Study on the Cosmic Ray Produced Longlived Mn-53 in Apollo-14 Samples.

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For exposure ages, activity profiles of the lunar surface and variations of the cosmic flux, the comparison of short and longlived spallation radionuclides is exceedingly helpful. Especially one of the latter group nuclide Mn-53 deserved our interest.

The K-emitting Mn-53, having a relatively high spallation yield, can be transformed by neutron capture to $\gamma$-emitting Mn-54. We first applied this technique to a larger number of iron meteorites, proving the usefulness and advantages of this technique even for mg quantities (1-3).

Depth profiles of Mn-53 in lunar rocks were recently presented by SHRELLDALFF (4) and also by our group (5).

In the last decade, however, one difficulty in dating-applications etc. on the Mn-53 basis, remained, because of an uncertainty in the respective half life. Earlier figures range from $T = 1.9 \times 10^6$ y.

Quite recently, new attempts were made in establishing the half value time, using different methods. Obviously, weight has the work of Honda et al. (6) succeeding by massspectrometric techniques on a man made sample, coming to a value $T = (3.7 \pm 0.4) \times 10^6$ y.

Three years ago, in view of the importance of this constant (2), we started independently an experiment in order to determine the Mn-53 halflife via activation.

The principle is: MnO$_2$ was extracted from the iron meteorite "Duchesne" and aliquots were neutron irradiated:
1.) for a "short" period of 24 days in a $^{14}$n cm$^{-2}$ s$^{-1}$ flux
2.) for a "long" period of 345 days, with a suitable Mn-54 monitor.

From the two describing activation equations the number of Mn-53 atoms are eliminated, thus allowing the evaluation of the cross section $Q_{53} = 70 \pm 10$ b.

The determination of the halflife was then possible by relating to the "Peace River" decay rate (best known value by J. R. Arnold; priv. comm.). So we resulted in $T_{53} = (3.8 \pm 0.7) \times 10^6$ y. Evidently this figure is in best agreement with Honda's value. The present work is based on our own figure.

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The counting was very much improved by a 75 cc Ge(Li)-Well-type detector, made by J. Eberth, Institut of Nuclear Physics, Cologne (resolution: 3.8 keV at 1.332 MeV; efficiency: 1.4% at the Mn-54 835 KeV line; background: 0.30 cpm under the total line).

The Mn-53 values related to iron are given in the table. The 11-14 soil samples are all in the range of 340-380 dpm/kg Fe, with the only exception of the "comprehensive soil" 14.259 (~1 cm from surface), being higher by a factor of nearly 2. Evidently this is due to a contribution of solar protons. Remarkable is the relatively low Mn-53 content of the mikrobreccia 14.305 BDI (interior part). This could mean that the exposure age is surprisingly short only about 6 x 10⁵ y. Further we redetermined sections from rock 10.017. The Mn-53 depth-dependance is demonstrated by the diagram. We were also able to check an aliquot of the "Tokyo Standard", kindly provided by Prof. M. Honda. Evidently best agreement is reached.

1.) Herpers, U., W. Herr and R. Woelfle, Radioactive Dating and Methods of Low-level Counting, 199, IAEA, Vienna (1967)
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W. Herr

53Mn-Content of Lunar Material

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Type</th>
<th>Sample Weight [mg]</th>
<th>53Mn (total) [cpm]</th>
<th>Contrib. of (n,2n) plus (n,p) [%]</th>
<th>53Mn [dpm/kg] [%]</th>
<th>Fe [dpm/kg Fe]</th>
<th>53Mn [dpm/kg Fe]</th>
</tr>
</thead>
<tbody>
<tr>
<td>14,163</td>
<td>soil</td>
<td>248</td>
<td>383 ± 0.016</td>
<td>27.8</td>
<td>26.9 ± 4.1</td>
<td>7.5</td>
<td>359 ± 54</td>
</tr>
<tr>
<td>14,259</td>
<td></td>
<td>231</td>
<td>562 ± 0.019</td>
<td>17.5</td>
<td>49.5 ± 7.5</td>
<td>7.7</td>
<td>639 ± 96</td>
</tr>
<tr>
<td>12,070</td>
<td></td>
<td>501</td>
<td>14.1 ± 0.2</td>
<td>25.8</td>
<td>49.4 ± 3.5</td>
<td>13.2</td>
<td>380 ± 57</td>
</tr>
<tr>
<td>10,084</td>
<td></td>
<td>980</td>
<td>17.7 ± 3.2</td>
<td>30.2</td>
<td>41 ± 7</td>
<td>12.0</td>
<td>34 ± 58</td>
</tr>
<tr>
<td>14,305 B01</td>
<td>brecc.</td>
<td>504</td>
<td>375 ± 0.015</td>
<td>49.4</td>
<td>12.9 ± 1.9</td>
<td>7.9</td>
<td>163 ± 24</td>
</tr>
<tr>
<td>12.021</td>
<td>rock</td>
<td>842</td>
<td>25.4 ± 0.3</td>
<td>38.8</td>
<td>33 ± 4</td>
<td>14.2</td>
<td>232 ± 28</td>
</tr>
<tr>
<td>0.022</td>
<td></td>
<td>1038</td>
<td>35.7 ± 0.4</td>
<td>36.6</td>
<td>38 ± 3</td>
<td>16.4</td>
<td>252 ± 24</td>
</tr>
<tr>
<td>0.053</td>
<td></td>
<td>1070</td>
<td>41.2 ± 0.4</td>
<td>34.1</td>
<td>41 ± 3</td>
<td>15.3</td>
<td>268 ± 20</td>
</tr>
</tbody>
</table>

*53Mn-, "Standard" - Solution: supplied by courtesy of Prof. M. Honda with a value of 0.395 dpm/g solution, (priv. comm.)

53Mn-Values in Relation to the Depth

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