannern B</td>
<td>5.50 ± 0.15</td>
<td>41.8 ± 1.9</td>
</tr>
</tbody>
</table>

Tab. 1: Cosmogenic \(38\)-Ar and \(81\)-Kr-83-Kr-exposure ages of 4 eucrite falls.

References: